Canadian Food Inspection Agency
Agence canadienne d'inspection des aliments

Food Safety Action Plan

REPORT

2012/13 Targeted Surveys

Targeted Survey Investigating Bacterial Pathogens and Generic *E. coli* in Tomatoes

RDIMS # 6018513

Canada

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Executive Summary

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

Tomatoes contaminated with bacterial pathogens have been associated with numerous outbreaks of foodborne illness in North America. The Food and Agriculture Organization of the United Nations/World Health Organization (FAO/WHO) has ranked tomatoes as the second highest priority group of concern in terms of microbiological hazards among fresh fruits and vegetables. Tomatoes can become contaminated with bacterial pathogens by various ways along the food chain during primary production, post-harvest handling, processing, preparation and storage. As tomatoes are often consumed raw, the presence of pathogens creates a potential risk for foodborne illnesses.

Considering the factors mentioned above and their relevance to Canadians, tomatoes has 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 five-year baseline study (2008/09 to 2012/13), approximately 5,000 tomato samples were collected from Canadian retail locations and tested for bacterial pathogens of concern.

The main objective of this targeted survey (2012/13) was to generate baseline surveillance data on the presence and distribution of bacterial pathogens *Salmonella* and *Shigella*, as well as on generic *Escherichia coli* (*E.coli*, an indicator of fecal contamination) in tomatoes. A total of 1262 tomato samples were analyzed. *Salmonella* and *Shigella* were not detected in any of the samples, and levels of generic *E. coli* were found to be acceptable in all the samples. All samples (100%) were assessed as satisfactory. These results suggest that the tomatoes in the Canadian market sampled during this survey were produced under Good Agricultural Practices (GAPs) and Good Manufacturing Practices (GMPs).

The Canadian Food Inspection Agency (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, it is important to note that 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. In addition, 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 strengthen 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) 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.

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 were collected over five 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 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 (2012/13) represents part of the collection of over 5,000 tomato samples over five years (2008/09 – 2012/13), and was designed to gather baseline information on the occurrence of bacterial pathogens of concern in tomatoes 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. Producers of fresh fruits and vegetables are encouraged to follow these international codes of practice. Of relevance for this survey are the *Code of Hygienic Practice for Fresh Fruits and Vegetables* (CAC/RCP 53-2003) [4] and the *Recommended International Code of Practice - General Principles of Food Hygiene* (CAC/RCP 1-1969, Rev. 4-2003) [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 the production of fresh fruits and vegetables from primary production to packaging.

Fresh fruits and vegetables available in 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 sold in Canada must also comply with the 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 portions of the FDA and FDR are enforced by the CFIA.

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

2 Survey on Tomatoes

2.1 Rationale

Fresh tomatoes contaminated by bacterial pathogens have been reported to be responsible for numerous outbreaks of foodborne illness worldwide. From 1990 to March 2013, there were 23 documented outbreaks worldwide associated with tomatoes contaminated with bacterial pathogens (Appendix B). *Salmonella* is the most commonly identified bacterial pathogen in tomato-associated outbreaks of foodborne illnesses (21 outbreaks).

Tomatoes can be contaminated with bacterial pathogens by various ways along the food chain. In primary production, tomatoes can be contaminated from the soil through the use of improperly composted manure, contaminated irrigation water, or wildlife feces. Experimental field studies have demonstrated that *Salmonella* can persist for extended periods of time in the soil [10]. Also, *Salmonella* is able to internalize and survive within the inner tissue of tomatoes as tomato fruits develop in the field [11, 12]. Post-harvest handling can also bring tomatoes into direct contact with pathogens through contaminated processing water or poor hygienic practices of workers handling the tomatoes. Studies suggest that *Salmonella* can infiltrate whole tomatoes during the washing process when the tomato temperature is higher than the water temperature in the dump tank [13]. Once internalized, the bacteria cannot be removed by normal washing practices. Laboratory studies also indicate that several serotypes of *Salmonella* can survive the acidic conditions of tomatoes (pH 4.1 - 4.4) during storage at refrigeration temperatures, and can grow rapidly when storage temperatures increase above that of refrigeration (e.g., 20 °C and 30°C) [14].

Tomatoes were identified as the second highest priority group of concern in terms of microbiological hazards among fresh fruits and vegetables during a joint FAO/WHO Experts Meeting in 2007 [15], based on multiple factors, such as historical outbreaks and the potential for contamination.

Based on the above information and the Food Safety Science Committee's recommendations [3], tomatoes have been selected for targeted surveillance under FSAP. The overall objective is to gather baseline information on the occurrence of bacterial pathogens of concern in tomatoes available to Canadians at retail. This targeted survey (2012/13) is part of the information collection with a focus on investigating the presence and distribution of bacterial pathogens *Salmonella* and *Shigella*, and the presence and levels of generic *Escherichia coli* (*E. coli*) in imported and domestically produced tomatoes.

2.2 Targeted Microorganisms

2.2.1 Bacterial Pathogens of Concern

Salmonella normally live in the intestines of animals such as poultry, swine, wild birds, domestic pets and reptiles. Therefore, *Salmonella* contamination often occurs in food of animal origin (e.g., poultry, eggs, and meat). However, in the last decade, foodborne illnesses of salmonellosis have been increasingly reported to be associated with the consumption of contaminated fruits and vegetables [16]. Tomatoes were one of the produce groups that contributed to the increased produce-associated salmonellosis.

Humans are the only host of the bacterial pathogen *Shigella* [17]. Food contaminated by infected food handlers with poor personal hygiene, 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 and vegetables [17].

2.2.2 Generic *E. coli* as 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 stools of humans and animals, the occurrence of *E. coli* in foods indicates direct or indirect contamination with fecal matter. The presence of generic *E. coli* in foods can also indicate potential contamination with pathogenic enteric microorganisms, such as *Salmonella*, 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 an 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 is an indication that contamination has 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, and other conventional retail located in various cities across Canada. The number of samples collected in the various regions was based on the relative proportion of the population in the respective regions. Samples were collected during the 2012/13 fiscal year (April 1, 2012 to March 31, 2013). Domestic samples were collected between June and November. Imported samples were collected primarily in the fall, winter, and spring months.

In this survey, a sample consisted of one consumer size pre-packaged tomato sample. This sampling approach has been used in many retail food surveys and is also used by other federal partners such as the Public Health Agency of Canada (PHAC) under the FoodNet retail surveillance [18].

Collected samples were required to be shipped under conditions that limited the growth of microorganisms during transit. If issues or questions arose about the conditions in which the sample was shipped, the sample was declared unfit for analysis.

2.4 Sample Distribution

Table 1 Tomato Sample Distribution by Country of Origin

Country of Origin	Production Practices		Total	
	Conventional	Organic		
	Number of Samples	Number of Samples	Number of Samples	Percentage of Samples
Canada	287	294	581	46.0
Subtotal - Domestic	*287*	*294*	*581*	*46.0*
Dominican Republic	**0**	**15**	**15**	1.2
Iceland	**0**	1	**1**	0.1
Israel	0	5	5	0.4
Italy	3	0	3	0.2
Mexico	221	250	471	37.3
United States	114	67	181	14.3
Unknown*	1	4	5	0.4
Subtotal - Imported	*339*	*342*	*681*	*54.0*
Total	**626**	**636**	**1262**	**100.0**

*unknown: country of origin was not identified for these samples, since they were sampled in winter months and were accounted as imported samples.

A total of 1262 tomato samples were collected, including imported (54.0%) and domestically (46.0%) produced, conventional (49.6%) and organically (50.4%) grown tomatoes. The imported tomatoes originated from Mexico (69.2%), the U.S. (26.6%), and four other countries. The country of origin could not be identified for 0.4% of the samples. The domestic tomato samples were obtained from several provinces across Canada.

2.5 Method Details

All samples were analyzed using the analytical methods published in Health Canada's *Compendium of Analytical Methods* for the Microbiological Analysis of Foods [19] (Appendix C). These methods are used for regulatory testing by the CFIA and are fully validated for the analysis of fresh fruits and vegetables, including tomatoes. 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 *Salmonella* and *Shigella*, samples were analyzed by cultural presence/absence methods. The laboratories had the option of using polymerase chain reaction (PCR)-based screening methods to first screen enrichment broth for the presence of genetic material from the pathogens of interest, followed by cultural confirmation of presumptive positives.

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

2.6 Assessment Guidelines

The assessment criteria used in this survey (Table 2&3) are based on principles of the *Health Products and Food Branch Standards and Guidelines for Microbiological Safety of Foods* [20] and associated methods published in Health Canada's *Compendium of Analytical Methods* [19].

Table 2 Assessment Guidelines for *Salmonella* and *Shigella* in Tomatoes

Bacterial Analysis* **(Method Identification Number)**	**Assessment Criteria**	
	Satisfactory	**Unsatisfactory**
Salmonella* spp.* (MFLP-29, modified and MFHPB-20)	Absent in 25 g	Present in 25 g
Shigella* spp.* (MFLP-26 and MFLP-25)	Absent in 25 g	Present in 25 g

* *Compendium of Analytical Methods* [19].

**No criteria have been established by Health Canada at this time for these bacterial pathogens in fresh fruits and vegetables. However, in the absence of a specified criteria, the presence of these pathogens in foods is considered to be a violation of FDA Section 4(1)a and is therefore assessed by the CFIA as unsatisfactory.

Table 3 Assessment Guidelines for Generic *E. coli* in Tomatoes

Bacterial Analysis* (Method Identification Number)	Assessment Criteria		
	Satisfactory	**Investigative**	**Unsatisfactory**
Generic *E. coli* (MFHPB-19 or MFHPB-27)	≤ 100 MPN/g or CFU/g	100 < x ≤ 1000 MPN/g or CFU/g	> 1000 MPN/g or CFU/g

* *Compendium of Analytical Methods*[19].

Unsatisfactory sample assessments were 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 form of follow-up activity. For example, further sampling may be done to verify the levels of generic *E. coli* in the samples in question.

2.7 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.

Finally, 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 is an insufficient number of samples in this survey to carry out a detailed analysis of the results based on country of origin.

3 Results

A total of 1262 tomato samples were analyzed for *Salmonella, Shigella* and generic *E. coli* (Table 4). *Salmonella* and S*higella* were not detected in any of the samples. Levels of generic *E. coli* were acceptable in all the samples. All samples were assessed as satisfactory.

Table 4 Summary of Results of Tomato Samples

Product Origin	Production Practices	Number of Samples	Assessment		
			Investigative	Unsatisfactory	Satisfactory
			Number of Samples	Number of Samples	Number of Samples
Imported	Conventional	339	0	0	339
	Organic	342	0	0	342
	Subtotal	*681*	*0*	*0*	*681*
Domestic	Conventional	287	0	0	287
	Organic	294	0	0	294
	Subtotal	*581*	*0*	*0*	*581*
Total		**1262**	**0**	**0**	**1262**

4 Discussion and Conclusion

In the 2012/13 survey, a total of 1262 tomato samples were analysed for *Salmonella, Shigella* and generic *E. coli*. All samples were assessed as satisfactory.

The overall finding of this survey suggests that the tomatoes in the Canadian market sampled during the survey were produced and handled under acceptable GAPs and GMPs.

Tomatoes have been involved in numerous salmonellosis outbreaks of foodborne illnesses in North America. Food safety authorities in Canada and the U.S have identified tomatoes as one of the commodities for enhanced surveillance. During five years of targeted surveys (2008/09 – 2012/13), the CFIA did not find any samples to be contaminated with *Salmonella* in a total of 5049 imported and domestically produced tomato samples tested. In studies conducted by the Ontario and Alberta Ministry of Agriculture in 2004 and 2007, *Salmonella* was found in one (0.7%) of the Ontario-grown tomatoes (141 samples) [21] and was not found in any of the Alberta-grown tomatoes (120 samples) [22]. Similarly, surveys conducted by the US FDA on bacterial

pathogens in fresh produce in 1999/2000 did not find any *Salmonella* positive samples (200 samples tested). More recent surveys (2005-2009) from the U.S. Department of Agriculture (USDA) Microbiological Data Program on fresh produce found that the prevalence of *Salmonella* in tomatoes sold in the U.S. was between 0 and 0.06% (1000 to 2000 samples tested each year) [23].

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

5 Acknowledgement

We would like to express our sincere thanks to Judy D. Greig, Public Health Agency of Canada for providing information on outbreaks (Appendix B).

6 References

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Appendix A: List of Acronyms

CDC: Centres for Disease Control and Prevention

CFIA: Canadian Food Inspection Agency

CFU: colony forming unit

E. coli: *Escherichia coli*

FAO: Food and Agriculture Organization of the United Nations

FDA: *Food and Drugs Act*

FDR: *Food and Drug Regulations*

FCSAP: Food and Consumer Safety Action Plan

FSAP: Food Safety Action Plan

GAPs: Good Agricultural Practices

GMPs: Good Manufacturing Practices

HC: Health Canada

MPN: Most Probable Number

PCR: Polymerase Chain Reaction

PHAC: Public Health Agency of Canada

***Salmonella* spp.**: *Salmonella* species

US FDA: the United States Food and Drug Administration

USDA: United States Department of Agriculture

WHO: World Health Organization

°C: Degree Celsius

g: gram

Appendix B: Global Foodborne Disease Outbreaks Associated with Tomatoes Contaminated with Bacterial Pathogens (1990 – March 2013)*

List Number	Year	Microorganism	Location	Number of Cases	Source
1	1990	*Salmonella* Javiana	Multiple US states	176	Epidemiol Infect 1999 122(3):385-93
2	1993	*Salmonella* Montevideo	Multiple US states	100	Epidemiol Infect 1999 122(3):385-93
3	1998	*Salmonella* Baildon	Multiple US states	86	Emerg Infect Dis. 2001 7(6):1046-8
4	1998	*Salmonella* virchow PT8	Australia,	32	Epidemiology and Infection Volume 131, Issue 3 (pp 1041-1048)
5	2000	*Salmonella* Thompson	Multiple US states	43	CDC line list 2000
6	2001	*Shigella flexneri* 2a	New York	886	Clinical Infectious Diseases 2006;42:163-9
7	2002	*Salmonella* Javiana	Florida, US	159	MMWR 2002 51(41):683-4; Emerg Infect Dis. Vol 11 2005; 610-612
8	2002	*Salmonella* Newport	Multiple US states	510	CDC line list 2002
9	2003	*Salmonella* Virchow	California, US	11	CDC line list
10	2004	*Salmonella*	Multiple US states	429	MMWR 2005/54(40);325-328.
11	2004	*Salmonella* Braenderup	Multiple US states	137	MMWR 2005/54(40);325-328.
12	2004	*Salmonella* Javiana	Ontario, Canada	7	MMWR 2005/54(40);325-328. CCDR Volume 31-21 2005
13	2004	Campylobacter	Ohio, US	13	CDC line list 2004
14	2005	*Salmonella* Braenderup	Multiple US states	84	CDC line list 2005
15	2005-06	*Salmonella* Newport	Multiple US states, 2005-2006	459	MMWR Weekly Volume 56, No. 35 2007
16	2006	*Salmonella* Berta	Multiple US states	16	CDC linelist 2006
17	2006	*Salmonella* Norfolk	Multiple US states	106	CDC
18	2007	*Salmonella*	Minnesota,	22	Post-Bulletin, Rochester MN
19	2007	*Salmonella* Newport	Multiple US states	65	CDC line list 2007
20	2007	*Salmonella* Newport	New York, US	10	CDC line list 2007
21	2007	*Salmonella* Typhimurium	Minnesota, US	23	CDC line list 2007
22	2009	*Salmonella* Saintpaul	US	21	CDC line list 2009
23	2011	*Salmonella* Strathcona	Mutiple Countries	58	ProMED Digest V2012 #369

* Information in the Appendix B is prepared by Judy D. Greig, Laboratory for Foodborne Zoonoses , PHAC (Public Health Agency of Canada)

Appendix C: Analytical Methods Used for Microbial Analysis

Bacterial Analysis	Method Identification Number (Date Issued)	Title of Method*
***Salmonella* spp.**	MFLP-29 (June 2012), 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
Generic *E. coli*	MFHPB-19 (April 2002)	Enumeration of Coliforms, Faecal Coliforms and *E. coli* in Foods
	MFHPB-27 (September 1997)	Enumeration of *Escherichia coli* in Foods by a Direct Plating (DP) Method

* *Compendium of Analytical Methods*[19].

** 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 with step 7.3.1.4 of the method.