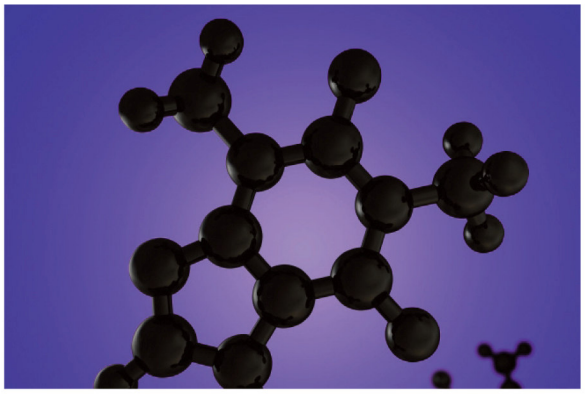
Canadian Food Inspection Agency
Agence canadienne d'inspection des aliments

Food Safety Action Plan

REPORT

2010-2011 Targeted Surveys

Chemistry



Aflatoxins in Dried Fruits, Nuts and Nut Products, and Corn Products

TS-CHEM-10/11-02

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.

Aflatoxins (AF) comprise a family of natural toxins produced by *Aspergillus* moulds. Although at least 20 different forms of AF exist, AF forms B1, B2, G1 and G2 are the most prevalent and the most toxic forms occurring in plant-based foods. AF is a potent liver carcinogen. AF infests corn and corn products, nutmeats, dried fruits, grains and spices grown and/or stored under hot, humid conditions. Most human exposure to aflatoxins through the diet has been determined to come from the consumption of AF-contaminated nuts and corn. Health Canada has established a 15 ppb standard for AFs in nuts and nut products as per B.01.046(n) of the *Food and Drug Regulations*.

The main objectives of the aflatoxin survey were to:

- provide baseline surveillance data regarding AF levels in dried figs, dried dates, corn products, and nut products (nutmeats and nut butters)
- compare AF prevalence in dried figs and in dried dates in 2009-2010 and in 2010-2011

A total of 628 samples were collected and analysed in this targeted survey. Samples were analysed for AF residues using a multi-residue method that detects the AF forms B1, B2, G1 and G2. Both the levels of the individual AF forms and the total AF levels were reported. Most of the samples (584/628 or 93%) did not contain detectable levels of AF.

None of the 90 samples of dried dates and dried figs contained detectable levels of AF. These results are similar to those from the FSAP 2009-2010 AF targeted survey where 100% of the dried date samples and 92% of the dried fig samples did not contain detectable levels of AF.

Two hundred eighty-five corn products were analysed for AF; 262 (92%) of these did not contain detectable levels of AF. Cornbread mix, canned corn, corn flour, corn grits, corn meal, corn starch, and corn tortillas did not have detectable levels of AF. Corn tacos (12/23), tortilla/corn chips (5/51), corn cereals (5/57), and popcorn (1/29) had total AF levels ranging from 0.1 ppb to 1.7 ppb.

Two hundred fifty-three nut products were analysed for AF; 232 (92%) of these did not contain detectable levels of AF. Nine of the 21 positive samples were associated with nut butters. Cashews, macadamia, pecan and pistachio nut products did not have detectable levels of AF. Peanut (10/45), Brazil nut (2/13), hazelnut (2/23), almond (4/51), and walnut (3/48) products had AF levels ranging from 0.1 to 28.7 ppb. Two of the samples exceeded the Canadian maximum limit of 15 ppb AF in nuts. These two samples were referred to the designated CFIA program for appropriate follow-up actions. These actions may include notification of the producer or importer, follow-up inspections, additional directed sampling, and product recalls. No product recalls were associated with any of violative samples from this survey.

1. Introduction

1.1. Food Safety Action Plan

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

The CFIA's Food Safety Action Plan (FSAP) is one element of the Government's broader 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 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 testing of foods from the Canadian marketplace. Targeted surveys are one tool that is 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 the Consumer Packaging and Labelling Act* and Regulations (CPLAR), and are generally referred to as non-federally registered commodities.

1.2. Targeted Surveys

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

Due to the vast number of chemical hazards and food commodity combinations, it is not possible, nor should it be necessary, to use targeted surveys to identify and quantify all chemical hazards in foods. To identify food-hazard combinations of greatest potential health risk, the CFIA uses a combination of scientific literature, media reports, and/or a risk-based model developed by the Food Safety Science Committee (FSSC). The FSSC performed a risk ranking on a number of toxin-commodity combinations. AF was ranked as a priority hazard because it is a potent liver carcinogen, it is associated mainly with imported products, and the degree of exposure of the Canadian population to AF from dried fruits and corn is largely unknown.

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* (FDAR).

Health Canada (HC) establishes health-based limits for contaminant residues in food. Tolerances are established as a risk management tool and are generally set only for foods that significantly contribute to the total dietary exposure. HC has established a 15 parts-per-billion (ppb) tolerance for aflatoxins in nutmeats and nut products (see section B.01.046 in the FDAR). There is no Canadian tolerance for aflatoxin in corn products or in dried fruits.

Foods for which standards have not been established may still make a small contribution to the total dietary exposure to aflatoxins. However, standards have not been established because they present a low health risk to the general Canadian population. Elevated levels of aflatoxins in specific foods may still be scrutinized and assessed by Health Canada on a case-by-case basis using the most current scientific data available. When levels of aflatoxins in food are deemed to be unsafe, corrective actions (such as public recalls, product retention and/or the establishment of maximum limits) may be taken by the CFIA and Health Canada.

Table 2.1 Canadian and International Tolerances/Standards/Maximum limits for Aflatoxins

Commodity	Canada	US	EU	Codex
Nuts and Nut Products	15 ppb	20 ppb for specific nuts, 20 ppb for all "foods" intended for consumption by humans	4-10 ppb total AF (depending on nut) for ready-to-eat nuts and nut products; 10-15 ppb total AF (depending on nut) for nuts intended for further physical treatment	15 ppb for peanuts, almonds, Brazil nuts, hazel nuts and pistachios intended for further processing; and 10 ppb for ready-to-eat almonds, Brazil nuts, hazel nuts and pistachios
Dried Fruit	None	20 ppb for all " foods" intended for consumption by humans	4 ppb (total AF) for ready-to-eat dried fruit; 10 ppb (total AF) for dried fruit intended for further physical treatment	None
Corn products	None	20 ppb for all "foods" intended for consumption by humans	4 ppb (total AF) for ready-to-eat cereals and cereal products; 10 ppb (total AF) for corn intended for further physical treatment	None

2. Aflatoxin Survey

2.1. Aflatoxin (AF)

Aflatoxins are naturally-occurring secondary metabolites of fungal species belonging to strains of the *Aspergillus* mould such as *A. flavus* and *A. parasiticus*. At least 20 different forms of AF exist. The four most common forms of alflatoxin in plant-based foods, in order of highest to lowest toxicity, are B1, G1, B2 and G2. AF B1 is the predominant AF form and the other three forms are rarely seen without some level of B1 contamination.

AF-producing fungi may contaminate fruit, nuts or corn if grown, stored and/or processed under conditions which favour fungal growth. Hot, humid climates and any pest pressures resulting in bruising or cuts on the commodity will favour the growth of the AF-producing fungi, either in the field or in storage. Prolonged storage and/or contamination during storage or transport have also been associated with higher AF levels[1,2].

Another factor affecting the levels of AF in dried fruits specifically is the type of drying method used. There are numerous variations and/or combinations of drying processes used by the food industry depending on the desired characteristics of the finished product, cost, and equipment availability. The typical temperatures in conventional drying processes do not exceed 120 °C and so are too low to cause appreciable aflatoxin degradation. The most commonly used drying method for fruit is sun-drying. [3,4]. Due to the nature of sun-drying, the fruit is still subject to climatic, weather and pest pressures which may favour fungal growth and hence result in the production of elevated levels of AF[5,6].

2.2. Rationale

The survey of aflatoxin levels in corn products, nut products and dried fruits was undertaken because of the human health effects of aflatoxin exposure, the lack of exposure data for the Canadian population, the widespread consumption of these products, and the 2009-2010 FSAP targeted survey results.

Aflatoxin is considered the most toxic of the mycotoxins. The International Agency for Research on Cancer (IARC) considers AF B1 to be a potent carcinogen, acting mainly on the liver[7]. In addition to its carcinogenic properties, AF is believed to have mutagenic, teratogenic, and immunosuppressive effects on humans and animals[8]. These human and animal health effects have prompted the adoption of Codex Codes of Practice to prevent and to reduce AF contamination in peanuts[9], dried figs[10] and tree nuts[11]. There are no Codex codes of practice specifically for the production and storage of nut butters because it is assumed that if nuts compliant with the regulations are used in the manufacture of the nut products and that the nut products are then stored appropriately, the nut butters will be compliant with the regulations.

AF is known to infest corn and corn products, nutmeats, dried fruits, grains and spices[5,6]. The major route of AF exposure in humans is through the consumption of contaminated nuts, nut products, and maize. Corn and nut products are popular as both directly

consumed foods and as ingredients. Due to its climate, Canadian-grown products are unlikely to contain aflatoxins. However, imported products may contain AF. The degree of exposure of the Canadian population to AF from dried fruits, cereal grains such as corn, spices and corn products is largely unknown.

AF levels in these nuts and nut products, corn products and dried fruits are not routinely monitored by CFIA. The 2009-2010 targeted survey of aflatoxin levels in dried figs and dried dates found that three samples of figs were above the EU MLs for directly consumed fruit. Expansion of the AF survey to further examine dried fruit and to include other commodity types such as corn and nut products was considered timely.

2.3. Targeted Survey Sample Overview

The 2010-2011 AF survey targeted imported dried figs and dried dates, domestic and imported nut products, and domestic and imported corn products. All foods were sampled at retail in grocery and specialty stores in 11 Canadian cities. A total of 628 samples (285 corn products, 90 dried fruit and 253 nut products) were tested for AF.

2.4. Method Details

Samples from the 2010-2011 AF targeted survey were analysed by an accredited third-party laboratory. A multi-residue method (MRM) was used for determination of AF in dried fruit, nut products, and corn products. This method allows for the simultaneous determination of the major forms of AF, including B1, B2, G1 and G2. The method was based on the CFIA reference method "BFCL-002 – "AF in Food Products - Immunoaffinity Column Method", which consists of immunoaffinity column separation followed by mass spectrometric detection. The reporting limit for each AF form is 0.1 ppb. Both the levels of the individual AF forms and the total levels of AF are reported. The evaluation of the results was based on the total AF level.

2.5. Limitations

The AF survey in foods was designed to provide a snapshot of the prevalence and levels of AF in dried fruit, corn and nut products available to Canadian consumers. In comparison to the total number of these products existing on the Canadian retail market, a sample size of 628 is small. Therefore, care should be taken in the interpretation of the results. This survey does not examine the impact of product shelf-life or the cost of the commodity on the open market. It is important to note that products 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 clearly identify the true origin of the product ingredients. Therefore, no distinct comparison could be made regarding countries of origin and the AF levels in products.

3. Results

3.1. Corn products

In total, 285 samples of corn products were tested for AF. Figure 1 shows the distribution of corn samples by product type.

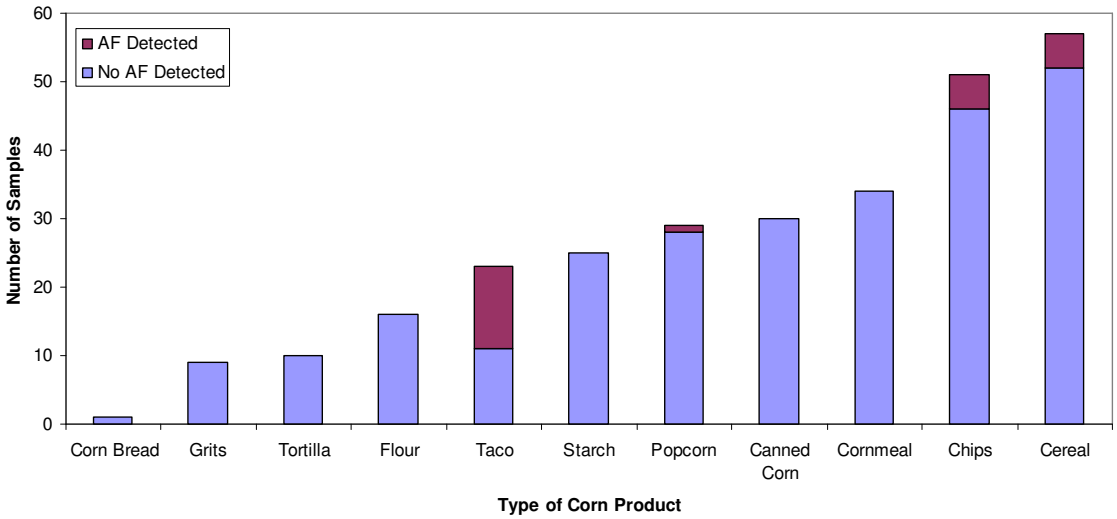

Figure 1. Distribution of corn product samples by product type

Of the 285 samples of corn products, 262 (92%) did not have detectable levels of AF. Cornbread mix, canned corn, corn flour, corn grits, corn meal, corn starch, and corn tortillas did not have detectable levels of AF. The positive samples were associated with corn tacos (12/23), tortilla/corn chips (5/51), corn cereals (5/57), and popcorn (1/29). The total AF levels in this targeted survey ranged from 0.1 to 1.7 ppb (see Figure 2). The average total AF level (calculated using only the positive results) was 0.5 ppb.

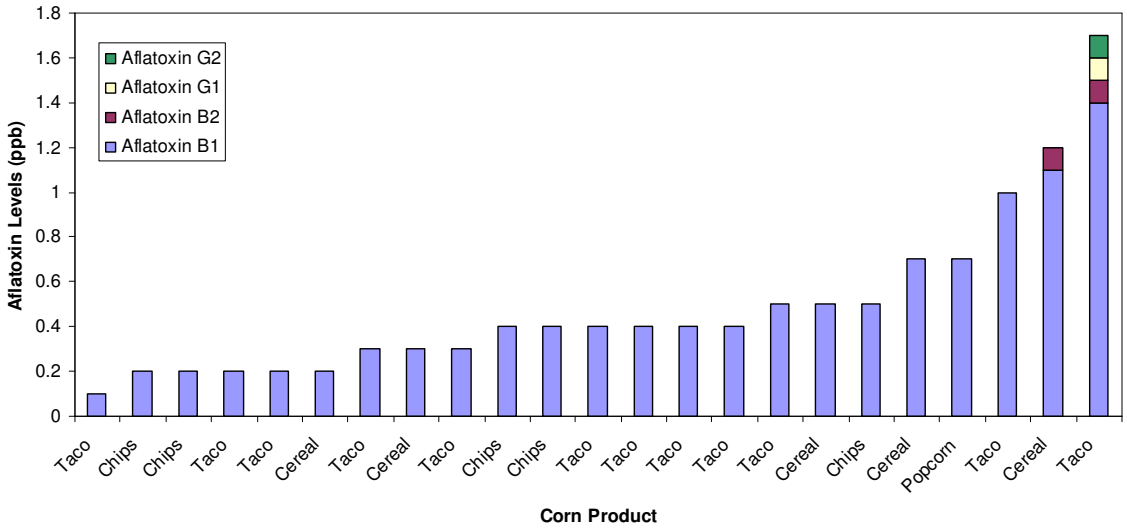

Figure 2. Total Aflatoxin Levels and Distribution of AF forms in positive samples of corn products

The products varied in the number of AF forms detected per sample. AF B1 was detected in all positive samples. One AF form was detected in 21 of 23 positive samples (see Figure 2). Two AF forms were detected in one sample of corn cereal, and four AF forms were detected in one sample of corn tacos.

3.2. Nut products

In total, 253 samples of nut products were tested for AF. The nut product samples included 234 samples of nutmeats (whole, halved, sliced, seasoned or roasted nuts) and 19 samples of nut butters. Figure 3 shows the distribution of samples by type of nut product.

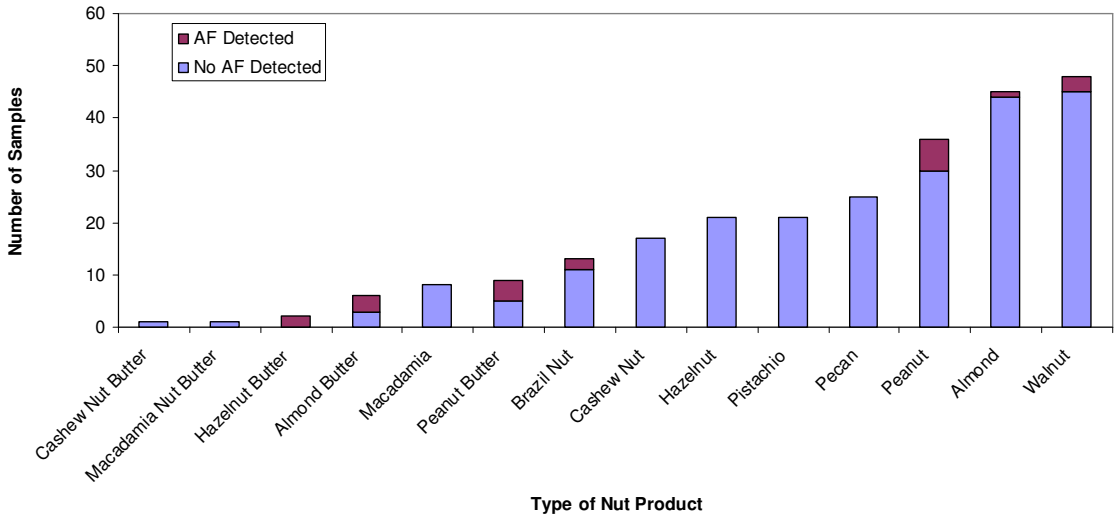

Figure 3. Distribution of nut product samples by product type

Of the 253 samples of nutmeats and nut butters analysed, 232 (92%) did not have detectable levels of AF. Cashew, macadamia, pecan and pistachio products did not have detectable levels of AF. The 21 positives were associated with peanut (10/45), Brazil nut (2/13), hazelnut (2/23), almond (4/51), and walnut (3/48) products. The measured levels of AF (total) in nut products (nutmeats and nut butters) ranged from 0.1 to 28.7 ppb. The average total AF level in nut products (calculated as the mean of the positive samples) was 4.1 ppb. Figure 4 shows the total AF levels as a function of product.

Of the 234 samples of nutmeats, 222 (95%) did not have detectable levels of AF. The 12 positives were associated with peanuts (6/36), Brazil nuts (2/13), walnuts (3/48) and almonds (1/45).The measured levels of AF (total) in nutmeats ranged from 0.1 to 28.7 ppb. The average total AF level in nutmeats (calculated as the mean of the positive samples) was 3.2 ppb.

Of the 19 samples of nut butters, 10 (53%) did not have detectable levels of AF. The nine positives were associated with hazelnut butters (2/2), almond butters (3/6), and peanut butters (4/9).The measured levels of AF (total) ranged from 0.1 to 16.0 ppb in nut butters.

The average total AF level in nut butters (calculated as the mean of the positive samples) was 5.3 ppb.

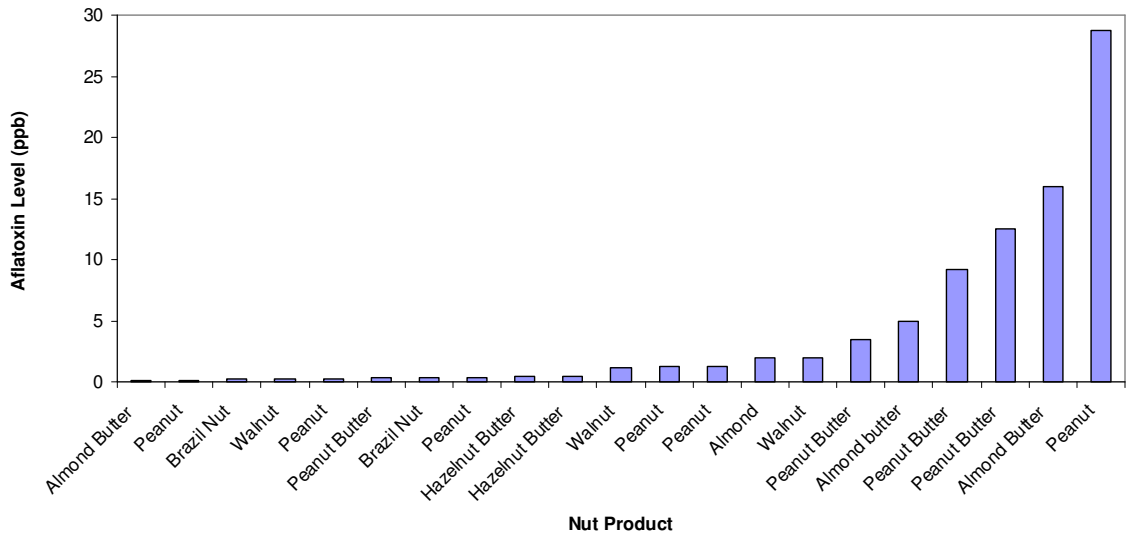

Figure 4. Total Aflatoxin Levels in positive samples of nut products

The products varied in the number of AF forms detected per sample. As depicted in Figure 5, AF B1 was detected in all 21 positive samples. One AF form was detected in ten of the positive samples. Two AF forms were detected in six samples (one sample each hazelnut butter, almond, walnut and peanut plus two samples of peanut butter). Five of these six samples were associated with B1 + B2 while one sample contained B1 and G1. Three AF forms (B1, B2 and G1) were detected in three samples (one sample each of walnut, almond butter, peanut butter). Four AF forms were detected in three samples (one sample of almond butter plus two samples of peanuts).

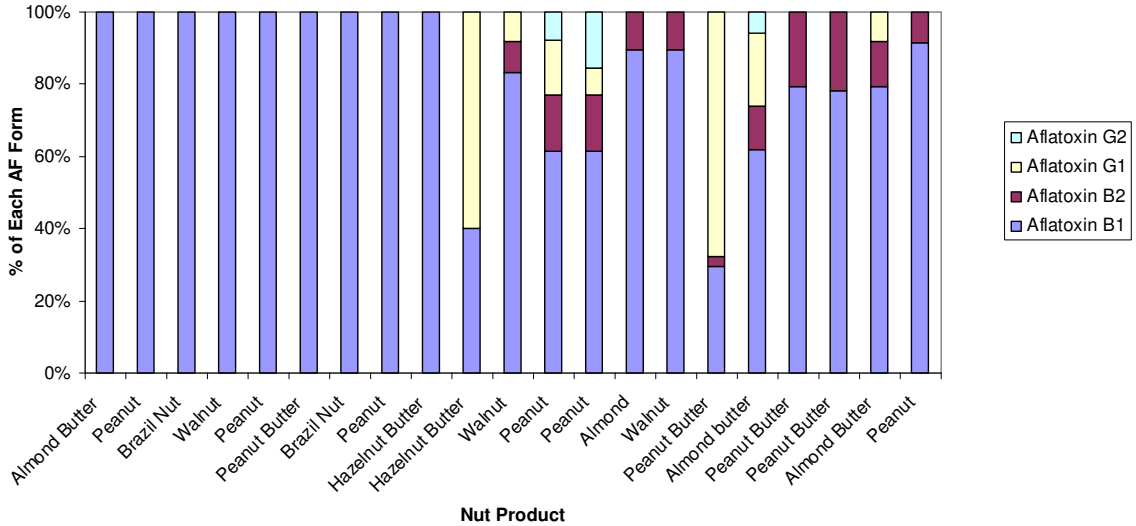

Figure 5. Distribution of AF forms in positive samples of nut products

3.3. Dried Figs and Dried Dates

A total of 90 samples of dried fruits were analysed for AF. The product types tested included 43 samples of dried figs and 47 samples of dried dates. None of the samples had detectable levels of AF.

4. Discussion

A total of 628 samples (285 corn products, 90 dried fruit and 253 nut products) were tested for AF. As presented in the Results section above, the majority of the products tested (93%) did not contain detectable levels of AF.

In 1998, The Joint FAO/WHO Expert Committee on Food Additives (JECFA) determined that the majority of the worldwide exposure to aflatoxins came from contaminated nut and corn products.[12] The JECFA evaluation indicated that peanuts, pistachios, and Brazil nuts were the most likely types of nuts to be contaminated[12]. An updated exposure assessment was conducted at the 68th meeting of JECFA in 2008 which confirmed that aflataoxin-contaminated nuts such as almonds, Brazil nuts, hazelnuts and pistachios were the major contributors to the dietary exposure to aflatoxins**Error! Bookmark not defined.**[13]. The data reported focused only on nutmeats.

In the FSAP 2010-2011 AF targeted survey, similar types of nuts were analysed. As in the JECFA evaluation, most of the positives were associated with peanut and Brazil nut products. The maximum levels of AF reported in this survey were substantially lower than in the JECFA evaluation for peanuts (28.7 ppb in this targeted survey vs. 10 to 8070 ppb in the JECFA report), for pistachios (< 0.1 ppb in this targeted survey vs. 450 to 8030 ppb for pistachios in the JECFA report) and for Brazil nuts (0.4 ppb in this targeted survey vs. 35 to 123 ppb in the JECFA report). Two of the 21 positive samples had levels of AF which exceeded the Canadian regulations. These were referred to the appropriate program for follow-up.

One of the violative samples (a nut butter sample) contained 16 ppb of total aflatoxins, and the second sample (a bulk blanched peanut sample) contained 28.7 ppb of total AF. It is important to note that although the *Food and Drug Regulations* state that 15 ppb is the maximum allowable level for aflatoxin in nuts, the analytical variability allows for a 50% variance in the aflatoxin testing methodology. For these reasons, results below 24 ppb are subject to interpretation and may not represent a violation of the provisions of the FDR. CFIA has provided guidance in its inspection activities in terms of what action should be taken if aflatoxin is present at levels above 24 ppb. The results and the determination of whether a violation is present takes into consideration the health effects association with aflatoxin which are based on chronic long term exposure. The consumption of the product in question was not considered by CFIA to pose a risk to human health. No direct product follow-up was required on the nut butter sample, for the reasons stated above. It was determined that direct product follow-up related to the bulk sample was not possible, given the potential that multiple different lots of bulk products may end up in bulk bins during product re-stocking. As well, there was a lack of

information regarding importers/producers of the bulk product. CFIA will continue its regular program and inspection activities to ensure the continued safety of the Canadian food supply.

This targeted survey differed from the JECFA evaluation in that nut butters were also analysed. The incidence of positive detections for AF in nut butters (47%) is higher than the percent positive detections in nut meats. However, care should be taken in the interpretation of this result as only nineteen samples of nut butters were analysed. AF is both a harvest and a storage toxin. Elevated levels of aflatoxins in nut products, such as nut butters, may be related to aflatoxin levels in the raw nuts used for the manufacture of the nut products and/or improper storage conditions for the final nut products. As the products in this survey were sampled at the retail level, it is not possible to determine which, if any, of these factors, is responsible for differences in AF levels observed.

In regards to corn, the JECFA report focused on levels of AF in raw corn. The positive rates reported ranged from 12-56%. The maximum levels of AF reported ranged from 66 to 2440 ppb. The report also indicated that processing of the maize would cause AF levels to be reduced by 90-99%[12].

The FSAP 2010-2011 AF targeted survey focused on corn products which had undergone some degree of processing. Cornbread mix, canned corn, corn flour, corn grits, corn meal, corn starch, and corn tortillas did not have detectable levels of AF. The positive samples were associated with corn tacos (12/23), tortilla/corn chips (5/51), corn cereals (5/57), and popcorn (1/29). The maximum level of AF detected in this survey was 1.7 ppb. This is below the European Union limit for AF in cereals and cereal-derived products and it is within the range of AF levels reported in the 1998 JECFA evaluation..

No AF was detected in the 90 samples of dried figs and dried dates analysed in the FSAP 2010-2011 AF targeted survey. These results are comparable to the FSAP 2009-2010 AF targeted survey of 100 samples of dried figs and dried dates. In the 2009-2010 survey, 92% of the dried fig and 100% of the dried date samples did not contain detectable levels of AF.

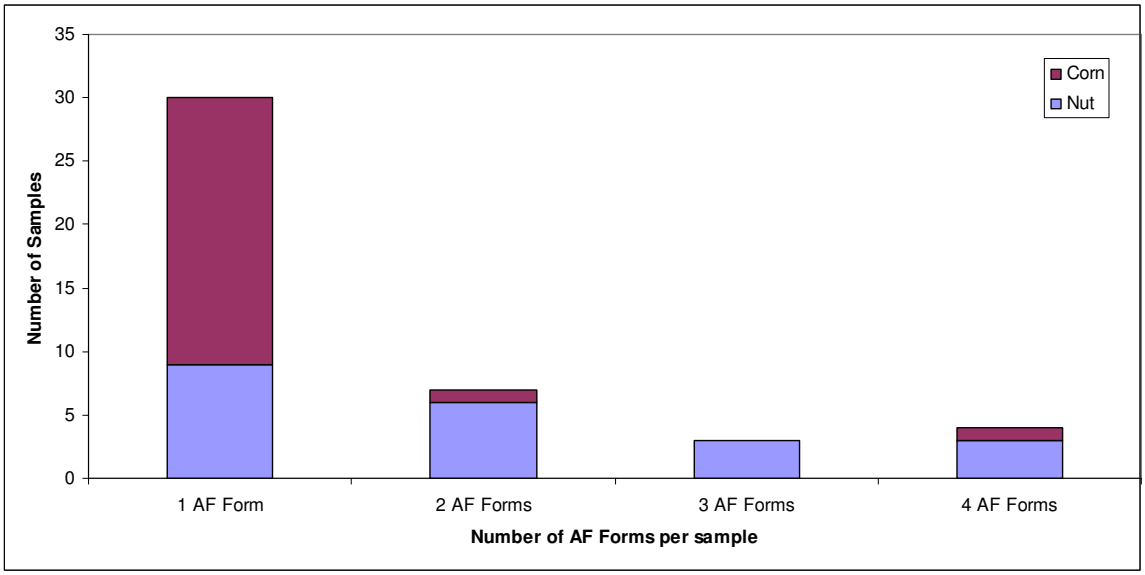

Figure 6. Distribution of AF forms in all positive samples for all commodities analyzed

According to the literature, AF B1 is the most prevalent (and the most toxic) of the AF forms.[12] All forty-four positives samples in this targeted survey had detectable levels of AF B1. As depicted in Figure 6, AF B1 was the only AF form detected in 30 of the 44 positive samples (21 corn product samples, 9 nut product samples). Two forms of AF were found in seven samples (six nut, one corn sample) - six of the seven positives were associated with AF B1 and AF B2 while the remaining sample was associated with AF B1 and AF G1. Three positive samples were associated with the presence of AF B1, B2 and G1. There was no apparent correlation between the AF form detected and the type of product analysed. The AF form detected in a product may be related to the *Aspergillus* species. Aflatoxin B_1 & B_2 are produced by *Aspergillus flavus* and *A. parasiticus*. Aflatoxin G_1 & G_2 are produced by *Aspergillus parasiticus*. [14]

5. Conclusions

This targeted survey was completed to elucidate the levels of AF in dried figs, dried dates, corn products, and nut products (nutmeats and nut butters), and to compare AF prevalence in dried figs and in dried dates in 2009-2010 and in 2010-2011. Most of the samples tested (584/628 or 93%) did not contain detectable levels of AF. The twenty-three positive corn product samples had AF levels ranging from 0.1 ppb to 1.7 ppb. These levels were below the EU regulatory limits for cereals and products derived from cereals. The twenty-one positive nut product samples had AF levels ranging from 0.1 ppb to 28.7 ppb. Two of the samples (one sample of peanuts, one sample of almond butter) exceeded the Canadian maximum limit of 15 ppb AF in nuts and nut products. These two samples were referred to the designated CFIA program for appropriate follow-up actions. None of the dried fig or dried date samples in the FSAP 2010-2011 AF targeted survey had detectable levels of AF. This is similar to the FSAP 2009-2010 survey results which indicated that none of the dried date samples and most of the dried fig samples (47/51) had detectable levels of AF.

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