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

FOOD SAFETY ACTION PLAN

REPORT

2013 – 2014
TARGETED SURVEYS – CHEMISTRY

Aflatoxins in Corn Products, Nuts and Nut Butters, Dried Fruits, Cocoa Powder, Breads, Breakfast and Infant Cereals, and Spice Powders

RDIMS #5818568
Data tables RDIMS #5820369

Special Surveys
Chemical Evaluation
Food Safety Division
Canadian Food Inspection Agency
1400 Merivale Road
Ottawa Ontario Canada
K1A 0Y9

Table of Contents

Executive Summary

Targeted surveys are used by the Canadian Food Inspection Agency (CFIA) to focus its surveillance activities on areas of highest risk. The information gained from these surveys provides both support for the prioritization of the Agency's activities to areas of greater concern and scientific evidence to address areas of lesser concern. Originally started under the Food Safety Action Plan (FSAP), targeted surveys have been incorporated into the CFIA's regular surveillance activities as a valuable tool for generating essential information on certain hazards in foods, identifying/characterizing new and emerging hazards, informing trend analysis, prompting/refining human health risk assessments, assessing compliance with Canadian regulations, highlighting potential contamination issues, and promoting compliance.

The main objectives of this targeted survey were to

- generate baseline surveillance data on the levels of aflatoxins in selected domestic and imported corn products, nuts and nut butters, dried fruits, cocoa powder, breads, breakfast and infant cereals, and spice powders available on the Canadian retail market,
- compare the aflatoxin levels in these results to other Canadian and international data on aflatoxins, where possible.

Aflatoxins are a family of mycotoxins (naturally-occurring, and toxic secondary metabolites) produced by *Aspergillus* fungi. Hot, humid conditions and pest damage during plant growth or storage can favour the growth of aflatoxin-producing fungi, leading to the presence of aflatoxins in foods. Aflatoxins are known to occur in corn and corn products, nuts and nut products, dried fruit, grains, and spices. Short-term exposure to high levels of aflatoxins can cause illness in humans which is characterized by vomiting, abdominal pain, convulsions, coma, and death. The illness is very rare in the developed world. Chronic or long-term exposure to higher levels of aflatoxins has been linked to a number of human health effects, including increasing the risk of developing liver cancer.

The 2013-2014 CFIA Aflatoxins survey targeted domestic and imported corn products, nuts and nut butters, cocoa powder, spice powders, breads, breakfast and infant cereals, and dried fruits. A total of 969 samples were collected from retail stores in 6 Canadian cities between July 2013 and March 2014. The samples collected included 238 nuts and nut butters, 228 corn products (e.g. corn tacos, corn/tortilla chips), 148 breakfast/infant cereals, 115 breads, 97 dried fruits, 94 spice powders, and 49 cocoa powders. Samples were analysed using a multi-analyte method that detects aflatoxin forms B1, B2, G1 and G2. Most of the samples (94.7%) did not contain a detectable level of aflatoxins. The total aflatoxin levels in the remaining samples ranged from 1.0 parts per billion (ppb) to 72.2 ppb.

In general, aflatoxin levels reported in the current targeted survey were consistent with the results obtained from the analysis of similar products from previous CFIA surveys. While a U.K. study detected lower average and maximum aflatoxin levels in paprika compared to the current CFIA survey, the data is still somewhat comparable, as is the data for raisins. In CFIA studies, 0-1% of raisin samples tested had detectable levels of aflatoxins while a study conducted in Iran showed 8% of the samples tested positive.

The Canadian Food and Drug Regulations specify a tolerance of 15 ug/kg (ppb) total aflatoxins in nut and nut products. All but one sample of nuts and nut butters (99.6%) were compliant with these regulations. Currently there are no regulations established in Canada for aflatoxin levels any of the remaining products tested so compliance with a numerical standard could not be evaluated. Health Canada reviewed all the data and has determined that none of the samples, including the nut product sample exceeding the tolerance, posed a concern to human health. No product recalls were warranted given the lack of a health concern.

The CFIA will continue its surveillance activities and inform the Canadian public and stakeholders of its findings.

1 Introduction

1.1 Targeted Surveys

The Canadian Food Inspection Agency (CFIA) monitors both domestic and imported foods in Canada for the presence of allergenic, microbiological, chemical, and physical hazards. One of the tools used to maintain this oversight are targeted surveys, which are a means to establish baseline information on specific hazards and to investigate emerging risks. Targeted surveys are part of the Agency's core activities along with other surveillance strategies, which include the National Chemical Residue Monitoring Program (NCRMP), the National Microbiological Monitoring Program (NMMP), and the Children's Food Project (CFP). The surveys are complementary to other CFIA surveillance activities in that they generate data on hazards and/or foods that are not routinely included in those monitoring programs.

Targeted surveys are used to gather information regarding the possible occurrence or prevalence of hazards in defined food commodities. These surveys generate essential information on certain hazards in foods, identify or characterize new and emerging hazards, inform trend analysis, prompt or refine human health risk assessments, assess compliance with Canadian regulations, highlight potential contamination issues, and/or influence the development of risk management strategies as appropriate.

Due to the vast number of hazard 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, the media, 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.

1.2 Acts, Regulations, and Codes of Practice

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 (ML) for chemical residues and contaminants in food sold in Canada. Certain MLs 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 for foods that significantly contribute to the total dietary exposure of that contaminant.

Nuts and nut products are considered contaminated if they contain more than 15 parts per billion (ppb) total aflatoxins in the nut meat portion of the product according to section B.01.046 (n) of the *Food and Drug Regulations*[1].

There is no Canadian tolerance for aflatoxins in corn products, cocoa powders, raisins, chili powders or paprika. For all commodities lacking an established ML, the levels of aflatoxins are examined by CFIA and 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 and could include additional sampling, additional inspections, or ultimately the recall of the product from the Canadian market place.

2 Survey Details

2.1 Aflatoxins

Aflatoxins are a family of naturally-occurring, toxic secondary metabolites produced by *Aspergillus flavus* and *A. parasiticus* fungi[3]. At least 20 different chemical forms of aflatoxins exist. The four most common forms of aflatoxins in plant-based foods, in order of toxic potencies from highest to lowest, are B_1, G_1, B_2, and G_2[3]. Aflatoxin B_1 is the predominant aflatoxin form, while the other forms tend to co-occur with B_1[3].

Aflatoxin-producing fungi may contaminate agricultural products (such as corn, nuts, spices, dried fruit) if grown, transported, stored, or processed under hot, humid conditions for prolonged periods of time, or with pest pressures resulting in bruising or cuts on the commodity[2,3]. Drought pressure on corn is also a major risk factor for the occurrence of aflatoxins in the field[2,3,4]. Due to the cooler Canadian climate, domestically-grown agricultural commodities (and products thereof) are less likely to contain aflatoxins than those imported from warmer climates. Canada produced almost 11 million tonnes of corn in 2011 and ranks as the 11th largest producer in the world[4].

Aflatoxins are not destroyed by heating, cooking or most other processing methods[5]. There is the potential for these processed foods (e.g. nut butters or corn-based chips) to contain aflatoxins if the raw agricultural products used in manufacturing (e.g. nuts and corn) are contaminated.

2.2 Rationale

Aflatoxins are known to contaminate corn, nuts, dried fruits, grains and spices[15,16]. The major route of human exposure to aflatoxins is through the consumption of contaminated nuts, nut butters, oilseeds, wheat, and corn products[6,7,8], which are consumed both directly as foods and as ingredients.

Aflatoxin B_1 is among the most potent naturally-occurring liver carcinogens known[9]. The International Agency for Research on Cancer (IARC) classified aflatoxins to be carcinogenic to humans (Group 1 carcinogen)[10]. Chronic exposure to aflatoxins has also been associated with growth impairment in children living in developing countries where exposure to aflatoxins is relatively high. Aflatoxins have been shown to cause immune suppression in experimental animals[8,11,.12,13,14] Short-term exposure to high levels of aflatoxins can cause illness in human which is characterized by vomiting, abdominal pain, convulsions, coma, and death. The illness is very rare in the developed world[14].

The Codex Alimentarius Commission, established by the United Nations' Food and Agriculture Organization and the World Health Organization in 1963, develops harmonized international

food standards, guidelines and codes of practice to protect the health of consumers and ensure fair practices in the food trade. The potential human health effects from aflatoxin exposure have prompted the establishment of several Codex Alimentarius Codes of Practice to prevent and to reduce aflatoxin contamination in peanuts[15], dried figs[16], tree nuts[17], and cereals[18]. To date, there are no Codex Codes of Practice specifically for the production and storage of nut butters, cocoa powder, raisins, chili powder or paprika.

Aflatoxin levels in foods other than nuts and nut butters are not routinely monitored by the CFIA. This targeted survey provides additional baseline surveillance data for aflatoxin levels in nuts, nut butters, and corn products. The scope of this targeted survey was extended to cocoa powder, raisins, chili powder and paprika, as these commodities have been shown in academic studies[19,20,21] and the previous targeted surveys to contain elevated levels of aflatoxins[3,10].

2.3 Sample Distribution

The 2013-2014 CFIA Aflatoxins survey targeted nuts, nut butters, corn products, dried fruits, cocoa powders, spice powders, breads, and breakfast and infant cereals. Samples were collected from retail stores in 6 Canadian cities between July 2013 and March 2014 by samplers under contract with the Government of Canada. Table 1 presents the distribution of survey samples.

Table 1. Distribution of survey samples by commodity

Commodity	Sub-Category (Total Number of Samples)
Nuts	Almond (20), Brazil Nut (20), Cashew (20), Hazelnut/Filbert (15), Macadamia Nut (10), Nutmeats – Other (15), Peanut (20), Pecan (14), Pistachio (15), Walnut (15).
Nut Butters	Butter – Almond (20), Butter – Cashew (19), Butter - Other Nut (16), Butter – Peanut (19).
Corn-based Products	Corn Bran (2), Corn Chips (48), Corn Taco Shells/Pasta (34), Corn Starch (32), Corn Flour (35), Cornmeal (42), Popcorn (35).
Breakfast and Infant Cereal	Adult Cereal (57), Children Cereal (42), Infant Cereal (49).
Breads	Bread (42), Bread – Bagel (15), Bread - English Muffin (15), Bread – Other (43).
Dried Fruit	Cranberry (15), Date (9), Fig (16), Mixed Fruit (2), Prune (15), Raisin (16).
Spices	Allspice (5), Anise (3), Caraway Seed (5), Cardamom (5), Cinnamon (10), Cloves (4), Cumin (5), Curry (10), Fennel (5), Fenugreek/Methi (4), Mace (4), Mustard (1), Nutmeg (5), Paprika (10), Pepper (5), Spice – other (4), Star Anise (4), Turmeric (5).
Cocoa Powder	Cocoa Powder (49).

The 969 samples collected included 179 domestic products, 433 imported products and 357 products of unspecified origin. Samples of unspecified origin are those 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 "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 identify 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.

2.4 Method Details

Samples in the Aflatoxins targeted survey were analyzed by an ISO 17025 accredited laboratory under contract with the Government of Canada.

The method used detects the major forms of aflatoxins, including B_1, B_2, G_1, and G_2. The limit of detection for each aflatoxin form is 1.0 ppb, with the exception of aflatoxin G_2, where the LOD is 2.0 ppb for spices, cocoa and chocolate. Samples were tested as sold, meaning that the product was not prepared as per the package instructions (if applicable). The aflatoxin level reported in this survey refers to the sum of the concentrations of the four aflatoxin forms. Aflatoxin forms that were not detected were set at a concentration of 0 ppb for the purpose of calculation of the totals aflatoxin.

2.5 Limitations

The current targeted survey was designed to provide a snapshot of the aflatoxin levels in nuts, nut butters, corn products, breads, infant and breakfast cereals, dried fruits, cocoa powders and spices available in Canada and 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. Few inferences or conclusions were made regarding the data with respect to country of origin. Regional differences, impact of product shelf-life, storage conditions, or cost of the commodity on the open market were not examined in this survey.

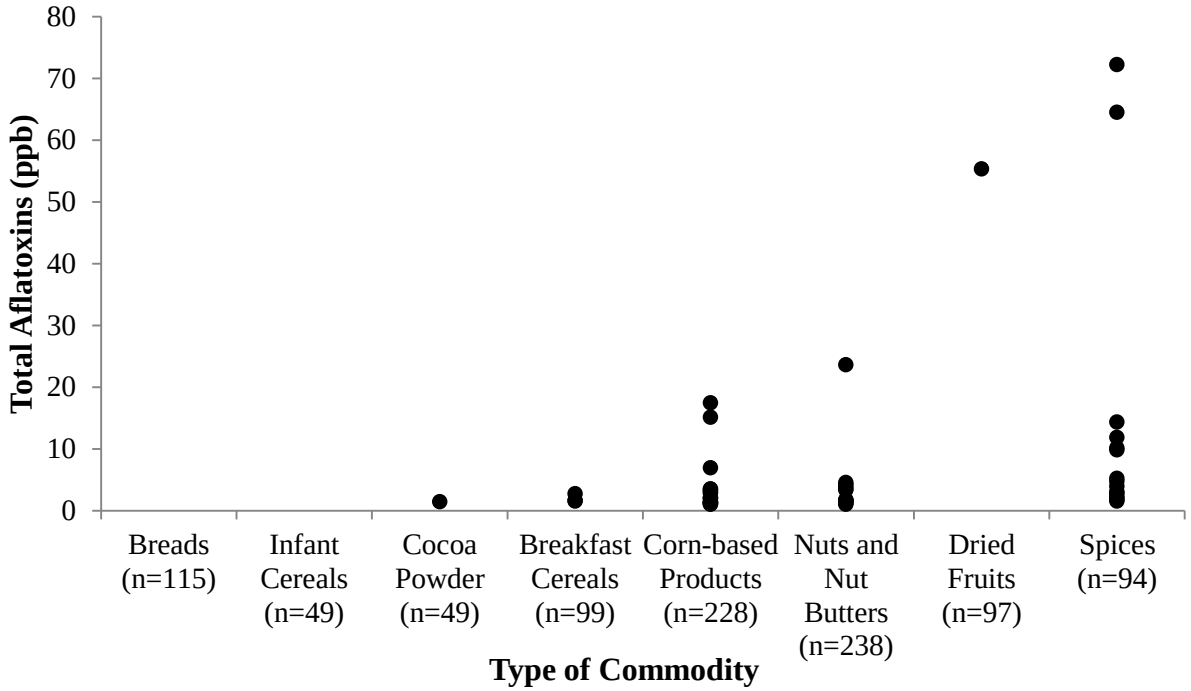
The limited sample size is noteworthy when interpreting the results of aflatoxin due to the way aflatoxins occur in nature. Contamination occurs in pockets and can be unevenly distributed. Despite taking a large sample size of 1 kg per sample, it is recognized that this size may not be large enough to account for the heterogeneity that may exist in a given lot.

Analysis was completed on products available on the Canadian retail market. Some of the products sampled in this survey are considered ingredients and/or require preparation prior to consumption (i.e., mixing with liquid). However, the results herein represent finished food products as sold and not as they would be consumed.

3 Results and Discussion

3.1 Overview of Aflatoxin Results

The 2013-2014 Aflatoxin targeted survey tested 969 samples obtained at the Canadian retail level. The samples included 238 nuts and nut butters, 228 corn-based products (e.g., corn tacos, corn/tortilla chips), 148 breakfast/infant cereals, 115 breads, 97 samples of dried fruits, 94 spice powders, and 49 samples of cocoa powders. Aflatoxins were not detected in 94.7% of the survey samples. In the 5.3% of samples with detectable levels of aflatoxins, the total aflatoxin levels ranged from 1.0 ppb to 17.4 ppb in corn products, 1.0 ppb to 23.6 ppb in nuts and nut butters, 1.5 ppb to 72.2 ppb in spices, and 1.5 ppb to 2.7 ppb in breakfast cereals. Aflatoxins were not detected in the infant cereals or bread products, nor were they detected in 96 out of the 97 dried fruits samples, and 48 out of the 49 cocoa powder samples. Figure 1 presents the total aflatoxin levels detected per sample by product type.



Note: only levels of aflatoxins above the limit of detection are depicted in the graph.

Figure 1. Distribution of total aflatoxin level per sample by product type (arranged by increasing maximum aflatoxin level)

There are no maximum levels (tolerances or standards) for aflatoxins in corn products, cocoa powder, dried fruits, breakfast cereals, or spices, therefore, compliance to a numerical standard could not be assessed. The Canadian tolerance for total aflatoxins in nuts and nut butters is 15 ppb. All but one nut and nut butter product sampled in this survey were compliant with this tolerance. Health Canada's Bureau of Chemical Safety evaluated the results of this survey and determined that none of the samples represent a health concern to Canadian consumers, including young children.

3.2 Aflatoxin Results by Product Type

Aflatoxin results by product types are presented in the following section. When possible, the results of the current survey were compared to previous targeted surveys and scientific literature. It is important to note the difference in LODs between targeted surveys. This difference in LODs could account for difference in prevalence and levels of aflatoxins detected.

3.2.1 Bread, Cocoa Powder, Dried Fruit, Infant and Breakfast Cereals

Of the 360 products in this category, 355 samples (98.6%) did not contain detectable levels of aflatoxin. The five positive samples included one sample of cocoa powder (1.4 pp), one sample of dried figs (55.3 ppb), and three samples of breakfast cereals contained (1.5 ppb, 1.6 ppb, and 2.7 ppb). None of the 49 infant cereals and 115 bread products contained detectable levels of aflatoxins in this survey.

Table 2 summarizes the current survey results in cocoa powder, raisin and date, and compares them to previous targeted surveys and scientific literature. In the current survey, the maximum and average aflatoxin levels detected in cocoa powder is much lower than that reported by Health Canada researchers, but is above the level reported in the previous targeted survey. For raisins, the current survey had the lowest levels of total aflatoxins. In this year's survey, none of the raisin samples tested positive for aflatoxins; this is somewhat comparable with a study conducted in Iran where 8% of the raisin samples tested positive. The results for the sampled dried figs and dates are comparable to earlier targeted surveys.

Table 2. Comparison of the 2013-2014 targeted survey to previous surveys and scientific literature

Study	Year	Number of Samples	Number (%) of Positive Samples	Maximum Total Aflatoxin Level (ppb)	Average Total Aflatoxin Level (ppb)
Cocoa Powder					
CFIA	2013-2014	49	1 (2)	1.4	N/A
CFIA	2012-2013	25	0 (0)	< LOD	< LOD
Health Canada[22]	2013	36	14 (39)	3.52	0.74
Raisins					
CFIA	2013-2014	16	0 (0)	< LOD	< LOD
CFIA	2012-2013	98	1 (1)	0.2	N/A
Iran[23]	2012	40	3 (8)	0.64	0.49
Dried Figs and Dates					
CFIA	2013-2014	25	1 (4)	55.3	N/A
CFIA	2010-2011	90	0 (0)	< LOD	< LOD
CFIA	2009-2010	100	4 (4)	78.7	57.5

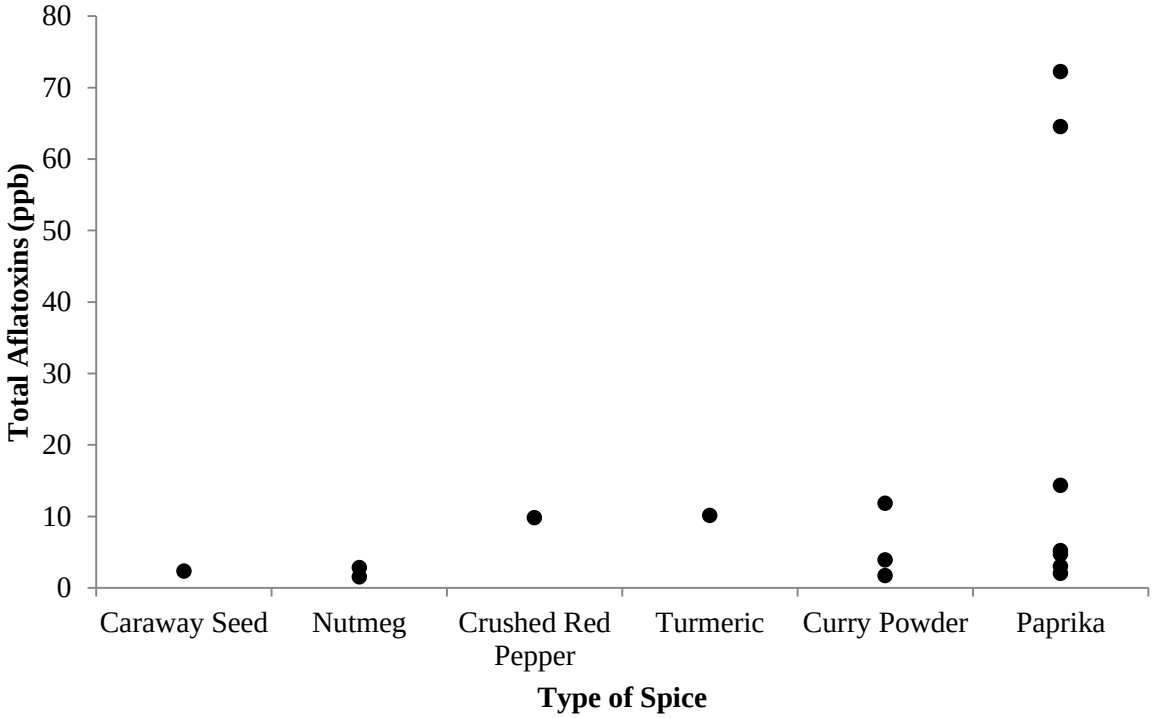
< LOD = below the limit of detection (1.0 ppb and aflatoxin G_2 in cocoa 2.0 ppb in the 2013-2014 year; 0.1 ppb for previous survey years)

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

3.2.2 Spices

Out of the 94 spice samples analyzed, 78 samples (83.0%) did not contain detectable levels of aflatoxins. The total aflatoxin levels in the remaining samples ranged from 1.5 ppb to 72.2 ppb.

Figure 2 shows the distribution of total aflatoxin by spice type. Two samples of paprika contained particularly high levels of total aflatoxins as compared to other positive spice samples.



Note: only levels of aflatoxins above the limit of detection are depicted in the graph.

Figure 2. Distribution of total aflatoxin results by spice type (arranged by increasing total aflatoxin level)

Table 3 summarizes the current survey results in paprika and compares them to previous targeted surveys and scientific literature. For paprika, the maximum and average total aflatoxins level in the current survey is higher than that reported in the previous survey and scientific literature. However, compared to the previous year's survey and to scientific literature, the percentage of paprika samples testing positive for aflatoxins is lower.

Caraway seed, curry powder, crushed red pepper, nutmeg and turmeric were not examined in the previous CFIA targeted surveys, or to our knowledge, in other scientific literature, and therefore no comparison is possible.

Table 3. Comparison of the 2013-2014 targeted survey to previous surveys and scientific literature

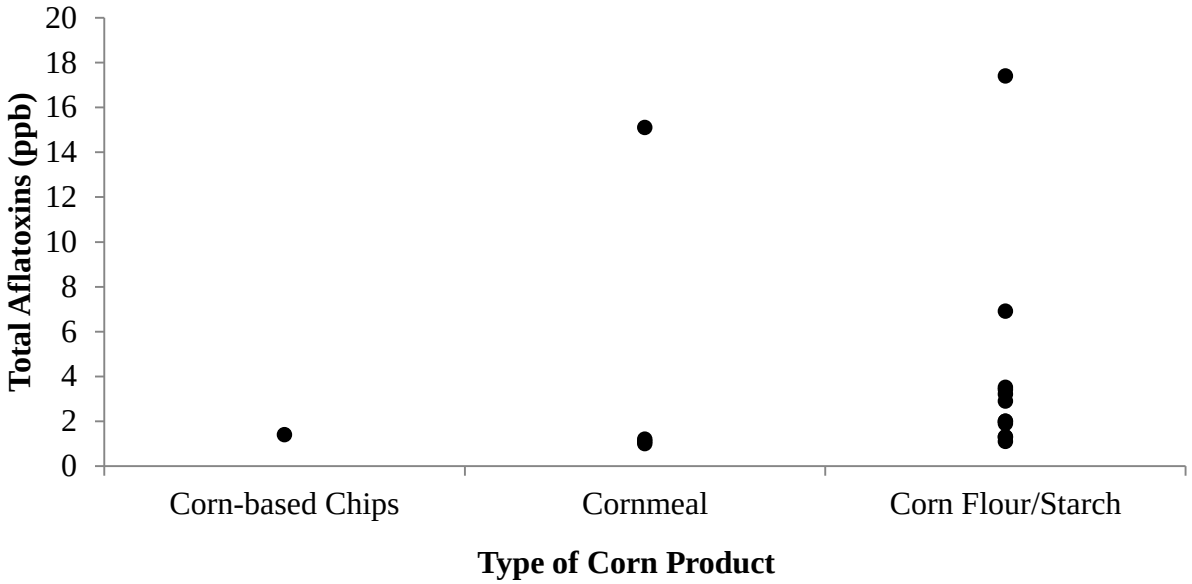
Study	Year	Number of Samples	Number (%) of Positive Samples	Maximum Total Aflatoxin Level (ppb)	Average Total Aflatoxin Level (ppb)
Paprika					
CFIA	2013-2014	10	6 (60)	72.2	11.5
CFIA	2012-2013	24	17 (71)	12.7	1.2
United Kingdom[24]	2005	11	11 (100)	2.9	1.7

< LOD = below the limit of detection (1.0 ppb and aflatoxin G_2 in spices 2.0 ppb in the 2013-2014 year; 0.1 ppb for previous survey years)
Note: Minimum, maximum and average values were calculated using only results for samples with detectable aflatoxin levels

3.2.3 Corn Products

Out of the 228 corn products analyzed in this survey, 209 corn product samples (91.7%) did not contain detectable levels of aflatoxins. The total aflatoxin levels in the remaining samples ranged from 1.0 ppb to 17.4 ppb.

Figure 3 shows the distribution of total aflatoxin results by type of corn product. Corn flour and corn starch samples had the highest total aflatoxin levels. One sample of cornmeal and one sample of corn flour contained particularly high levels of total aflatoxins compared to other positive samples. Aflatoxins were not detected in popcorn, corn-based pasta, corn taco shells, or corn bran.



Note: only levels of aflatoxins above the limit of detection are depicted in the graph.

Figure 3. Distribution of total aflatoxin results by type of corn product (arranged by increasing aflatoxin level)

Table 4 summarizes the current survey results in corn products and compares them to previous targeted surveys and scientific literature. The corn products results from the current targeted survey are consistent with the results obtained in the previous surveys[25,26,27], with the exception of the maximum and average aflatoxin levels in corn-based breakfast/infant cereals. It is noteworthy that no infant cereals tested positive for aflatoxins – the three positive samples came from adult and children's breakfast cereals. Drought pressure on corn is a major risk factor for the occurrence of aflatoxins in the field. The years 2012 and 2013 were particularly trying years in the southern United States[28,29] with regards to drought and the presence of aflatoxins. There are still some concerns regarding leftover crop from 2012 that may make its way into corn products.

Table 4. Total aflatoxin levels in corn products per survey year by product type

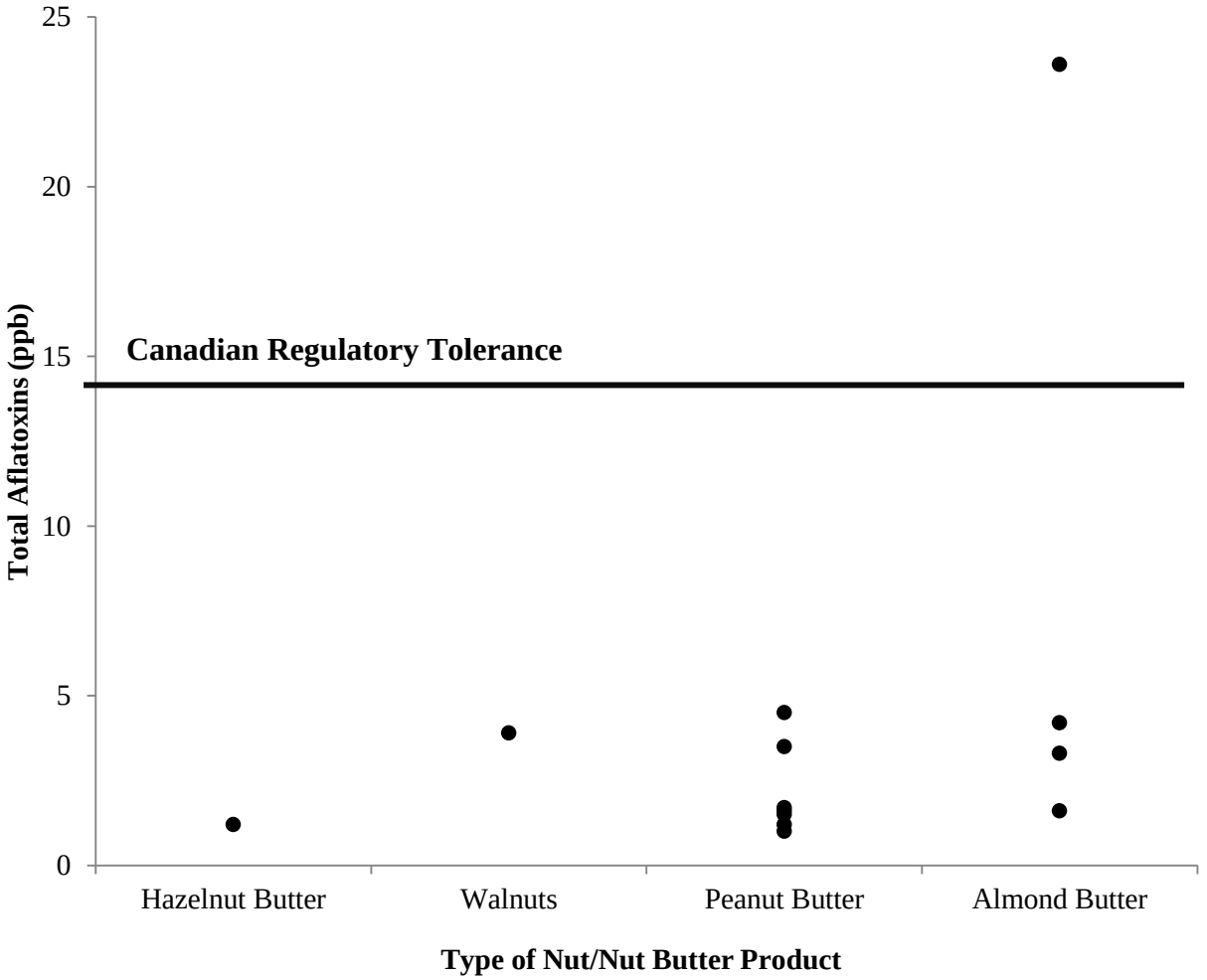
Product Type	CFIA Survey Year	Number of Samples	Number (%) of Positive Samples	Maximum Total Aflatoxin Level (ppb)	Average Total Aflatoxin Level (ppb)
Popcorn	2013-2014	35	0 (0)	< LOD	< LOD
	2012-2013	73	0 (0)	< LOD	< LOD
	2011-2012	32	0 (0)	< LOD	< LOD
	2010-2011	29	1 (3)	0.7	N/A
Taco	2013-2014	9	0 (0)	< LOD	< LOD
	2012-2013	68	17 (25)	1.4	0.4
	2011-2012	13	1 (8)	0.1	N/A
	2010-2011	23	12 (52)	1.7	0.5
Tortilla/ Corn Chips	2013-2014	48	1 (2)	1.4	N/A
	2012-2013	81	11 (14)	2.0	0.8
	2011-2012	55	6 (11)	0.5	0.2
	2010-2011	51	5 (10)	0.5	0.3
Corn-based Breakfast /Infant Cereal	2013-2014	11	3 (11)	2.7	1.9
	2012-2013	73	12 (16)	0.8	0.3
	2011-2012	72	6 (8)	0.7	0.4
	2010-2011	57	5 (9)	1.2	0.6

< LOD = below the limit of detection (1.0 ppb for 2013-2014 year; 0.1 ppb for previous survey years)
Note: Minimum, maximum and average values were calculated using only results for samples with detectable aflatoxin levels

3.2.4 Nuts and Nut Butters

Out of the 164 nut samples tested, 163 (99.4%) did not contain detectable levels of aflatoxins. One walnut sample contained 3.9 ppb of aflatoxins. Out of the 74 nut butter samples tested, 62 (83.8%) did not contain detectable levels of aflatoxins. In the remaining 12 samples, aflatoxin levels ranged from 1.0 ppb to 23.6 ppb. All but one sample, a sample of almond butter, (99.6%) were compliant with the Canadian *Food and Drug Regulations* tolerance of 15 ppb total aflatoxins in nut and nut products.

Figure 4 shows the distribution of total aflatoxin results by type of nut and nut butter. Aflatoxins were not detected in almonds, Brazil nuts, cashews, hazelnuts, macadamia nuts, peanuts, pecans, pine nuts, pistachios, cashew butter, macadamia nut butter or nut butter blends. Nut butter blends include two or more types of nut butters. The highest total aflatoxin levels were observed in almond butter and peanut butter.



Note: Only the levels of aflatoxins above the limit of detection are depicted in the graph.

Figure 4. Distribution of total aflatoxin results by type of nut and nut butter (arranged by increasing total aflatoxin level)

Table 5 summarizes the current survey results in nuts and compares them to previous targeted surveys. For most of the nut types, the results of the current survey are consistent with the results obtained in the previous survey[25,26,27]. Differences were highlighted by the non-detection of aflatoxins in peanuts and Brazil nuts, as well as the maximum concentration of aflatoxins observed in walnuts.

Table 5. Aflatoxin levels in nuts per survey year by nut type

Product Type	CFIA Survey Year	Number of Samples	Number (%) of Positive Samples	Maximum Total Aflatoxin Level (ppb)	Average Total Aflatoxin Level (ppb)
Almond	2013-2014	20	0 (0)	< LOD	< LOD
	2012-2013	45	0 (0)	< LOD	< LOD
	2011-2012	38	1 (3)	0.2	N/A
	2010-2011	45	1 (2)	1.9	N/A
Pistachio	2013-2014	15	0 (0)	< LOD	< LOD
	2012-2013	22	0 (0)	< LOD	< LOD
	2011-2012	30	1 (3)	0.6	N/A
	2010-2011	21	0 (0)	< LOD	< LOD
Walnut	2013-2014	15	1 (7)	3.9	N/A
	2012-2013	73	2 (3)	0.7	0.5
	2011-2012	31	2 (6)	0.5	0.4
	2010-2011	48	3 (6)	1.9	1.1
Brazil Nut	2013-2014	20	0 (0)	< LOD	< LOD
	2012-2013	46	8 (17)	14.4	2.6
	2011-2012	30	6 (20)	3.5	1.1
	2010-2011	13	2 (15)	0.4	0.3
Peanut	2013-2014	20	0 (0)	< LOD	< LOD
	2012-2013	97	9 (9)	28.3	3.8
	2011-2012	39	7 (18)	7.6	1.4
	2010-2011	36	6 (17)	28.7	5.3
Hazelnut	2013-2014	15	0 (0)	< LOD	< LOD
	2011-2012	36	0 (0)	< LOD	< LOD
	2010-2011	21	0 (0)	< LOD	< LOD
Pecan	2013-2014	14	0 (0)	< LOD	< LOD
	2011-2012	31	1 (3)	0.4	N/A
	2010-2011	25	0 (0)	< LOD	< LOD
Cashew	2013-2014	20	0 (0)	< LOD	< LOD
	2011-2012	31	1 (3)	0.6	N/A
	2010-2011	17	0 (0)	< LOD	< LOD
Macadamia Nut	2013-2014	10	0 (0)	< LOD	< LOD
	2011-2012	28	2 (7)	0.6	0.5
	2010-2011	8	0 (0)	< LOD	< LOD

< LOD = below the limit of detection (1.0 ppb for 2013-2014 year; 0.1 ppb for previous survey years)
Note: Minimum, maximum and average values were calculated using only results for samples with detectable aflatoxin levels

Table 6 summarizes the current survey results in nut butters and compares them to previous targeted surveys. For nut butters, there was good agreement between the current year's total aflatoxin levels to past years' levels, with the exception of almond butter where the maximum and average concentrations were higher in the current survey year.

Table 6. Aflatoxin levels in nut butters per survey year by nut butter type

Product Type	CFIA Survey Year	Number of Samples	Number (%) of Positive Samples	Maximum Aflatoxin Level (ppb)	Average Aflatoxin Level (ppb)
Cashew Butter	2013-2014	20	0 (0)	< LOD	< LOD
	2012-2013	5	0 (0)	< LOD	< LOD
	2011-2012	11	1 (9)	0.2	N/A
	2010-2011	1	0 (0)	< LOD	< LOD
Macadamia Nut Butter	2013-2014	1	0 (0)	< LOD	< LOD
	2012-2013	5	0 (0)	< LOD	< LOD
	2011-2012	4	1 (25)	2.1	N/A
	2010-2011	1	0 (0)	< LOD	< LOD
Nut Butter Blends*	2013-2014	2	0 (0)	< LOD	<LOD
	2012-2013	5	1 (20)	0.2	N/A
	2011-2012	3	1 (33)	0.3	N/A
Hazelnut Butter	2013-2014	12	1 (8)	1.2	N/A
	2012-2013	38	10 (26)	2.4	0.8
	2011-2012	24	4 (17)	1.9	1.2
	2010-2011	2	2 (100)	0.5	0.5
Almond Butter	2013-2014	20	4 (20)	23.6	8.2
	2012-2013	46	17 (37)	5.7	1.1
	2011-2012	31	10 (32)	12.5	2.9
	2010-2011	6	3 (50)	16.0	7.0
Peanut Butter	2013-2014	19	7 (37)	4.5	2.1
	2012-2013	54	32 (59)	8.5	1.9
	2011-2012	27	17 (63)	3.7	1.4
	2010-2011	9	4 (44)	12.5	6.4

*Blends refers to butter prepared with two or more types of nut
< LOD = below the limit of detection (1.0 ppb for 2013-2014 year; 0.1 ppb for previous survey years)
Note: Minimum, maximum and average values were calculated using only results for samples with detectable aflatoxin levels

In both the current and the previous targeted surveys[25,26,27], the percentage of samples with detectable aflatoxin levels and the observed levels were typically higher in nut butters than in their comparable nut meats. In all survey years, hazelnut, almond, and peanut butter were associated with the highest detectable levels of aflatoxins. In contrast, macadamia nut and cashew butter had very low levels of aflatoxins. The maximum total aflatoxin level noted in nut butter samples was slightly higher in this survey (23.6 ppb) than in the previous targeted surveys (12.5 and 16.0 ppb). The compliance rate for nuts and nut butters in this survey year is very similar to the previous targeted survey year; in both cases, one sample of nut butter was found in excess of the 15 ppb tolerance in the Canadian *Food and Drugs Regulations*[1]

4 Conclusions

The 2013-2014 Aflatoxins targeted survey generated additional baseline surveillance data on the total aflatoxin levels in domestic and imported corn products, nuts and nut butters, dried fruits, cocoa powder, breads, breakfast/infant cereals, and spices available on the Canadian retail market. The 969 samples included 238 nuts and nut butters, 228 corn-based products (e.g., corn tacos, corn/tortilla chips), 148 breakfast/infant cereals, 115 breads, 97 samples of dried fruits, 94 spice powders, and 49 samples of cocoa powders.

Aflatoxins were not detected in 94.7% of the survey samples. Aflatoxins were detected in 1% of dried fruit samples, 2% of cocoa powder samples, 2% of breakfast cereal samples, 5% of nuts and nut butter samples, 8% of corn product samples, and 17% of spice samples. The detectable levels of aflatoxins ranged from 1.0 ppb to 72.2 ppb.

When feasible, the prevalence and levels of aflatoxins in corn products, nuts and nut butters, spices, dried fruits, and cocoa powder in this survey were comparable to those of similar products in the previous CFIA Aflatoxins targeted surveys and to the scientific literature. Over all the survey years, nut butters had a higher level of aflatoxins relative to their corresponding nutmeats, spices and dried figs have been found to be the commodities with the highest level of aflatoxins reported, and aflatoxin levels corn products sampled remained consistently low.

For the total aflatoxins detected in corn products, cocoa powder, dried fruits, breads, breakfast/infant cereals and spices, no compliance to a numerical standard could be evaluated as there are no Canadian regulations or maximum levels (tolerances or standards) set for these commodities. All but one sample had total aflatoxin levels below the 15 ppb tolerance established in the Canadian *Food and Drug Regulations* (99.6% compliance – one almond butter sample tested positive for a level of total aflatoxins of 23.6 ppb). This compares quite similarly to the previous targeted survey year in which one sample of nut butter also exceeded the 15 ppb tolerance. Health Canada determined that none of the samples posed a health concern to Canadian consumers. There were no product recalls associated with this survey.

5 Appendix

Established Canadian and international tolerances / standards / maximum levels for aflatoxin in selected foods

Commodity	Canada[1]	US[30]	European Union[31]	Codex[15,16,17,18]
Nuts and Nut butters	15 ppb on the basis of the nut meat portion of the product	20 ppb for specific nuts; 20 ppb, in general, for all foods intended for consumption by humans	4-10 ppb (depending on nut) for ready-to-eat nuts and nut butters*; 10-15 ppb (depending on nut) for nuts intended for further physical treatment**	15 ppb for peanuts, almonds, Brazil nuts, hazelnuts and pistachios intended for further processing; and 10 ppb for ready-to-eat almonds, Brazil nuts, hazelnuts and pistachios
Breakfast Cereals	None	20 ppb for all foods intended for consumption by humans	4 ppb for ready-to-eat cereals and cereal products	None
Corn products	None	20 ppb for all foods intended for consumption by humans	10 ppb for corn intended for further physical treatment	None
Cocoa Powder	None	20 ppb for all foods intended for consumption by humans	None	None
Raisins	None	20 ppb for all foods intended for consumption by humans	4 ppb for ready-to-eat raisins; 10 ppb for raisins intended for further physical treatment	None
Spices	None	20 ppb for all foods intended for consumption by humans	10 ppb for whole or ground chillies, chilli powder, cayenne, white and black pepper, nutmeg, ginger, turmeric, and any mixtures of spices containing one or more of the abovementioned spices	None

*Almond, pistachio, hazelnut and Brazil nut are subject to a maximum level of 10 ppb aflatoxins while other tree nuts are subject to a 4 ppb regulatory limit if intended for direct human consumption;
** Almond, pistachio, hazelnut and Brazil nut are subject to a maximum level of 15 ppb aflatoxins while other tree nuts are subject to a 10 ppb regulatory limit if intended for further physical treatment

6 References

[1] Justice Canada. *Food and Drugs Act and Regulations* [online]. 1985. Accessed *May 9, 2015*. http://laws-lois.justice.gc.ca/eng/acts/F-27/

[2] Buchanan, J.R., Sommer, N.F., Fortlage, R.J. Aspergillus flavus Infection and Aflatoxin Production in Fig Fruits. *Applied Microbiology* [online]. 30.2 (1975): 238-241. Accessed *May 9, 2015*. http://aem.asm.org/cgi/reprint/30/2/238

[3] Wogan, G.N. "Chemical Nature and Biological Effects of the Aflatoxins." *Bacteriological Reviews* [online]. 30.2 (1966): 460-470. Accessed *May 9, 2015*. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC441006/pdf/bactrev00193-0205.pdf

[4] Statistics Canada. Corn: Canada's third most valuable crop [online]. Modified on February 18, 2015. Accessed on May 8, 2015. http://www.statcan.gc.ca/pub/96-325-x/2014001/article/11913-eng.htm

[5] Zinedine, A. and Manes, J. Occurrence and legislation of mycotoxins in food and feed from Morocco. *Food Control*. 20. (2009):334-344. Print.

[6] Medline Plus. Aflatoxin [online]. Updated January 2013. Consulted *May 9, 2015*. http://www.nlm.nih.gov/medlineplus/ency/article/002429.htm

[7] European Food Safety Authority. Aflatoxins (sum of B1, B2, G1, G2) in cereals and cereal-derived food products. Supporting Publications 2013: EN-4056. 2013. Accessed *May 9, 2015*. http://www.efsa.europa.eu/en/search/doc/406e.pdf

[8] Opinion of the Scientific Panel on contaminants in the food chain on a request from the Commission related to the potential increase of consumer health risk by a possible increase of the existing maximum levels for aflatoxins in almonds, hazelnuts and pistachios and derived products. *The EFSA Journal* 446 (2007):1-127. http://www.efsa.europa.eu/en/efsajournal/doc/446.pdf

[9] Liu, Y., Wu, F. "Global burden of aflatoxin-induced hepatocellular carcinoma: a risk assessment. *Environmental Health Perspectives* [online]. Vol. 118(6) 818-824.

[10] International Agency for Research on Cancer – IARC (2012). In *A Review of Human Carcinogens: Chemical Agents and Related Occupations*, IARC Monographs, Volume 100 – Part F. pp 225-248. Accessed *May 9, 2015*. http://monographs.iarc.fr/ENG/Monographs/vol100F/mono100F-23.pdf

[11] Brera, C., De Santis, B., Debegnach, F., Miraglia, M. "Mycotoxins". *Comprehensive Analytical Chemistry: Food Contaminants and Residue Analysis*. Spain: Elsevier, 2008. 363-427. Print.

[12] Joint FAO/WHO Expert Committee on Food Additives (JECFA). Aflatoxins [online]. 1998. Accessed May 8, 2015. http://www.inchem.org/documents/jecfa/jecmono/v040je16.htm

[13] Wild, CP., Gong YY., 2010. Mycotoxins and human disease: a largely ignored global health issue. Carcinogenesis. 31:71-78.

[14] Williams JH, Phillips TD, Jolly PE, Stiles JK, Jolly CM, Aggarwal D. Human aflatoxicosis in developing countries: a review of toxicology, exposure, potential health consequences, and interventions. *American Journal of Clinical Nutrition* 80.5 (2004): 1106-1122.Accessed May 7, 2015. http://ajcn.nutrition.org/content/80/5/1106.full

[15] Codex Alimentarius. *Code of Practice for the Prevention and Reduction of Aflatoxin Contamination in Peanuts (CAC/RCP 55 – 2004)* [online]. 2004. Accessed *May 9, 2015*. http://www.codexalimentarius.org/standards/list-of-standards/en/%3Fprovide%3Dstandards%26orderField%3DfullReference%26sort%3Dasc%26num1%3DCAC/RCP

[16] Codex Alimentarius. *Code of Practice for the Prevention and Reduction of Aflatoxin Contamination in Dried Figs (CAC/RCP 65 – 2008)* [online]. 2008. Accessed *May 9, 2015*. http://www.codexalimentarius.org/standards/list-of-standards/en/%3Fprovide%3Dstandards%26orderField%3DfullReference%26sort%3Dasc%26num1%3DCAC/RCP

[17] Codex Alimentarius. *Code of Practice for the Prevention and Reduction of Aflatoxin Contamination in Tree Nuts (CAC/RCP 59 – 2005, Rev.I1 2010)* [online]. 2006. Accessed *May 9, 2015*. http://www.codexalimentarius.org/standards/list-of-standards/en/%3Fprovide%3Dstandards%26orderField%3DfullReference%26sort%3Dasc%26num1%3DCAC/RCP

[18] Codex Alimentarius. *Code of Practice for the Prevention and Reduction of Mycotoxin Contamination in Cereals, including Annexes on Ochratoxin A, Zearalenone, Fumonisins, Trochothecenes and Aflatoxins (CAC/RCP 51-2003, Rev 2015, CCCF Step 3 – CX/CF 15/9/10)*. 2003. Accessed March 17, 2015. ftp://ftp.fao.org/codex/meetings/cccf/cccf9/cf09_10e.pdf

[19] Martins ML, Martins HM, Bernardo F. Aflatoxins in spices marketed in Portugal. Food Additives & Contaminants 18.4 (2001): 315-319. Accessed May 8, 2015. http://www.tandfonline.com/doi/abs/10.1080/02652030120041

[20] Cho S-H, Lee C-H , Jang M-R, Son Y-W, Lee S-M, Choi I-S, Kim S-H, Kim D-B. Aflatoxins contamination in spices and processed spice products commercialized in Korea. *Food Chemistry* 107.3 (2008): 1283–1288. Accessed May 8, 2015. http://www.sciencedirect.com/science/article/pii/S0308814607008448

[21] Ozbey F, Kabak B. Natural co-occurrence of aflatoxins and ochratoxin A in spices. *Food Control* 28.2 (2012): 354–361. Accessed May 8, 2015. http://www.sciencedirect.com/science/article/pii/S0956713512002629

[22] Turcotte, A.M. Scott, P.M., Tague. B.. Analysis of cocoa products for ochratoxin A and aflatoxins. *Mycotoxin Research* 29.3 (2013): 193–201. DOI 10.1007/s12550-013-0167-x. Accessed May 14, 2014. http://worldcocoafoundation.org/wp-content/files_mf/turcotte2013postharvestqualitymycotoxin.pdf

[23] Feizy, J., Beheshti, H.R., Asadi, M.. Ochratoxin A and aflatoxins in dried vine fruits from the Iranian market. *Mycotoxin Research* 28..4 (2012): 237-242. Accessed May 22, 2014. http://link.springer.com/article/10.1007%2Fs12550-012-0145-8

[24] Food Standards Agency (United Kingdom). *Survey of Spices for Aflatoxins and Ochratoxin A* [online]. March 2005. Accessed May 12, 2014. http://tna.europarchive.org/20110116113217/http://www.food.gov.uk/multimedia/pdfs/fsis7305.pdf

[25] Canadian Food Inspection Agency. 2010-2011 *FSAP Survey: Aflatoxin in Dried Fruits, Nuts and Nut Products, and Corn Products* [online]. Modified September 2012. Accessed May 22, 2014. http://www.inspection.gc.ca/food/chemical-residues-microbiology/chemical-residues/aflatoxins/eng/1347377061474/1347377332021

[26] Canadian Food Inspection Agency. 2011-2012 *FSAP Survey: Aflatoxin in Corn Products, Nuts and Nut Butters* [online]. Modified July 31, 20014. Consulted January 13, 2016. http://www.inspection.gc.ca/food/chemical-residues-microbiology/chemical-residues/2011-2012-aflatoxins/eng/1430757541452/1430757542530

[27] Canadian Food Inspection Agency. 2012-2013 *FSAP Survey: Aflatoxin in Corn Products, Nut Products, Raisins, Spices, and Cocoa Powder* [online]. To be posted…

[28] Reuters. *US grain sector on high alert for aflatoxin in drought*. [online]. August 30, 2012. Accessed May 12, 2014. http://in.reuters.com/article/2012/08/29/usa-drought-aflatoxin-idINL2E8JTA5T20120829

[29] Ingwersen, J. 2013. *Grain handlers wary of toxin lingering in '12 U.S. corn harvest*. [online] Accessed August 15, 2014 http://www.reuters.com/article/2013/04/19/us-usa-crops-aflatoxin-idUSBRE93I11I20130419

[30] U.S. Food and Drug Administration. *CPG Sec. 570.375 Aflatoxin in Peanuts and Peanut Products* [online].Updated December 2009. Accessed May 22, 2014. http://www.fda.gov/ICECI/ComplianceManuals/CompliancePolicyGuidanceManual/ucm074598.htm

[31] European Commission. Eur-Lex. *COMMISSION REGULATION (EC) No 1881/2006 of 19 December 2006 setting maximum levels for certain contaminants in foodstuffs (Text with EEA relevance)* [online].December 2006. Accessed May 22, 2014. http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CONSLEG:2006R1881:20100701:EN:PDF