



Canadian Food
Inspection Agency

Agence canadienne
d'inspection des aliments

Bacterial pathogens and indicators in fresh whole leafy vegetables - April 1, 2020, to March 31, 2025

Food microbiology - Targeted surveys - Final report



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Summary

A targeted survey¹ analyzed 1613 samples of imported (832) and domestic (781) fresh whole leafy vegetables over a 5-year period from April 1, 2020 to March 31, 2025. Samples were tested for the presence of the bacterial pathogens Shiga toxin-producing *E. coli* (STEC) O157:H7, non-O157 STEC, and *Salmonella* spp. All samples were also tested for generic *E. coli*, an indicator of the overall effectiveness of Good Agricultural Practices (GAP) and sanitary conditions along the food chain from production to the point of sale.

A large majority (99.7%) of the samples tested were found to be satisfactory. STEC O157:H7 and *Salmonella* spp. were not detected in any of the 1609 and the 1451 samples, respectively. Non-O157 STEC was detected in 3 (0.2%) of the 1609 samples. Elevated levels (> 100 and ≤ 1000 CFU/g) of generic *E. coli* were found in 2 (0.1%) of the 1613 samples. The Canadian Food Inspection Agency (CFIA) conducted appropriate follow-up activities as necessary.

Overall, our survey results indicate that fresh whole leafy vegetables sold in Canada are generally safe for consumption however contamination with bacterial pathogens can occur. As with all foods, and especially those that are ready-to-eat (RTE), good hygienic practices are recommended for producers, importers, retailers, and consumers.

Why the survey was conducted

The survey was conducted to provide enhanced oversight on the microbiological safety (STEC O157:H7, non-O157 STEC, *Salmonella* spp.) and quality (generic *E. coli*) of imported and domestically produced fresh whole leafy vegetables on the Canadian retail market.

Fresh leafy vegetables are commonly consumed by Canadians as part of a healthy diet. Unfortunately, fresh leafy vegetables have been associated with numerous foodborne illness outbreaks². STEC O157:H7 is an important pathogen that has been implicated in leafy vegetable associated foodborne outbreaks^{3,4}. Non-O157 STEC is an emerging food safety hazard in fresh leafy vegetables⁵. Cattle are considered to be the principle natural reservoir of STEC (O157:H7 and non-O157)⁵. Leafy vegetables in growing fields located in close proximity to cattle feeding zones can be contaminated by STEC from cattle feces or via contaminated irrigation water^{4,6}.

When the survey was conducted

The survey was conducted over a 5-year period from April 1, 2020, to March 31, 2025.

Where the samples were collected from

Samples were collected from national retail chains and local/regional grocery stores located in the following 11 major cities across Canada:

- Halifax
- Moncton
- Quebec City
- Montreal
- Toronto
- Ottawa
- Vancouver
- Victoria
- Calgary
- Saskatoon
- Winnipeg

The planned number of samples to be collected from each city was based on the population of the province in which the city was located relative to the total population of Canada.

Total number and description of samples collected

A total of 1613 fresh whole leafy vegetable samples including 781 domestic samples and 832 imported samples were collected over the 5-year survey period. A sample consisted of one or more consumer sized packages or bulk samples from the same lot weighing at least 250 g.

What the samples were tested for

The fresh leafy vegetable samples were tested for the presence of STEC O157:H7, non-O157 STEC, *Salmonella* spp., and generic *E. coli*. STEC O157:H7, non-O157 STEC and *Salmonella* spp. are pathogenic bacteria while generic *E. coli* is an indicator of the overall effectiveness of GAP and sanitary conditions under which the samples have been produced, processed, stored, and transported.

Methods used to test the samples

Samples were analyzed using analytical methods published in Health Canada's *Compendium of Analytical Methods for the Microbiological Analysis of Foods*⁷ that were suitable for the testing of leafy vegetables.

How the samples were assessed

The samples were assessed using criteria based on the principles of Health Canada's *Health Products and Food Branch (HPFB) Standards and Guidelines for Microbiological Safety of Foods – An Interpretive Summary*⁸. At the time of writing this report, no assessment guidelines had been established in Canada for the presence of non-O157 STEC and *Salmonella* spp. in fresh leafy vegetables. The detection of non-O157 STEC was assessed as investigative, indicating that further follow-up actions may be warranted. As assessment guidelines have been established for *Salmonella* spp. in other RTE foods⁸, its presence in fresh leafy vegetables might be considered a violation of the *Food and Drugs Act* Section 4(1)(a)⁹ and therefore assessed as unsatisfactory (table 1).

Table 1 - Assessment criteria

Bacteria	Satisfactory	Investigative	Unsatisfactory
STEC O157:H7	Not detected/25 g	Not applicable	Detected/25 g
Non-O157 STEC	Not detected/25 g	Detected/25 g	Not applicable
<i>Salmonella</i> spp.	Not detected/25 g	Not applicable	Detected/25 g
Generic <i>E. coli</i>	≤ 100 CFU/g	>100 and ≤ 1000 CFU/g	>1000 CFU/g

Survey result

A large majority (99.7%) of the samples were found to be satisfactory. STEC O157:H7 and *Salmonella* spp. were not detected in any of the samples. Non-O157 STEC was detected in 3 (0.2%) of the samples. Elevated levels (>100 and ≤ 1000 CFU/g) of generic *E. coli* were found in 2 (0.1%) of the samples (table 2).

Table 2 - Analysis assessment results

Bacterial analysis	Number of samples tested	Satisfactory (%)	Investigative (%)	Unsatisfactory
STEC O157:H7	1609	1609 (100.0)	Not applicable	0
Non-O157 STEC	1609	1606 (99.8)	3 ^a (0.2)	Not applicable
<i>Salmonella</i> spp.	1451	1451 (100.0)	Not applicable	0
Generic <i>E. coli</i>	1613	1611 (99.9)	2 ^b (0.1)	0

Assessment results are also presented as product type (table 3), production practice (table 4), and country of origin (table 5).

^a Domestic green leafy lettuce, and kale and spinach imported from the US. All 3 samples were conventionally produced.

^b Domestic green leafy lettuce (110 CFU/g) and domestic spinach (290 CFU/g).

Table 3 - Assessment results by product type

Product type	Number of samples tested (%)	Satisfactory	Investigative	Unsatisfactory
Arugula	22 (1.4)	22	0	0
Beet greens	4 (0.3)	4	0	0
Chicory	86 (5.3)	86	0	0
Collard greens	3 (0.2)	3	0	0
Kale	291 (18.0)	290	1	0
Red or green leaf lettuce	520 (32.2)	518	2	0
Mustard greens	4 (0.3)	4	0	0
Radicchio	3 (0.2)	3	0	0
Romaine lettuce	333 (20.6)	333	0	0
Spinach	257(15.9)	255	2	0
Swiss chard	72 (4.5)	72	0	0
Watercress	18 (1.1)	18	0	0
Total (%)	1613 (100.0)	1608 (99.7)	5 (0.3)	0

Table 4 - Assessment results by production practice

Production practice	Number of samples tested (%)	Satisfactory	Investigative	Unsatisfactory
Conventional	1389 (86.1)	1384	5	0
Organic	224 (13.9)	224	0	0
Total (%)	1613 (100.0)	1608 (99.7)	5 (0.3)	0

Table 5 - Assessment results by country of origin

Country of origin	Number of samples tested (%)	Satisfactory	Investigative	Unsatisfactory
Belgium	7 (0.4)	7	0	0
Canada	781 (48.4)	778	3	0
China	1 (< 0.1)	1	0	0
Mexico	68 (4.2)	68	0	0
Netherlands	13 (0.8)	13	0	0
United States	738 (45.8)	736	2	0
United States, Mexico	2 (0.1)	2	0	0
Unknown ^c (imported)	3 (0.2)	3	0	0
Total (%)	1613 (100.0)	1608 (99.7)	5 (0.3)	0 (0.0)

What the survey results mean

A previous study¹⁰ conducted by the CFIA on the microbial quality and safety of fresh leafy vegetables has shown results approximating those in this study, however the previous survey did not include non-O157 STEC testing. The results of the CFIA baseline survey (2009 to 2013) indicated a very low prevalence of STEC O157:H7 (0%, 0 in 11392 samples) and *Salmonella* spp. (0.02%, 2 in 11400 sample) in fresh leafy vegetables¹⁰. The current CFIA enhanced

^c Country of origin could not be assigned from the product label or available sample information.

oversight survey (2020 to 2025) also shows a low prevalence of STEC O157:H7 (0%, 0 in 1609 samples) and *Salmonella* spp. (0%, 0 in 1451 samples) as neither pathogen was detected in any of the whole leafy vegetable samples. This current study however included testing for non-O157 STEC which is an emerging food safety hazard in fresh leafy vegetables. Non-O157 STEC was identified in 0.2% (3 in 1609 samples) of the leafy vegetable samples. As part of CFIA follow-up activities, the non-O157 STEC identified in this study were characterized using whole genome sequencing and based on their virulence genes were determined to belong to the lowest risk level according to the FAO/WHO risk categories⁵ and may be related to diarrheal illnesses.

Overall, our survey results indicate that fresh leafy vegetables sold in Canada are generally safe for consumption, however contamination with bacterial pathogens can occur. As with all foods, and especially those that are RTE, good hygienic practices are recommended for producers, importers, retailers and consumers.

What is done with the survey results

All results are used to:

- inform risk management decisions
- support program design and re-design

No illnesses have been reported related to the non-O157 STEC positive samples. Appropriate follow-up activities were conducted including:

- food safety investigations
- follow-up with the importers regarding the product origin and distribution

Where to access the survey data

The data will be accessible on the [Open Government Portal](#).

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