



Canadian Food
Inspection Agency

Agence canadienne
d'inspection des aliments

Bacterial Pathogens and Indicators in Ready-to-eat Non-Soy Plant-based Meat Alternatives - April 1, 2020 to March 31, 2023

Food microbiology - Targeted surveys - Final report



Summary

A 3-year targeted survey¹ analysed 1026 samples of ready-to-eat (RTE) non-soy plant-based meat alternatives for the presence of the pathogens *Salmonella* species (spp.), *Listeria monocytogenes* (*L. monocytogenes*), and *Staphylococcus aureus* (*S. aureus*). All samples were also tested for generic *Escherichia coli* (*E. coli*) which is an indicator of the overall hygienic and sanitary conditions of the food supply chain from production to the point of sale.

All of the samples tested were found to be satisfactory. *Salmonella* spp., *L. monocytogenes*, *S. aureus* (>10⁴ CFU/g), and generic *E. coli* (>10² CFU/g) were not found in any of the samples.

Overall, our survey results indicate that RTE non-soy plant-based meat alternatives sold in Canada are generally safe for consumption. However, as with all foods, and especially with those that are RTE, good hygienic practices are recommended for producers, retailers, and consumers.

Why was this survey conducted

The survey was conducted to generate baseline information on the quality and safety of RTE non-soy plant-based meat alternatives sold at retail in Canada. A similar survey was conducted from 2013 to 2014 and 2015 to 2016² which included RTE plant-based meat alternatives, however all of the samples were soy-based while those tested in this survey were derived from other plant-based sources such as peas, beans, grains, and vegetables.

The consumption of plant-based meat alternatives has a long history in many parts of Asia³. However, in recent years they have grown in popularity and a wide variety of products is now available on the Canadian retail marketplace⁴. Unfortunately, plant-based meat alternatives have been associated with recalls^{5,6}, and foodborne illness outbreaks^{7,8,9}.

Contamination with bacterial pathogens can occur at any step in the food supply chain such as during production, processing, packaging, distribution, at retail, and/or during preparation for consumption. Consequently, if pathogens are present, there is a potential for foodborne illness.

When was the survey conducted

The survey was conducted over a 3-year period from April 1, 2020 to March 31, 2023.

Where were the samples 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.

How many and what kind of samples were collected

A total of 1026 refrigerated plant-based meat alternative samples were collected. Soy-based products were excluded from this survey and sampling was focused on plant-based burgers, patties, and sausages. All products collected under this survey were labelled as being fully cooked or RTE. A sample consisted of a single or multiple consumer sized packages of the same lot weighing at least 250g.

What were the samples tested for

All samples were tested for *Salmonella* spp., *L. monocytogenes*, *S. aureus*, and generic *E. coli*. *Salmonella* spp., *L. monocytogenes*, and *S. aureus* are pathogenic bacteria while generic *E. coli* is an indicator of the overall hygienic and sanitary conditions under which the samples have been produced, processed, stored, and transported.

What methods were 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*¹⁰ that were appropriate for the testing of plant-based meat alternatives.

How were the samples 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 Food - An Interpretive Summary*¹¹, *Policy on Listeria monocytogenes in Ready-to-Eat Foods*¹², the *Food and Drugs Act*¹³ (Section 4(1)), and guidelines developed by international food safety authorities^{14,15}.

Table 1 - Assessment criteria

Bacteria	Satisfactory	Investigative	Unsatisfactory
<i>Salmonella</i> spp.	Not detected	Not applicable	Detected
<i>L. monocytogenes</i>	Not detected	Not applicable (category 1 ^a) Detected and $\leq 10^2$ CFU/g (category 2 ^a)	Detected (category 1 ^a) > 10^2 CFU/g (category 2 ^a)
<i>S. aureus</i>	$\leq 10^4$ CFU/g	> 10^4 CFU/g	Not applicable
Generic <i>E. coli</i>	$\leq 10^2$ CFU/g	> 10^2 and $\leq 10^3$ CFU/g	> 10^3 CFU/g

^a The pH and water activity of the sample were used to determine the product category

No assessment guidelines had been established in Canada for the presence of *Salmonella* spp., *S. aureus* or indicator organisms in plant-based meat alternatives at the time of writing this report.

As *Salmonella* spp. is considered pathogenic to humans, its presence was assessed as unsatisfactory as it is considered to be a violation of the *Food and Drugs Act*¹³ Section 4(1)a.

S. aureus can produce toxins capable of causing foodborne illness and therefore their presence at elevated levels was assessed as investigative, possibly resulting in further follow-up actions.

Unlike bacterial pathogens, most strains of generic *E. coli* are harmless. Generic *E. coli* is considered to be an indicator organism as their levels present in a food product are used to assess the overall sanitation conditions throughout the food chain from production to the point of sale. Their presence at some levels is tolerated, however elevated levels were assessed as investigative, possibly resulting in follow-up actions. High levels of generic *E. coli* were assessed as unsatisfactory as it may indicate a breakdown in sanitation controls, and therefore warranting follow-up actions.

What were the survey results

All of the samples tested were found to be satisfactory. *Salmonella* spp., *L. monocytogenes*, *S. aureus* (> 10⁴ CFU/g), and generic *E. coli* (>10² CFU/g) were not found in any of the samples.

Table 2 - Assessment results

Bacterial analysis	Number of samples tested	Satisfactory (%)	Investigative	Unsatisfactory
<i>Salmonella</i> spp.	1026	1026	Not applicable	0
<i>L. monocytogenes</i>			0	0
<i>S. aureus</i>			0	Not applicable
Generic <i>E. coli</i>			0	0
Total	1026	1026 (100)	0	0

Survey results are also presented by the product's format (table 3), production practice (table 4), country of origin (table 5), and main ingredient(s) (table 6).

Table 3 - Assessment results by non-soy plant-based meat alternative product types

Product type	Number of samples tested (%)	Satisfactory
RTE plant-based bites	182 (17.7)	182
RTE plant-based burgers	262 (25.5)	262
RTE plant-based ground/crumble	2 (0.2)	2
RTE plant-based patties	166 (16.2)	166
RTE plant-based sausages	414 (40.4)	414
Total	1026	1026

Table 4 - Assessment results by production practice

Production practice	Number of samples tested (%)	Satisfactory
Conventional	1023 (99.7)	1023
Organic	3 (0.3)	3
Total	1026	1026

Table 5 - Assessment results by country of origin

Product origin	Number of samples tested (%)	Satisfactory
Canada	436 (42.5)	436
United States	282 (27.5)	282
Unknown ^b	2 (0.2)	2
Unknown ^b (processed in Canada)	357 (34.8)	357
Total	1026	1026

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

Table 6 - Assessment results by product's main^c ingredient

Product's main ^c ingredient	Number of samples tested (%)	Satisfactory
Beets	49 (4.8)	49
Black beans	10 (1.0)	10
Broccoli	3 (0.3)	3
Carrots	6 (0.6)	6
Cauliflower	1 (0.1)	1
Chickpeas	5 (0.5)	5
Corn	41 (4.0)	41
Green beans	62 (6.0)	62
Kale	2 (0.2)	2
Lentils	6 (0.6)	6
Millet	1 (0.1)	1
Mushroom	2 (0.2)	2
Pea protein	92 (9.0)	92
Potato	101 (9.8)	101
Rice	1 (0.1)	1
Seitan (Water and gluten)	386 (37.6)	386
Yam	3 (0.3)	3
Yellow split peas	255 (24.9)	255
Total	1026	1026

^c First ingredient in the list of ingredients found on the product label.

What do the survey results mean

No previously published studies on the microbiological quality or safety of RTE non-soy plant-based meat alternatives were found at the time of writing this report. An earlier targeted survey² was conducted on the microbiological quality and safety of RTE soy-based products which included RTE soy-based meat alternatives. In both the current and previous² studies, all samples tested were found to be of satisfactory microbiological quality and safety.

Overall, our survey results indicate that RTE non-soy plant-based meat alternatives sold in Canada are generally safe for consumption. However, as with all foods, and especially with those that are RTE, good hygienic practices are recommended for producers, 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

Can I access the survey data

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

References

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10. Health Canada, [Compendium of Analytical Methods](#). 2011.
11. Health Canada, [Health Products and Food Branch \(HPFB\) Standards and Guidelines for Microbiological Safety of Food - An Interpretive Summary](#). 2008.
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