Canadian Food Inspection Agency
Agence canadienne d'inspection des aliments

Food Safety Action Plan

REPORT

2010-2011 Targeted Surveys

Targeted Survey Investigating Bacteria of Concern in Fresh Berries

Canada

Table of Contents

Executive Summary

The Food Safety Action Plan (FSAP) aims 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.

Fresh berries have been implicated in seven bacterial foodborne outbreaks around the world between 1999 and 2010. Berries can be exposed to foodborne pathogens in the field through contaminated irrigation water, improperly composted manure or contact with animals, as well as during picking, packing, and transportation. Berries are unique as their small size requires harvest by hand by a large number of workers, thus increasing the risk of being contaminated by an infected individual. Their delicate structure generally precludes washing before sale, so as not to shorten their shelf-life. In addition to outbreaks of bacterial illness, they have been implicated in outbreaks worldwide involving viruses and parasites – pathogens which come into contact with berries through similar exposure routes to bacteria of concern. Therefore, an assessment of the prevalence of pathogenic bacteria and indicators of faecal contamination in fresh berries at retail is warranted.

Considering these factors and their relevance to Canadians, berries have been selected as one of the priority commodity groups of fresh fruits and vegetables for enhanced surveillance under the FSAP. Over the course of a four-year baseline study (2009/10 - 2012/13), over 3,200 samples of berries were collected from Canadian retail locations and tested for the presence of various pathogens of concern.

The main objectives of the 2010/11 survey were to generate baseline surveillance data on bacterial pathogens *Salmonella*, *Shigella,* and *E. coli* O157:H7, as well as on the indicator of faecal contamination generic *E. coli,* in imported and domestically produced **fresh berries** available in the Canadian market. A total of 580 imported and 290 domestic samples of fresh berries 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. The microbiological quality of all the samples was assessed as satisfactory and did not require any further action by the CFIA. These results suggest that the berries tested during this survey were produced under Good Agricultural Practices (GAPs) and Good Manufacturing Practices (GMPs).

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 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.

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 bacterial pathogens of concern in fresh berries 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 Food and Agriculture Organization of the United Nations / World Health Organization (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 Practices for Fresh Fruits and Vegetables* (CAC/RCP 53-2003) (4) and the *General Principles of Food Hygiene* (CAC/RCP 1-1969) (5). 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.

Fresh fruits and vegetables available on the Canadian market must comply with the *Food and Drugs Act* (FDA) (6) and the *Food and Drug Regulations* (FDR) (7), 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.

Fresh fruits and vegetables that are imported or domestically produced and marketed inter-provincially must also comply with safety requirements of the *Fresh Fruit and Vegetable Regulations* (8) under the *Canada Agricultural Products Act* (9). These regulations are intended to ensure that fresh fruits and vegetables sold to consumers are safe, wholesome and properly graded, packaged and labelled.

The *Fresh Fruit and Vegetable Regulations* and the food-related sections of the FDA and FDR are enforced by the CFIA.

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. No such results were obtained in this survey.

2 Survey on Berries

2.1 Rationale

Fresh produce has been the source of numerous foodborne outbreaks associated with bacterial pathogens (e.g., *E. coli* O157, *Salmonella*, *Shigella*) around the world (10), (11). Fruits and vegetables could be exposed to pathogens in the field by contaminated irrigation water, improperly composted manure or contact with animals, as well as during harvest, storage, washing, packing and transportation (12), (13). In the case of berries, the risk may be increased due to their delicate structure and small size which not only call for manual harvest by a large number of workers, increasing the chance of contamination through an infected handler (14), but also usually preclude washing before packaging, in order to extend their shelf life (15). Berries may also be packaged directly in the field, reducing product damage through extensive handling but making quality control more difficult (16). Berries are farmed extensively in open fields and are also harvested from the wild. As such, they are exposed to wild animals and their faeces which increases the potential risk of contamination with pathogenic organisms (17). One example of wild animals contaminating berries occurred in 2011, when deer droppings on a strawberry farm in the United States caused an outbreak of *E. coli* O157:H7 which resulted in 15 reported cases, seven hospitalizations and two deaths (18).

From 1999-2010, there were seven reported outbreaks worldwide associated with bacterial pathogens in berries (Appendix B). These include four outbreaks caused by *Salmonella enterica*, one by pathogenic *E. coli*, one by *Shigella* and one by *Bacillus cereus*. A joint FAO/WHO Expert Meeting in 2007 classified berries in the second highest priority group of concern among fresh fruits and vegetables in terms of microbiological hazards. This was primarily due to their implication in outbreaks caused by parasites, such as *Cyclospora cayetenensis* and *Cryptosporidium parvum*, and viruses, predominantly Norovirus and Hepatitis A (14). The strong link existing between berries and viruses as well as parasites indicates that bacterial pathogens in berries could also be cause for investigation, since the routes of exposure to all of these contaminants (e.g., through irrigation water, extensive handling or contact with animal faeces) are often similar. In a report written for the United States Food and Drug Administration (US FDA), berries/*E. coli* O157:H7 and berries/*Salmonella enterica* were identified as two of 52 identifiable pathogen-commodity pairs which could be linked to disease in humans (19). In addition, research has shown that *Salmonella* and *E. coli* O157:H7 are able to survive on fresh strawberries for more than seven days, indicating that once contamination occurs, the bacteria would be viable for a sufficient amount of time to cause concern and potentially result in illness (20).

Based on the above information and the Food Safety Science Committee's recommendations (3), berries have been selected for targeted surveillance under FSAP.

The overall objective is to generate baseline information to gain insights on the occurrence of pathogens of concern (pathogenic bacteria, viruses and parasites) and indicators of faecal contamination in these commodities available to Canadians at retail. The CFIA is conducting separate surveys to determine baseline levels of viruses and parasites in berries on the Canadian market. This specific survey is part of the information collection with a focus on investigating the presence of bacterial pathogens (*Shigella*, *E. coli* O157:H7, and *Salmonella*) and the presence and levels of the indicator bacteria generic *E. coli* in imported and domestic berries.

2.2 Targeted Microorganisms

2.2.1 Bacterial Pathogens (*Salmonella* spp., *E. coli* O157 and *Shigella* spp.)

Bacterial pathogens, such as *Salmonella* and *E. coli* O157, are found naturally in the intestines of animals, such as poultry and cattle respectively (21). Most outbreaks associated with these bacterial pathogens are linked to the consumption of contaminated food of animal origin (e.g., chicken, beef). However, fresh fruits and vegetables have emerged as significant sources for these bacterial pathogen related illnesses in the last decade (22).

Humans are the only host of the bacterial pathogen *Shigella* spp. 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 (21).

2.2.2 Generic *E. coli* as an Indicator of Faecal Contamination

Typically, *E. coli* bacteria that inhabit the large intestines of humans and animals are harmless. Due to their regular presence in stools of humans and animals, the occurrence of *E. coli* in foods indicates direct or indirect contamination with faecal matter (23). The presence of generic *E. coli* in foods can also indicate potential contamination with pathogenic enteric microorganisms, 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 fresh produce sold at retail are an indication that contamination occurred at some point between production and the time of sale.

2.3 Sample Collection

All samples were collected from national chain and local/regional grocery stores as well as other conventional retail, natural food stores and farmers' markets 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. Samples were collected between April 2010 and March 2011. Domestic samples were collected during the spring and summer months (April-September). Imported samples were collected primarily in the fall, winter, and spring months (October-June).

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. This sampling approach is typical for surveys conducted at retail, and is also used by other federal partners such as the Public Health Agency of Canada (PHAC) for the retail component of their FoodNet Surveys (24).

Collected samples were required to be shipped under conditions that limited the growth of microorganisms during transit. Samples were declared unfit for analysis if there were issues regarding the conditions in which the sample was handled or shipped.

2.4 Sample Distribution

A total of 870 fresh berry samples were collected and examined for bacterial pathogens of interest. The distribution by country of origin is presented in Table 1, and the distribution by product type is presented in Table 2.

Table 1. Distribution of Fresh Berry Samples by Country of Origin

Country of Origin	Number of Samples
Canada	290 (33.3%)
Argentina	36 (4.1%)
Chile	75 (8.6%)
Guatemala	6 (0.7%)
Mexico	201 (23.1%)
New Zealand	1 (0.1%)
United States	254 (29.2%)
Uruguay	5 (0.6%)
Unknown	2 (0.2%)
Total Imported	580 (66.7%)
Total	**870 (100%)**

Domestic samples accounted for one third, or approximately 33.3% or all samples, while the remainder were imported. The majority of imported samples were from the United States or Mexico (455/580 in total, 78.4%). The remaining samples came from Chile (75/580, 12.9%), Argentina (36/580, 6.2%), Guatemala (6/580, 1.0%), New Zealand (1/580, 0.2%), and Uruguay (5/580, 0.9%). Two samples (0.3%) were of unknown origin.

Table 2. Distribution of Fresh Berry Samples by Product Type

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

Product Type	Origin		Total Number of Samples
	Imported	Domestic	
Blackberry	153 (17.6%)	18 (2.1%)	**171** (19.7%)
Blueberry	146 (16.8%)	112 (12.9%)	**258** (29.7%)
Cranberry	11 (1.3%)	3 (0.3%)	**14** (1.6%)
Gooseberry	0 (0%)	3 (0.3%)	**3** (0.3%)
Raspberry	133 (15.3%)	38 (4.4%)	**171** (19.7%)
Strawberry	136 (15.6%)	114 (13.1%)	**250** (28.7%)
Unknown	1 (0.1%)	2 (0.2%)	**3** (0.3%)
Total	**580** (66.7%)	**290** (33.3%)	**870** (100%)

The majority of samples (850/870, 97.7%) consisted of four berry types: blackberry, blueberry, raspberry, and strawberry. The remaining samples consisted of 14 samples of cranberries, three samples of gooseberries, and three samples for which the product type was not specified.

There were a total of thirteen (1.4%) organic samples (samples that were labelled as organic at retail). This survey was not specifically geared toward determining the baseline levels of microbial contamination of organic and conventional berries separately. As a result, no targets were set for the proportion of organic berries to be sampled. The organic samples were not segregated in this analysis.

2.5 Method Details

Samples were analysed using the analytical methods published in Health Canada's *Compendium of Analytical Methods for the Microbiological Analysis of Foods* (25) (Appendix C). These methods are used for regulatory testing by the CFIA and are fully validated for the analysis of fresh produce. A modified version of the method from Health Canada's Compendium was used for *Salmonella* testing, as indicated in Appendix C.

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

Generic *E. coli* was assessed using methods contained in Health Canada's *Compendium of Analytical Methods* or a method determined to be equivalent by the CFIA (Appendix C). The bacterial count 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* (26) and associated methods published in Health Canada's *Compendium of Analytical Methods (25).*

Table 3. Assessment Guidelines for *Salmonella, Shigella* and *E. coli* O157 in Fresh Berries

Bacterial Analysis* (**Method Identification Number**)	**Assessment Criteria**	
	Satisfactory	**Unsatisfactory**
***E. coli* O157:H7** (MFLP-30 & MFLP-80 if required for confirmation)	Absent in 25 g	Present in 25 g
Salmonella* spp.* (MFLP-29 modified & MFHPB-20 if required for confirmation)	Absent in 25 g	Present in 25 g
Shigella* spp. * (MFLP-26 & MFLP-25 if required for confirmation)	Absent in 25 g	Present in 25 g

* *Compendium of Analytical Methods (25).*

**No criteria have been established by Health Canada at this time for these bacterial pathogens in fresh fruits. 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.

Table 4. Assessment Guidelines for Generic *E. coli* in Fresh Berries

Bacterial Analysis* **(Method Identification Number)**	**Assessment Criteria**		
	Satisfactory	**Investigative**	**Unsatisfactory**
Generic *E. coli* (MFHPB-19, MFHPB-27 or CFIAFSSD-001)**	≤ 100	100 < x ≤ 1,000	> 1,000

** Compendium of Analytical Methods (25).*
** Concentration unit depends on method used. For MFHPB-19 method: MPN/g, for MFHPB-27 or CFIAFSSD-001 method: CFU/g.

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 Limitations

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 generalisation of the result to the specific lot in the absence of additional information.

The survey was designed to elucidate the prevalence of microbial hazards in foods available at retail. Given the seasonality as well as the varying channels of commerce, the source of the products can change dramatically from one season to the next. As such, there are an insufficient number of samples in this study to carry out a detailed analysis of the results based on country of origin. In cases of positive results, unsatisfactory rates between countries or production practices are not considered to be statistically comparable.

3 Results

Table 5. Summary of Results for Fresh Berries Analysed for *Salmonella, Shigella, E. coli* O157:H7 and Generic *E. coli*

Product Type	Total Number of Samples	Assessment		
		Unsatisfactory	Investigative	Satisfactory
Blackberry	171	0	0	171
Blueberry	258	0	0	258
Cranberry	14	0	0	14
Gooseberry	3	0	0	3
Raspberry	171	0	0	171
Strawberry	250	0	0	250
Unknown	3	0	0	3
Total	870	0	0	870 (100%)

The bacterial pathogens *Salmonella*, *Shigella*, and *E. coli* O157:H7 were not found in any of the samples tested. The level of generic *E. coli*, an indicator of faecal contamination, was below the satisfactory threshold of 100 CFU/g in all the samples. All 870 samples (100%) were assessed as satisfactory. No results requiring follow-up activities by the CFIA were obtained in this survey.

4 Conclusion and Discussion

The results of this survey (2010/11) indicate that no pathogens (i.e., *Salmonella, Shigella,* and *E. coli* O157:H7) were detected in any of the 870 samples of berries analyzed. Furthermore, levels of the faecal indicator generic *E. coli* were always found to be acceptable. The microbiological quality of all the samples was assessed as satisfactory and did not require any further action by the CFIA.

The overall finding of this survey suggests that berries in the Canadian market are generally produced and handled under acceptable GAPs and GMPs. Surveys conducted by other jurisdictions in Canada and in the U.S. on a variety of berry samples identified similar trends to the present survey, suggesting that the prevalence of bacteria of interest in berries in Canada and the United States is very low (27, 28, 29, 30, 31).

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]*. 2012. Accessed August 2013, http://www.tbs-sct.gc.ca/hidb-bdih/initiative-eng.aspx?Hi=85

2. Canadian Food Inspection Agency. *Food Safety Action Plan [online]*. 2012. Accessed August 2013, http://merlin/english/fssa/action/actione.asp

3. Canadian Food Inspection Agency. *Food Safety Science Committee Summary Report 2008 [online]*. 2008. Accessed October 2012, http://merlin.cfia-acia.inspection.gc.ca/english/fssa/invenq/guidoce.asp#refman5

4. CODEX Alimentarius Committee on Food Hygiene. *The Code of Hygienic Practices for Fresh Fruits and Vegetables (CAC/RCP 53-2003) [online]*. 2011. Accessed August 2013, http://www.codexalimentarius.net/download/standards/10200/CXP_053e.pdf

5. CODEX Alimentarius Committee On Food Hygiene. *Recommended International Code of Practice - General Principles of Food Hygiene (CAC/RCP 1-1969) [online]*. 2011. Accessed August 2013, http://www.codexalimentarius.net/download/standards/23/cxp_001e.pdf

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

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

8. Department of Justice Canada. *Fresh Fruit and Vegetable Regulations [online]*. 2011. Accessed October 2012, http://laws-lois.justice.gc.ca/eng/regulations/C.R.C.,_c._285/index.html

9. Department of Justice Canada. *Canada Agricultural Products Act [online]*. 2005. Accessed August 2013, http://laws-lois.justice.gc.ca/eng/acts/C-0.4/

10. Greig J. D. & Ravel A. Analysis of Foodborne Outbreak Data Reported Internationally for Source Attribution *Int J Food Microbiol* 2009; 130**,** 77-87.

11. Rangel J. M., Sparling P. H., Crowe C., Griffin P. M. & Swerdlow D. L. Epidemiology of Escherichia coli O157:H7 Outbreaks, United States, 1982-2002 *Emerg Infect Dis* 2005; 11**,** 603-9.

12. Hackl E.; Hölzl, C.; Konlechner, C.; Sessitsch; A. Food of Plant Origin: Production Methods and Microbiological Hazards Linked to Food-Borne Disease *[online]*. 2013. Accessed August 2013, http://www.efsa.europa.eu/en/supporting/pub/403e.htm

13. Han Y., Selby T. L., Schultze K. K., Nelson P. E. & Linton R. H. Decontamination of Strawberries Using Batch and Continuous Chlorine Dioxide Gas Treatments *J Food Prot* 2004; 67**,** 2450-5.

14. WHO/FAO. *Microbiological Risk Assessment Series 14: Microbiological Hazards in Fresh Leafy Vegetables and Herbs [online]*. 2011. Accessed August 2013, ftp://ftp.fao.org/docrep/fao/011/i0452e/i0452e00.pdf

15. Bialka K. L. & Demirci A. Efficacy of Pulsed UV-Light for the Decontamination of *Escherichia coli* O157:H7 and *Salmonella* spp. On Raspberries and Strawberries *J Food Sci* 2008; 73**,** M201-7.

16. Health EFSA Panel on Plant. Scientific Opinion on the Risk Posed by Pathogens in Food of Non-Animal Origin. Part 1 (Outbreak Data Analysis and Risk Ranking of Food/Pathogen Combinations)1 *[online] EFSA Journal* 2013; 11 (1): 3025. Accessed August 2013, www.efsa.europa.eu/en/efsajournal/doc/3025.pdf

17. Authority European Food Safety. The European Union Summary Report on Trends and Sources of Zoonoses, Zoonotic Agents and Food-Borne Outbreaks in 2011 *[online] EFSA Journal* 2013; 11 (4): 3129. Accessed August 2013, http://www.efsa.europa.eu/en/efsajournal/pub/3129.htm

18. Center for Disease Control and Prevention. *Foodborne Outbreak Online Database (Food)* In *[online]*. Accessed Aug 2013, http://wwwn.cdc.gov/foodborneoutbreaks/

19. International RTI. Fresh Produce Risk Ranking Tool Summary: Identification of Priority Pathogen-Commodity Combinations for Quantitative Microbial Risk Assessment *[online]*. 2009. Accessed August 2013 http://foodrisk.org/default/assets/File/Produce_RRT_report_RTI.pdf

20. Knudsen D. M., Yamamoto S. A. & Harris L. J. Survival of *Salmonella* spp. And *Escherichia coli* O157:H7 on Fresh and Frozen Strawberries *J Food Prot* 2001; 64**,** 1483-8.

21. U.S.FDA. *Bad Bug Book : Foodborne Pathogenic Microorganisms and Natural Toxins Handbook [online]*. 2011. Accessed August 2013, http://www.fda.gov/Food/FoodSafety/FoodborneIllness/FoodborneIllnessFoodbornePathogensNaturalToxins/BadBugBook/ucm071284.htm

22. Kozak G. K., MacDonald D., Landry L. & Farber J. M. Foodborne Outbreaks in Canada Linked to Produce: 2001 through 2009 *J Food Prot* 2013; 76**,** 173-83.

23. Forsythe S. J. . *The Micorbiology of Safe Food*. 2nd Edition. Blackwell Publishing Ltd., 2011:214.

24. Public Health Agency of Canada. *C-Enternet*. http://www.phac-aspc.gc.ca/c-enternet/index-eng.php

25. Health Canada. *Compendium of Analytical Methods [online]*. 2011. Accessed October 2012, http://www.hc-sc.gc.ca/fn-an/res-rech/analy-meth/microbio/index-eng.php

26. Health Canada. *Health Products and Food Branch Standards and Guidelines for the Microbiological Safety of Food - an Interpretive Summary [online]*. 2008. Accessed October 2012, http://www.hc-sc.gc.ca/fn-an/res-rech/analy-meth/microbio/volume1/intsum-somexp-eng.php

27. Bohaychuk V.M., Bradbury R.W., Dimock R., Fehr M., Gensler G.E., King R.K., Rieve R. & Romero Barrios P. A Microbiological Survey of Selected Alberta-Grown Fresh Produce from Farmers' Markets in Alberta, Canada *J Food Prot.* 2009; 72**,** 415-420.

28. Mukherjee A., Speh D., Jones A.T., Buesing K.M. & Diez-Gonzalez F. Longitudinal Microbiological Survey of Fresh Produce Grown by Farmers in the Upper Midwest *J Food Prot.* 2006; 69**,** 1928-1936.

29. Mukherjee A., Speh D., Dyck E. & Diez-Gonzalez F. Preharvest Evaluation of *Coliforms, Escherichia coli, Salmonella,* and *Escherichia coli* O157:H7 in Organic and Conventional Produce Grown by Minnesota Farmers *J Food Prot.* 2004; 67**,** 894-900.

30. U.S.FDA. *Fda Survey of Domestic Fresh Produce Fy 2000/2001 Field Assignment Accessed March 02, 2011*. 2001. http://www.fda.gov/Food/FoodSafety/Product-

SpecificInformation/FruitsVegetablesJuices/GuidanceComplianceRegulatoryInformation/ucm118306.htm

31. U.S.FDA. *Fda Survey of Imported Fresh Produce Fy 1999 Field Assignment [online]*. 2001. Accessed 2011, http://www.fda.gov/Food/FoodSafety/Product-SpecificInformation/FruitsVegetablesJuices/GuidanceComplianceRegulatoryInformation/ucm118891.htm

Appendix A: List of Acronyms and Abbreviations

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

Appendix B: Global Foodborne Disease Outbreaks Associated With Berries Contaminated with Bacterial Pathogens* (1999-2010)

Commodity	Microorganism	Country	Year	Cases	Hospitalized	Deaths	Source
Strawberries	*Shigella sonnei*[*1]	United States	1999	3	1		(18)
Strawberries	*Salmonella enterica* Group B	United States	2003	13	2		CDC line list 2003 ***
Various berries	*Bacillus cereus*	Finland	2005	15			European 2005 linelist ***
Strawberries and blueberries	*E. coli* O26:NM	United States	2006	5	1		CDC line list 2006 ***
Strawberries (with curd cheese)	*Salmonella enterica* Enteritidis PT 13	Germany	2009	26	2		EFSA Journals 2011, 9(3):2090-2476
Blueberries	*Salmonella enterica* Muenchen	United States	2009	14			CDC line list 2009***
Blueberries	*Salmonella enterica* Newport	United States	2010	6	1		*J of Food Protection*, 2010, 76(5):762-769

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

*1 In this case, the etiology of the outbreak is not confirmed.

*** Information provided by Judy D. Greig, Laboratory for Foodborne Zoonoses, PHAC

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**	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
	CFIAFSSD-001*** (August 2010)	Enumeration of *Escherichia coli* in Fresh Produce Using Compact Dry EC Medium Count Plates (equivalent to MFHPB-27)

* All these methods used are published in the *Compendium of Analytical Methods* (24), except when indicated otherwise.

** 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.

*** Method validated by the Canadian Food Inspection Agency and assessed to be equivalent to MFHPB-27