



Canadian Food
Inspection Agency

Agence canadienne
d'inspection des aliments

Bacterial Pathogens and Indicators in Ground Pork, Beef, Veal, and Lamb - November 1, 2014, to March 31, 2021

Food microbiology - Targeted surveys - Final report



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Summary

Targeted surveys¹ analyzed 3276 samples of raw ground meats (pork, beef, veal, and lamb) over a 6.5-year period from November 1, 2014, to March 31, 2021. Samples were tested for the presence of the pathogen Shiga toxin-producing *E. coli* (STEC) O157:H7. Some samples were also tested for non-O157 STEC, *Salmonella* spp., and generic *E. coli*. Generic *E. coli* is an indicator of the overall effectiveness of Good Manufacturing Practices and sanitary conditions of the food supply chain from production to the point of sale.

Most of the meat samples tested were found to be satisfactory. STEC O157:H7 was detected in 4 of the 3276 (0.1%) samples. Non-O157 STEC was detected in 158 of the 2977 (5.3%) samples. *Salmonella* spp. was detected in 6 of the 226 (2.7%) samples. Generic *E. coli* at levels >100 colony-forming units (CFU)/g were found in 58 of the 2388 (2.4%) samples. The Canadian Food Inspection Agency (CFIA) conducted appropriate follow-up activities and food recalls were issued by industry. There were no reported illnesses related to these products.

Overall, our survey results indicate that raw ground meats sold in Canada are generally safe for consumption, however they can occasionally be contaminated. Consequently, as with all foods, good hygienic practices are recommended for producers, retailers, and consumers. Additionally, ground meats must be fully cooked prior to consumption to prevent foodborne illnesses.

Why the survey was conducted

Foods of bovine origin, such as undercooked ground beef and veal have been the primary sources of foodborne STEC outbreaks². Foods of non-bovine animal origin, such as pork and lamb have also been associated with sporadic foodborne STEC outbreaks^{3,4}.

Ground beef and veal produced in Canadian meat processing facilities undergo routine regulatory sampling and testing for STEC O157:H7 as part of the CFIA's National Microbiological Monitoring Program⁵. Non-O157 STEC have emerged in recent years as important foodborne pathogens and with the development of non-O157 STEC isolation methodologies and whole genome sequencing capabilities in the CFIA laboratories⁶, multi-year surveys for STEC O157:H7 and non-O157 STEC in retail ground meats of pork, beef, veal, and lamb were conducted to generate baseline information.

When the survey was conducted

The surveys were conducted over a 6.5-year period from November 1, 2014, to March 31, 2021.

- Ground pork: November 1, 2014, to March 31, 2016
- Ground beef: April 1, 2016, to March 31, 2017
- Ground veal: April 1, 2017, to March 31, 2021
- Ground lamb: April 1, 2018, to March 31, 2021

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
- St. John or Moncton
- Quebec City
- Montreal
- Ottawa
- Toronto
- Winnipeg
- Saskatoon
- Calgary
- Vancouver
- Kelowna or Victoria

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 3276 pre-packaged refrigerated or frozen ground pork (879 samples), beef (589 samples), veal (1240 samples), and lamb (568 samples) samples were collected. A sample consisted of a single or multiple consumer sized packages of the same lot weighing at least 250g.

What the samples were tested for

The ground meat samples (pork, beef, veal, and lamb) were tested for the presence of the pathogen STEC O157:H7. Some samples were also tested for non-O157 STEC, *Salmonella* spp., and generic *E. coli*. Generic *E. coli* is an indicator of the overall effectiveness of Good Manufacturing Practices and sanitary conditions of the food supply chain from production to the point of sale (table1).

Table 1 - Bacterial analyses by ground meat type

Meat type	Fiscal year	Bacteria	Number of samples tested
Ground pork	2014-2015	STEC O157:H7	299
Ground pork	2015-2016	STEC (O157:H7 and non-O157), generic <i>E. coli</i>	580
Ground beef	2016-2017	STEC (O157:H7 and non-O157)	589
Ground veal	2017-2018 2018-2019 2019-2020 2020-2021	STEC (O157:H7 and non-O157), generic <i>E. coli</i>	1132
Ground veal	2018-2019	STEC (O157:H7 and non-O157), generic <i>E. coli</i> , <i>Salmonella</i> spp.	108
Ground lamb	2018-2019 2020-2021	STEC (O157:H7 and non-O157), generic <i>E. coli</i>	450
Ground lamb	2019-2020	STEC (O157:H7 and non-O157), generic <i>E. coli</i> , <i>Salmonella</i> spp.	118

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 appropriate for the testing of ground meats.

How the samples were assessed

The samples were assessed using criteria based on the principles of Health Canada's *Guidance document for E. coli O157:H7 and E. coli O157:NM in raw beef*⁸, and the *Food and Drugs Act*⁹ (Section 4(1)). See table 2.

Table 2 - Assessment criteria

Bacteria	Satisfactory	Investigative	Unsatisfactory
STEC O157:H7	Not detected/65 g	Not applicable	Detected/65 g
Non-O157 STEC	Not detected/65 g	Detected/65 g	Not applicable
<i>Salmonella</i> spp.	Not detected/65 g	Detected/65 g	Not applicable
Generic <i>E. coli</i>	≤ 10 ² CFU/g	> 10 ² CFU/g	Not applicable

Health Canada's guidelines for STEC O157:H7 and generic *E. coli* in ground beef and veal⁸ do not allow for the presence of STEC O157:H7 and consider the generic *E. coli* at levels ≤ 100 CFU/g to be an indicator of effective Good Manufacturing Practices. These criteria were also applied to ground pork and lamb (table 2).

At the time of writing this report, no assessment guidelines had been established in Canada for the presence of non-O157 STEC or *Salmonella* spp. in ground beef, veal, pork, and lamb. The detection of non-O157 STEC or *Salmonella* spp. was assessed as investigative, indicating that further follow-up actions may be warranted.

Survey results

Over 95% of the raw meat samples were found to be satisfactory for STEC (STEC O157:H7 and non-O157 STEC) (table 3). STEC O157:H7 was detected in 0.1% (4/3276) of the samples. Non-O157 STEC was detected in 5.3% (158/2977) of the samples.

Table 3 - Assessment results for STEC O157:H7 and non-O157 STEC

Meat types	Number of samples tested	Satisfactory (%)	Investigative (%) (non-O157 STEC)	Unsatisfactory (%) (STEC O157:H7)
Ground pork	879	865 (98.4)	13 (2.2) ^a	1 (0.1)
Ground beef	589	582 (98.8)	7 (1.2)	0 (0.0)
Ground veal	1240	1182 (95.3)	55 (4.4)	3 (0.2)
Ground lamb	568	485 (85.4)	83 (14.6)	0 (0.0)
Total	3276	3114 (95.1)	158 (5.3)^b	4 (0.1)

On average, 97.6% of the ground pork, veal, and lamb samples were found to be satisfactory for generic *E. coli* levels (*i.e.* generic *E. coli* ≤ 10² CFU/g) (table 4). Generic *E. coli* levels greater than 10² CFU/g were reported in 2.4% of the samples.

^a 580 of 879 ground pork samples tested for non-O157 STEC

^b 2977 of 3276 ground pork, beef, veal, and lamb samples tested for non-O157 STEC

Table 4 - Assessment results for generic *E. coli*

Meat types	Number of samples tested	Satisfactory (%)	Investigative (%)
Ground pork	580	557 (96.0)	23 (4.0)
Ground veal	1240	1207 (97.3)	33 (2.7)
Ground lamb	568	566 (99.6)	2 (0.4)
Total	2388	2330 (97.6)	58 (2.4)

Salmonella spp. was detected in 5.6% (6/108) of the veal samples. *Salmonella* spp. was not detected in any of the lamb samples (0/118) (table 5).

Table 5 - Assessment results for *Salmonella* spp.

Meat types	Number of samples tested	Satisfactory (%)	Investigative (%)
Ground veal	108	102 (94.4)	6 (5.6)
Ground lamb	118	118 (100.0)	0 (0)
Total	226	220 (97.3)	6 (2.7)

Survey results for STEC are also presented by the country of origin for each meat type (tables 6-9).

Table 6 - Assessment results for STEC in ground pork by country of origin

Country of origin	Number of samples (%)	Satisfactory	Investigative (non-O157 STEC)	Unsatisfactory (STEC O157:H7)
Canada	638 (72.6)	627	11	0
Unknown ^c	241 (27.4)	238	2	1
Total	879 (100)	865	13	1

Table 7 - Assessment results for STEC in ground beef by country of origin

Country of origin	Number of samples tested (%)	Satisfactory	Investigative (non-O157 STEC)	Unsatisfactory (STEC O157:H7)
Canada	238 (40.4)	235	3	0
Australia	2 (0.3)	2	0	0
USA	2 (0.3)	2	0	0
Unknown ^c	181 (30.7)	179	2	0
Unknown ^c (processed in Canada)	166 (28.2)	164	2	0
Total	589 (100)	582	7	0

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

Table 8 - Assessment results for STEC in ground veal by country of origin

Country of origin	Number of samples tested (%)	Satisfactory	Investigative (non-O157 STEC)	Unsatisfactory (STEC O157:H7)
Canada	507 (40.9)	478	26	3
New Zealand	2 (0.2)	2	0	0
USA	1 (0.1)	1	0	0
Unknown ^c	571 (46.0)	545	26	0
Unknown ^c (processed in Canada)	159 (12.8)	156	3	0
Total	1240 (100)	1182	55	3

Table 9 - Assessment results for STEC in ground lamb by country of origin

Country of origin	Number of samples tested (%)	Satisfactory	Investigative (non-O157 STEC)	Unsatisfactory (STEC O157:H7)
Canada	106 (18.7)	85	21	0
Australia	165 (29.0)	137	28	0
New Zealand	221 (38.9)	202	19	0
USA	3 (0.5)	3	0	0
Unknown ^c	67 (11.8)	52	15	0
Unknown ^c (processed in Canada)	6 (1.1)	6	0	0
Total	568 (100)	485	83	0

What the survey results mean

The prevalence of STEC O157:H7 in Canadian retail raw ground meats as found in this study is considered low and approximates the prevalence of STEC O157:H7 in ground beef from US (0.1%, 17/22845, 2016-2017)¹⁰ and Canadian (0.2%, 4/2505, 2016-2020)⁵ processing facilities, and US retail (0.2%, 2/1142, 2016-2017)¹⁰ around the same period of time.

The prevalence and virulence potential of non-O157 STEC in Canadian retail raw ground pork, beef, veal, and lamb have been described previously^{11,12}.

The prevalence of *Salmonella* spp. was reported to be 4.2% (172/4136) in ground beef¹³, and 3.4% (46/1368) and 1.8% (5/274) in beef and veal pre-chill carcasses, respectively¹⁴ from US meat processing facilities. The presence of *Salmonella* spp. in veal has been found to be associated with the contamination of young calves and the processing of veal¹⁵. The results of the current study indicate that the contamination of ground veal with *Salmonella* spp. can occur and the differing prevalence rates between studies may be attributable to differences in the origin of the products tested, the product types tested, processing procedures, or study design.

Most (97.6%) of the ground pork, veal, and lamb samples were found to be of satisfactory quality (generic *E. coli* $\leq 10^2$ CFU/g) suggesting these ground meat samples were processed under adequate Good Manufacturing Practices and sanitary conditions.

Overall, our survey results indicate that ground meats sold in Canada are generally safe for consumption, however they can occasionally be contaminated. Consequently, as with all foods, good hygienic practices are recommended for producers, retailers and consumers. Additionally, raw ground meats must be stored and handled properly and cooked to a safe internal temperature of 71°C (160°F)¹⁶ prior to consumption to prevent foodborne illnesses.

What is done with the survey results

All results are used to:

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

While no illnesses were related to the investigative and unsatisfactory samples, these results triggered appropriate follow-up actions including:

- facility inspections
- additional sampling and testing
- food recalls

Where to access the survey data

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

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