Canadian Food Inspection Agency
Agence canadienne d'inspection des aliments

Food Safety Action Plan

REPORT

2010-2011 Targeted Surveys

Targeted Survey Investigating Bacterial Pathogens and Generic *E. coli* in Low-Moisture Foods

RDIMS # 3802837

Canada

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Executive Summary

The objective of the Food Safety Action Plan (FSAP) is to modernize and enhance Canada's food safety system in order to better protect Canadians from unsafe food and ultimately reduce the occurrence of foodborne illness.

Low-moisture foods, such as dried fruits, cereals, spices, dry mixes and tree nuts, have historically been considered safe products as they do not support the growth of bacterial pathogens. However, a number of outbreaks and recalls associated with contaminated low-moisture foods in recent years and in several countries have prompted many experts to question the safety of these foods in terms of microbial hazards. Low moisture foods can become contaminated with bacterial pathogens such as *Salmonella, Escherichia coli* (*E. coli*) O157 and *Shigella* at various stages of the production chain. The presence of these pathogens in low moisture foods and their implication in foodborne illnesses have been reported in North America and Europe.

In view of this information, the Canadian Food Inspection Agency (CFIA) has selected certain low-moisture foods (i.e., spices, dried fruits, dried ingredients and dry mixes) for enhanced surveillance under the FSAP. Over the course of this baseline study (2010/11-2012/13), approximately 3,000 samples were collected from Canadian retail locations and tested for the presence of bacterial pathogens of concern.

The main objectives of the 2010/11 survey were to generate baseline surveillance data on bacterial pathogens *Salmonella, E .coli* O157:H7 and *Shigella,* as well as on the indicator of fecal contamination generic *E. coli,* for a variety of low-moisture foods available in the Canadian market.

A total of 822 low moisture foods were collected at retail. No pathogens were detected in any of the samples tested, and levels of generic *E. coli* were always found to be acceptable. All the samples were assessed as satisfactory. These results suggest that the low moisture foods sampled during this survey were produced and handled under good sanitation and hygiene practices.

The CFIA regulates and provides oversight to the industry, works with provinces and territories, and promotes safe handling of foods throughout the food production chain. However, the food industry and retail sectors in Canada are ultimately responsible for the food they produce and sell, while individual consumers are responsible for the safe handling of the food they have in their possession. Moreover, general advice for the consumer on the safe handling of foods is widely available. The CFIA will continue its surveillance activities and inform stakeholders of its findings.

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) (1), aims to modernize and enhance Canada's safety system for food, health and consumer products. The FCSAP initiative unites multiple partners in ensuring safe food for Canadians.

The Canadian Food Inspection Agency's (CFIA's) Food Safety Action Plan (FSAP) (2) 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 of occurrence of these risks, improve import and domestic food controls, and identify food importers and manufacturers.

Within the FSAP, there are 12 main areas of activity, one of which is risk mapping and baseline surveillance. The main objective of this area is to better identify, assess and prioritize potential food safety hazards through risk mapping, information gathering and analysis of foods in the Canadian marketplace. Targeted surveys are one tool used to test for the presence and level of particular hazards in specific foods.

Within the current regulatory framework, some commodities, such as meat products, traded internationally and interprovincially are regulated by specific Acts and Regulations. These are referred to as federally registered commodities. Under the current regulatory framework, the non-federally registered commodities, which are regulated solely under the *Food and Drugs Act* and *Regulations,* encompass 70% of domestic and imported foods. Spices, dried fruits and dry mixes belong to this category. Targeted surveys are primarily directed towards non-federally registered commodities.

1.2 Targeted Surveys

Targeted surveys are used to gather information regarding the potential occurrence of hazards in food commodities. The microbiological targeted surveys aim to establish baseline data on priority and/or emerging microbiological hazards in targeted commodities, primarily fresh fruits and vegetables and imported food ingredients. A statistically significant number of samples will be collected over several years to allow for seasonal and/or production variations. This work differs from regular CFIA microbiological monitoring activities, which test samples of a broad range of commodities for multiple hazards and are aimed to determine the compliance of defined lots with established microbial standards or guidelines for regulatory purposes.

To identify food-hazard combinations of greatest potential health risk for the targeted surveys, the CFIA uses a combination of scientific literature, documented outbreaks of foodborne illness, and/or information gathered from the Food Safety Science Committee (FSSC), a group of Canadian federal, provincial and territorial subject matter experts in the area of food safety (3).

This targeted survey (2010/11) was designed to generate baseline surveillance data on the occurrence of microorganisms of concern in spices, dried fruits and dry mixes available to Canadians at retail.

1.3 Codes of Practice, Acts, and Regulations

International food safety standards, codes of practice, and guidelines relating to food, food production and food safety are developed under the joint FAO/WHO Codex Alimentarius Commission. Food producers and processors across the world are encouraged to follow these international codes of practice. Of relevance for this survey are the *Code of Hygienic Practice for Spices and Dried Aromatic Plants* (CAC/RCP 42-1995) (4), the *Code of Hygienic Practice for Dried Fruits* (CAC/RCP 3-1969) (5) and the *General Principles of Food Hygiene* (CAC/RCP 1-1969) (6). These codes address Good Agricultural practices (GAPs) and Good Manufacturing Practices (GMPs) which, when applied, control and reduce the potential for contamination with microbial, chemical, and physical hazards at all stages of production and processing of foods and food products, from primary production to packaging.

Low-moisture foods available in the Canadian market must comply with the *Food and Drugs Act* (FDA) (7) and the *Food and Drug Regulations* (FDR) (8), which prescribe certain restrictions on the production, importation, sale, composition and content of foods and food products. Section 4(1)a of the FDA prohibits the sale of food contaminated with foodborne pathogens, while sections 4(1)e and 7 prohibit the sale of unsafe food and food produced under unsanitary conditions.

FSAP targeted surveys are primarily conducted for surveillance and not for regulatory compliance verification purposes. However, results indicating a potential risk to public health for any samples tested under this survey will trigger a food safety investigation, including activities such as follow-up sampling, inspections of facilities, and consultations with Health Canada for health risk assessments. Depending on the findings of the investigation, a recall of the affected products may be warranted.

2 Survey on Certain Low-Moisture Foods

2.1 Rationale

Low-moisture foods, which include dry foods such as spices, dried fruits and dry mixes, have been implicated in several outbreaks of foodborne illness over recent years (9). From 1994 to 2010, there were 12 documented outbreaks associated with dry foods contaminated with bacterial pathogens (Appendix B) reported in North America and Europe. Most of these outbreaks were associated with *Salmonella* contaminated spices.

Low-moisture foods have been customarily perceived as safe based on the fact that low water activity (i.e. low moisture) prevents the growth of bacterial pathogens. However, several pathogens (e.g., *Salmonella, E. coli* O157), which can be introduced via contaminated incoming ingredients or cross-contamination during processing, are able to survive for extended periods of time in dry foods (10). Pathogens in dry foods are also more resilient to heat processing, and it is therefore very difficult to eliminate them from this type of foods (10). The risk associated with the presence of pathogens in dry foods depends on the end-use of these foods. For example, a dipping sauce reconstituted from a dry mix could create growth opportunity for pathogens, and could become a source of foodborne illness. Similarly, a contaminated dry ingredient used to add flavour to a ready-to-eat food (e.g. paprika sprinkled on chips) could cause illness if a pathogen like *Salmonella* is present.

The potential presence of *Salmonella* in spices is well documented (11). A study carried out by the British Health Protection Agency in 2004 determined that the prevalence of *Salmonella* in dried spices and herbs in the United Kingdom (UK) was 1% (12). Another study conducted by the United States Food and Drug Administration (US FDA) in 2007/2009 on imported spices identified a prevalence of 6.6% (13). Irradiation is an effective treatment used to reduce the bacterial load in spices. It is allowed in Canada for a limited number of commodities, which include spices (14). However, irradiation is not a practice that is permitted under the Canadian Organic Standards (15), and is therefore not an option in the production of organic spices, which were targeted in this survey (2010/11).

The presence of *E. coli* O157 and *Salmonella* in dry mixes has also been documented (10). In early 2010, hundreds of dry mixes were recalled in the US and in Canada because they contained an ingredient, hydrolyzed vegetable protein, which was contaminated with *Salmonella* (16, 17).

Pathogens such as *Salmonella*, *Shigella* and *E. coli* O157 can be present on fruits due to fecal contamination or poor hygiene practices during production (11, 18). However, dried fruits are generally believed to be safe. Sulphur dioxide, a chemical used in the drying of

numerous fruits to prevent browning, usually completely eliminates the microflora, including harmful bacteria, present on fruits (18). A study in the UK determined that, of a variety of ready-to-eat foods sampled between 2003 and 2005, dried fruits had the best microbiological quality (19). However, there is currently only limited information regarding the microbial contamination of dried fruits offered at retail in Canada and in other jurisdictions.

Based on the above information, spices, dry mixes and dried fruits have been selected for targeted surveillance under FSAP. The overall objective is to generate baseline information to gain insights on the occurrence of microorganisms of concern in these commodities available to Canadians at retail.

2.2 Targeted Micro-organisms

2.2.1 Bacterial Pathogens of Concern

Bacterial pathogens, such as *Salmonella* and *E. coli* O157, are found naturally in the intestines of animals, such as poultry and cattle respectively (20). Most outbreaks associated with these bacterial pathogens are linked to the consumption of contaminated food of animal origin (e.g., chicken, raw milk and beef burger). However, low moisture foods have also been identified as a potential vehicle for these pathogens (10). Dry foods such as spices and dried fruits can become contaminated during primary production in the field, by improperly composted manure, contaminated water, and/or wildlife feces, as well as during subsequent handling (sorting, drying, packaging) (4, 5, 6).

Humans are the only host of the bacterial pathogen *Shigella*. Food contaminated by infected food handlers and water contaminated with human feces are the most common causes of shigellosis. Shigellosis illnesses have been known to be associated with consumption of contaminated fruits, vegetables, shellfish and chicken (20). Even though *Shigella* is believed to be fragile, studies have shown that it can survive in dry environments for several weeks (18), and could therefore be a concern in dried foods. The infective dose for these pathogens can be as low 10 organisms (20) and therefore their presence alone, even at low levels in a food that does not support their growth, represents a potential source of illness.

2.2.2 Generic *E. coli* - an Indicator of Fecal Contamination

Typically, *E. coli* bacteria that inhabit the large intestines of humans and animals are harmless. Due to their regular presence in the stools of humans and animals, the occurrence of *E. coli* in foods indicates direct or indirect contamination with fecal matter (21). The presence of generic *E. coli* in foods can also indicate potential contamination with pathogenic enteric micro-organisms, such as *Salmonella* or *E. coli* O157 that also live

in the intestines of infectious humans and animals. It is important to note that the presence of generic *E. coli* in food only implies the increased risk of contamination with pathogenic microorganisms but does not conclusively indicate that these pathogenic organisms are present. High levels of generic *E. coli* in dry foods sold at retail are an indication that contamination occurred at some point between primary production and final packaging.

2.3 Sample Collection

All samples were collected from national chain and local/regional grocery stores, as well as other conventional retail and natural food stores located across Canada. The number of samples collected in various geographic regions across Canada was based on the relative proportion of the population in the respective regions.

In this survey, a sample consisted of a single sampling unit (e.g., individual consumer-size package(s) from a single lot) with a total weight of at least 150 g.

2.4 Sample Distribution

A total of 822 pre-packaged dry food samples were collected and analyzed for selected bacteria. The distribution by product type is presented in Table 1, and the distribution by country of origin is presented in Table 2.

Table 1. Distribution of Samples by Product Type

(Percentage of total number of samples are shown in brackets)

Organic Spices		Dried Fruits		Dry Mixes	
Anise	9 (3.4%)	Apples	5 (1.7%)	Baking Mix	5 (1.9%)
Chilli powder	8 (3.1%)	Apricots	61 (20.4%)	Bouillon Mix	13 (5.0%)
Chipotle powder	1 (0.4%)	Bananas	3 (1.0%)	Dressing or Dipping Sauce Mix	8 (3.1%)
Cinnamon	33 (12.5%)	Blueberries	2 (0.7%)		
Cloves	1 (0.4%)	Cherries	1 (0.3%)	Gravy Mix	18 (6.9%)
Cumin	23 (8.7%)	Cranberries	46 (15.4%)	Jelly Mix	1 (0.4%)
Curry	13 (4.9%)	Currants	1 (0.3%)	Noodle Mix	2 (0.8%)
Garlic	29 (11.0%)	Dates	10 (3.3%)	Pancake/Waffle Mix	3 (1.2%)
Ginger	22 (8.3%)	Figs	9 (3.0%)		
Mustard	18 (6.8%)	Kiwis	2 (0.7%)	Rice Mix	1 (0.4%)
Nutmeg	1 (0.4%)	Mangoes	41 (13.7%)	Sauce Mix	18 (6.9%)
Paprika	20 (7.6%)	Papaya	21 (7.0%)	Seasoning	42 (16.2%)
Pepper, black	25 (9.5%)	Peaches	2 (0.7%)	Soup Mix	147 (56.8%)
Pepper, cayenne	3 (1.1%)	Pears	2 (0.7%)	Dry mix, unspecified	1 (0.4%)
Pepper, chili	11 (4.2%)	Pineapple	1 (0.3%)		
Pepper, red	3 (1.1%)	Plums	39 (13.0%)		
Pepper, white	4 (1.5%)	Raisins	41 (13.7%)		
Turmeric	3 (1.1%)	Fruit mixes	12 (4.0%)		
Spice, unspecified	37 (14.0%)				
Total	**264 (100%)**	**Total**	**299 (100%)**	**Total**	**259 (100%)**
Grand Total = 822					

Products sampled under each category represented a wide variety of product types and were generally fairly evenly distributed, except for dry mixes, where more than half the samples consisted of soup mixes.

Table 2. Distribution of Samples by Country of Origin

(Percentage of total number of samples are shown in brackets)

Organic Spices		Dried Fruits		Dry Mixes	
Canada*	90 (34.1%)	Canada*	7 (2.3%)	Austria	2 (0.8%)
China	11 (4.2%)	Chile	1 (0.3%)	Canada*	21 (8.1%)
Egypt	6 (2.3%)	China	7 (2.3%)	Chile	1 (0.4%)
France	1 (0.4%)	Costa Rica	2 (0.7%)	China	2 (0.8%)
Hungary	2 (0.8%)	Iran	2 (0.7%)	Croatia	5 (1.9%)
India	25 (9.5%)	Mexico	2 (0.7%)	Egypt	4 (1.5%)
Indonesia	9 (3.4%)	New Zealand	1 (0.3%)	India	11 (4.2%)
Israel	6 (2.3%)	Pakistan	1 (0.3%)	Israel	3 (1.2%)
Mexico	5 (1.9%)	Philippines	28 (9.4%)	Italy	1 (0.4%)
Peru	1 (0.4%)	Saudi Arabia	2 (0.7%)	Japan	1 (0.4%)
Spain	2 (0.8%)	South Africa	5 (1.7%)	Jordan	10 (3.9%)
Sri Lanka	12 (4.5%)	Thailand	10 (3.3%)	Mexico	1 (0.4%)
South Africa	1 (0.4%)	Tunisia	1 (0.3%)	Pakistan	3 (1.2%)
Syria	1 (0.4%)	Turkey	57 (19.1%)	Philippines	6 (2.3%)
Turkey	3 (1.1%)	United States	112 (37.5%)	Saudi Arabia	1 (0.4%)
United Kingdom	1 (0.4%)	Unknown	61 (20.4%)	Thailand	6 (2.3%)
United States	61 (23.1%)			Turkey	1 (0.4%)
Unknown	20 (7.6%)			United Kingdom	1 (0.4%)
Vietnam	7 (2.7%)			United States	116 (44.8%)
				Unknown	63 (24.3%)
Total	**264 (100%)**	**Total**	**299 (100%)**	**Total**	**259 (100%)**

* Products labelled as product of Canada may be grown or produced in different countries.

Imported samples accounted for 65.9% of the spice samples, 97.7% of the dried fruit samples and 91.9% of the dry mix samples. The majority of imported samples came from the United States. A large proportion of imported samples were of "unknown origin". This can be explained by the current labelling requirements for pre-packaged spices, dried fruits and dry mixes in Canada, which stipulate that a label must indicate that a product was imported, with no mandatory claim for the country of origin.

2.5 Method Details

All samples were analysed using the analytical methods published in Health Canada's *Compendium of Analytical Methods* for the Microbiological Analysis of Foods (22) (Appendix D). These methods are used for regulatory testing by the CFIA and are fully validated for the analysis of dry mixes, dried fruits and spices. A modified version of the method from Health Canada's Compendium was used for *Salmonella* testing, as indicated in Appendix D.

For the detection of *E. coli* O157:H7/NM, *Salmonella* and *Shigella*, a two-step procedure was employed. Samples were first screened by polymerase chain reaction (PCR)- based methods and any positive result, if obtained, would require confirmation by isolation, purification and identification procedures.

The count of generic *E. coli* was obtained using the most probable number (MPN) or direct plating procedure.

2.6 Assessment Guidelines

The assessment criteria presented below (Table 3 & 4) are based on the principles of the *Health Products and Food Branch Standards and Guidelines for Microbiological Safety of Foods* (23) and associated methods published in Health Canada's *Compendium of Analytical Methods* (22).

Based on the current regulatory standards and microbiology testing criteria, results of these surveys were assessed as "satisfactory" "unsatisfactory", or "investigative".

Table 3. Assessment Guidelines for Spice Samples

Bacterial Analysis*	**Assessment Criteria**		
(Method Identification Number)	**Satisfactory**	**Investigative**	**Unsatisfactory**
***Salmonella* spp.** (MFLP-29 modified and MFHPB-20 if required for confirmation)	Absent in 25 g	N/A	Present in 25 g
Generic *E. coli* (MFHPB-19 or MFHPB-27)**	≤ 100	100 < x ≤ 1,000	> 1,000

* *Compendium of Analytical Methods* (22).
** Concentration unit depends on method used. For MFHPB-19 method: MPN/g (Most Probable Number/gram), for MFHPB-27 method: CFU/g (Colony Forming Unit/gram).

Table 4. Assessment Guidelines for Dried Fruit Samples*

Bacterial Analysis** **(Method Identification Number)**	**Assessment Criteria**		
	Satisfactory	**Investigative**	**Unsatisfactory**
***Salmonella* spp.** (MFLP-29 modified and MFHPB-20 if required for confirmation)	Absent in 25 g	N/A	Present in 25 g
***E. coli* O157** (MFLP-30, MFLP-30 Supplement 2 & MFLP-80 if required for confirmation)	Absent in 25 g	N/A	Present in 25 g
***Shigella* spp.** (MFLP-26 & MFLP-25 if required for confirmation)	Absent in 25 g	N/A	Present in 25 g
Generic *E. coli* (MFHPB-19 or MFHPB-27)***	≤ 100	$100 < x \leq 1{,}000$	$> 1{,}000$

* No criteria have been established by Health Canada at this time for dried fruits. However, in the absence of a specified criteria, presence of bacterial pathogens in foods is considered to be a violation of FDA Section 4(1)a and the detection of generic *E. coli* at levels above 1,000 CFU/g or MPN/g is considered to be a violation of FDA Section 7, and are therefore assessed by the CFIA as unsatisfactory.
** *Compendium of Analytical Methods* (22).
*** Concentration unit depends on method used. For MFHPB-19 method: MPN/g (Most Probable Number/gram), for MFHPB-27 method: CFU/g (Colony Forming Unit/gram).

Table 5. Assessment Guidelines for Dry Mix Samples

Bacterial Analysis* **(Method Identification Number)**	**Assessment Criteria**		
	Satisfactory	**Investigative**	**Unsatisfactory**
***Salmonella* spp.** (MFLP-29 modified & MFHPB-20 if required for confirmation)	Absent in 25 g	N/A	Present in 25 g
E. coli* O157* (MFLP-30, MFLP-30 Supplement 2 & MFLP-80 if required for confirmation)	Absent in 25 g	N/A	Present in 25 g
Shigella* spp.* (MFLP-26 & MFLP-25 if required for confirmation)	Absent in 25 g	N/A	Present in 25 g
Generic *E. coli* (MFHPB-19 or MFHPB-27)***	≤ 10	10 < x ≤ 1,000	> 1,000

* *Compendium of Analytical Methods* (22).
**No criteria have been established by Health Canada at this time for *E. coli* O157 and *Shigella* spp. in dry mixes. However, in the absence of a specified criteria, presence in foods is considered to be a violation of FDA Section 4(1)a and is therefore assessed by the CFIA as unsatisfactory.
*** Concentration unit depends on method used. For MFHPB-19 method: MPN/g (Most Probable Number/gram), for MFHPB-27 method: CFU/g (Colony Forming Unit/gram).

Unsatisfactory samples are subject to follow-up actions, such as directed follow-up sampling, inspection of establishment, health risk assessment, and/or product action (e.g. product recall).

Samples assessed as investigative require some follow-up activity. This could include, for example, further sampling (to verify the levels of generic *E. coli* in the samples in question) or data gathering for program design purposes.

2.7 Survey Limitations

Samples tested during this survey were collected at retail locations across Canada, as opposed to monitoring samples that are picked up at distribution points and warehouses. As such, products sampled at retail could be mixed and originate from different shipments and/or suppliers. Though this represents what the Canadian consumer experiences, this imposes certain limitations with respect to the traceability of the products and the identification of the source of contamination in the case of positive results.

Results obtained for a targeted survey sample are from the analysis of a single sample unit. This sampling and testing strategy generally precludes the extrapolation of the laboratory result to the whole production lot as it is not statistically representative. This imposes certain limitations in the interpretation of the results to the specific lot in the absence of additional information.

The number of samples collected and analysed during this survey (i.e., 264 samples of organic spices, 299 of dried fruits and 259 of dry mixes) is very limited considering the wide selection of product types and origins available to Canadians under each category. The results of this survey only provide a snapshot of the microbiological quality of these commodities, and care must be taken when interpreting and extrapolating these results.

3 Results

3.1 Spices

The bacterial pathogen *Salmonella* was not detected in any of the organic spice samples tested, and the indicator generic *E. coli* was never found at levels exceeding the satisfactory threshold. All organic spice samples that were analyzed during this survey were assessed as satisfactory (Table 6).

Table 6. Summary of Results for Organic Spices Analysed for *Salmonella* spp. and Generic *E. coli*

Product Origin	Number of Samples	Assessment		
		Satisfactory	Investigative	Unsatisfactory
Imported	174	174	0	0
Domestic	90	90	0	0
Total	**264**	**264 (100%)**	**0**	**0**

3.2 Dried fruits and dry mixes

The bacterial pathogens *Salmonella*, *Shigella* and *E. coli* O157 were not detected in any of the samples of dried fruits and dry mixes that were tested, and generic *E. coli* was not found at levels exceeding the satisfactory threshold. All samples that were analyzed during this survey were assessed as satisfactory (Table 7).

Table 7. Summary of Results for Dried Fruits and Dry Mixes Analysed for *Salmonella* spp., *Shigella* spp., *E. coli* O157:H7 and Generic *E. coli*

Product Type	Number of Samples	Assessment		
		Satisfactory	Investigative	Unsatisfactory
Dried Fruits	299 (7 domestic)	299	0	0
Dry Mixes	259 (21 domestic)	259	0	0
Total	**558**	**558 (100%)**	**0**	**0**

4 Conclusion and Discussion

The results of this survey (2010/11) indicate that no pathogens were detected in the low-moisture food samples analyzed. Furthermore, all the samples had acceptable results for the fecal indicator generic *E. coli*.

The overall finding of this survey suggests that dry products in the Canadian market are produced and handled under good sanitation and hygiene practices. However, the limited number of samples collected does not represent the actual variety of products of this nature available to Canadians. Further sampling is necessary and will continue to gather more information on the prevalence of microbial organisms of concern in spices, dried fruits and dry mixes available in the Canadian market.

While the food industry and retail sectors in Canada are ultimately responsible for the food they produce and sell, and individual consumers are responsible for the safe handling of the food they have in their possession, the CFIA regulates the industry, provides oversight and promotes safe handling of foods throughout the food production chain. Surveillance activities will continue and the CFIA will inform stakeholders of its findings.

5 References

(1) Government of Canada. *Food and Consumer Product Safety Action Plan*. [online]. April 2009. Accessed March 2011, http://www.tbs-sct.gc.ca/hidb-bdih/initiative-eng.aspx?Hi=85

(2) Canadian Food Inspection Agency. *Food Safety Action Plan*. [online] 2009, Accessed March 2011, http://www.inspection.gc.ca/english/fssa/concen/concengov/govplane.shtml

(3) Canadian Food Inspection Agency. *Food Safety Science Committee Summary Report 2008*. Accessed March 21, 2011, http://merlin.cfia-acia.inspection.gc.ca/english/fssa/invenq/guidoce.asp#refman5

(4) CODEX Alimentarius committee on Food Hygiene. *Code of Hygienic Practice for Spices and Dried Aromatic Plants (CAC/RCP 42-1995)*. [online]. Accessed April 2013, http://www.greenfoodec.eu/documents/codeofhygienicpracticeforspicesanddriedaromaticplants.pdf

(5) CODEX Alimentarius committee on Processed Fruits and Vegetables. *Code of Hygienic Practice for Dried Fruits (CAC/RCP 3-1969)*. [online]. 2011. Accessed May 2013, http://www.codexalimentarius.org/input/download/standards/263/CXP_003e.pdf

(6) CODEX Alimentarius committee on Food Hygiene. *Recommended International Code of Practice - General Principles of Food Hygiene (CAC/RCP 1-1969)*. [online]. 2011. Accessed March 2011, http://www.codexalimentarius.net/download/standards/23/cxp_001e.pdf

(7) Department of Justice Canada. *Food and Drugs Act* [online]. 2008 June, Accessed 2012 Oct, http://laws-lois.justice.gc.ca/eng/acts/F-27/

(8) Department of Justice Canada. *Food and Drug Regulations* [online]. 2012 August, Accessed 2012 Oct, http://laws-lois.justice.gc.ca/eng/regulations/C.R.C.,_c._870/index.html

(9) Joint FAO/WHO Food Standards Programme, Codex Committee on Food Hygiene, Discussion Paper on a Code of Hygienic Practice for Low-moisture Foods. Accessed April 2013, ftp://ftp.fao.org/codex/meetings/ccfh/ccfh44/fh44_11e.pdf

(10) L.R. Beuchat, E. Komitopoulou, H. Beckers, R.P. Betts, F. Bourdichon, S. Fanning, H.M. Joosten, and B.H. Ter Kuile, *Low-Water Activity Foods: Increased Concern as Vehicles of Foodborne Pathogens*, Journal of Food Protection, Vol. 76, No. 1, 2013, Pages 150-172.

(11) International Commission on Microbiological Specifications for Foods (ICMSF) Microorganisms in Foods 6: *Microbial Ecology of Food Commodities*, Kluwer Academic/Plenum Publishers, 2005: Chapter 7.

(12) Advisory Committee on the Microbiological Safety of Food, Information Paper, *Microbiological Examination of Dried Spices and Herbs from production and retail*

Premises in the United Kingdom, June 2008, Accessed online April 2013 http://www.food.gov.uk/multimedia/pdfs/committee/acm913spices.pdf

(13) J.M. Van Doren, D. Kleinmeier, T.S. Hammack, A. Westerman, *Prevalence, serotype diversity, and antimicrobial resistance of Salmonella in imported shipments of spice offered for entry to the United States, FY2007-FY2009*, Food Microbiology 34 (2013) 239-251

(14) CFIA website, *Information for Consumers, Food Irradiation*, Accessed Online May 2013: http://www.inspection.gc.ca/food/information-for-consumers/fact-sheets/labelling-food-packaging-and-storage/irradiation/eng/1332358607968/1332358680017

(15) *Organic Production Systems General, Principle and Management Standards*, CAN/CGSB-32.310-2006, Accessed Online May 2013: http://www.tpsgc-pwgsc.gc.ca/ongc-cgsb/programme-program/normes-standards/internet/bio-org/documents/032-0310-2008-eng.pdf

(16) U.S. FDA, Recall: Products Containing Hydrolyzed Vegetable Protein, Accessed online April 2013: http://www.cog.ca/index.php?page=consumers-and-standards

(17) CFIA Food Recall Archives, 2010, March and April, Accessed online April 2013: http://epe.lac-bac.gc.ca/100/206/301/cfia-acia/2011-09-21/www.inspection.gc.ca/english/corpaffr/recarapp/2010e.shtml#a04

(18) International Commission on Microbiological Specifications for Foods (ICMSF) Microorganisms in Foods 5: *Characteristics of Microbial Pathogens*, Blackie Academic & Professional, 1996: Chapter 16.

(19) R.J. Meldrum, R.M.M. Smith, P. Ellis, J. Garside on behalf of the Welsh Food M*icrobiological Forum, Microbiological quality of randomly selected ready-to-eat foods sampled between 2003 and 2005 in Wales, UK*, Internal Journal of Food Microbiology 108 (2006) 397-400.

(20) Food and Drug Administration (FDA). *Bad Bug Book: Foodborne Pathogenic Microorganisms and Natural Toxins Handbook*. 2nd Edition. 2012. Available at URL: http://www.fda.gov/downloads/Food/FoodborneIllnessContaminants/UCM297627.pdf

(21) Forsythe, S.J. *The Microbiology of Safe Food*. 2nd Edition. Blackwell Publishing Ltd., 2011.

(22) Health Canada. *Compendium of Analytical Method*. [online]. Accessed March, 2013, http://www.hc-sc.gc.ca/fn-an/res-rech/analy-meth/microbio/index-eng.php

(23) Health Canada. *Health Products and Food Branch Standards and Guideline for the Microbiological Safety of Food - An Interpretive Summary* [online]. 2011, Accessed March, 2011, http://www.hc-sc.gc.ca/fn-an/res-rech/analy-meth/microbio/volume1/intsum-somexp-eng.php

(24) J.M. Van Doren, K.P.Neil, M. Parish, L. Gieraltowski, L.H. Gould and K.L. Gombas, *Foodborne illness outbreaks from microbial contaminants in spices, 1973-2010*, Food Microbiology (2013) 1-9

Appendix A: List of Acronyms and Abbreviations

CFIA: Canadian Food Inspection Agency
CDC: Centres for Disease Control and Prevention
CFU/g: colony forming units per gram
E. coli: *Escherichia coli*
FAO: Food and Agriculture Organization of the United Nations
FDA: Food and Drug Act
FCSAP: Food and Consumer Safety Action Plan
FSAP: Food Safety Action Plan
GMPs: Good Manufacturing Practices
HPB/MFHPB: Health Protection Branch/ Microbiology Food Health Protection Branch
MFLP: Microbiology Food Laboratory Procedures
MPN: Most Probable Number
NM: non-motile
PCR: Polymerase Chain Reaction
PFGE: Pulsed Field Gel Electrophoresis
PHAC: Public Health Agency of Canada
spp.: species
UK: United Kingdom
US FDA: United States Food and Drug Administration
WHO: World Health Organization
g: gram

Appendix B: Global Foodborne Disease Outbreaks Associated With Low-Moisture Foods (Spices, Dried Fruits and Dry Mixes) Contaminated with Microbial Pathogens*

Year	Micro-organisms	Vehicle	Country	Cases	Source
1993	*Salmonella*	Paprika and paprika-powdered potato chips	Germany	1,000	Giedon online & ProMed May 21, 2007 (Information provided by Judy D. Greig, Laboratory for Foodborne Zoonoses , PHAC)
1999	*Salmonella* Java PT Dundee	Desiccated coconut	UK	168	See reference #10
2002	*Salmonella* Braenderup	Curry powder used by caterers	England	20	CDR Archives (Information provided by Judy D. Greig, Laboratory for Foodborne Zoonoses , PHAC)
2002	*Salmonella* Agona	Anise seed in herbal tea	Germany	40	Biometrical Journal 46(S1):140. Emerg. Infect. Dis. 11(7) 2005 (Information provided by Judy D. Greig, Laboratory for Foodborne Zoonoses , PHAC)
2005	*Salmonella* Typhimurium	Cake mix used in cake batter ice cream	USA	26	See reference #10
2007	*Salmonella* Wandsworth & *Salmonella* Typhimurium	Seasoning mix & broccoli powder (coating a snack puff)	USA (China for dried broccoli powder)	69 & 18	See reference #24
2007	*Bacillus cereus*	Spice blend used in couscous dish	France	146	European Food Safety Authority 2007 (Information provided by Judy D. Greig, Laboratory for Foodborne Zoonoses , PHAC)
2007-2008	*Salmonella* Senftenberg	Fennel seed	Serbia	14	See reference #24

Year	Micro-organisms	Vehicle	Country	Cases	Source
2008	*Salmonella* Rissen	Ground pepper imported, packaged and distributed by a California company	USA	87	Oregon Depart. of Human Services Public Health Division (Information provided by Judy D. Greig, Laboratory for Foodborne Zoonoses , PHAC)
2009	*Bacillus Cereus*	Rosepaprika (spice)	Denmark	48	The European Union Summary Report on Trends and Sources of Zoonoses, Zoonotic Agents and Foodborne Outbreaks in 2009 (Information provided by Judy D. Greig, Laboratory for Foodborne Zoonoses , PHAC)
2009-10	*Salmonella* Montevideo	Salami products made with contaminated Imported Black and Red Pepper	USA	272	CDC (Information provided by Judy D. Greig, Laboratory for Foodborne Zoonoses , PHAC)

*The data presented in the above table were collected from several sources of information, such as peer-reviewed journals, newspapers, press releases, health units, national laboratory and government websites.

Appendix C: Analytical Methods* Used for Microbial Analysis

Bacterial Analysis	Method Identification Number (Date Issued)	Title of Method*
***Salmonella* spp.**	MFLP-29 (July 2007, modified)**	The Qualicon Bax® System Method for the Detection of Salmonella in a Variety of Food and Environmental Samples
	MFHPB-20 (March 2009)	Methods for the Isolation and Identification of *Salmonella* from Foods and Environmental Samples
***Shigella* spp.**	MFLP-26 (February 2006)	Detection of *Shigella* spp. In Foods by the Polymerase Chain Reaction (PCR)
	MFLP-25 (March 2006)	Isolation and Identification of *Shigell*a spp. From Foods
***E. coli* O157:H7/NM**	MFLP-30 (May 2003, Supplement 1 May 2005 & Supplement 2 November 2006)	The Dupont Qualicon Bax® System Method for the Detection of E. Coli O157:H7 in Raw Beef and Fruit Juice
	MFLP-80 (March 2008)	Isolation of *E. coli* O157:H7 or NM in Foods
Generic *E. coli*	MFHPB-19 (April 2002)	Enumeration of Coliforms, Faecal Coliforms and of *E. coli* in Foods
	MFHPB-27 (September 1997)	Enumeration of *Escherichia coli* in Foods by the Direct Plating (DP) Method

* All methods used are published *in the Compendium of Analytical Methods* (22)

** MFLP-29 was performed as written with the following modification: Secondary enrichment was performed as outlined for cantaloupes, i.e., transferred from buffered peptone broth as specified to RVS and TBG broths (Rappaport-Vassiliadis Soya Peptone broth and Tetrathionate Brilliant Green broth) and incubated for 24 ± 2 h at 42.5°C. After incubation 2 ml from each of RVS and TBG are combined to one sample and analysis proceeds at step 7.3.1.4 of the method.