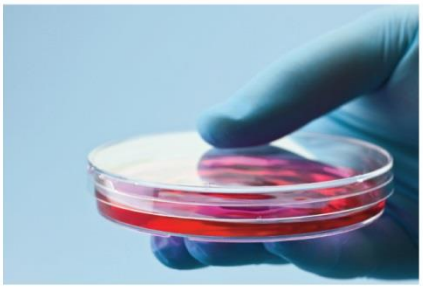
Canadian Food Inspection Agency | Agence canadienne d'inspection des aliments

Annual Report

2013/14

National Microbiological Monitoring Program



Foods of Plant and Animal Origin

RDIMS #5690002

Canada

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Acronyms and Abbreviations

ACC	Aerobic Colony Count
BSE	Bovine Spongiform Encephalopathy
CFIA	Canadian Food Inspection Agency
CFU	Colony Forming Unit
CNS	Central Nervous System
DNA	Deoxyribonucleic Acid
E. coli	*Escherichia coli*
FAO	Food and Agriculture Organization of the United Nations
FDA	Food and Drug Administration
FDR	Food and Drug Regulations
HC	Health Canada
ICMSF	International Commission on Microbiological Specifications for Foods
L. monocytogenes	*Listeria monocytogenes*
MPN	Most Probable Number
NMMP	National Microbiological Monitoring Program
PFGE	Pulsed-Field Gel Electrophoresis
PHAC	Public Health Agency of Canada
RTE	Ready-To-Eat
S. aureus	*Staphylococcus aureus*
spp.	Species
T. spiralis	*Trichinella spiralis*
vCJD	Variant Creutzfeld-Jakob Disease
VTEC	Verotoxigenic *Escherichia coli*
WHO	World Health Organization

Glossary of Terms

Acidified low-acid food means a naturally low-acid food which has been treated in a manner so that all components attain an equilibrium pH of 4.6 or below by the time thermal processing and cooling is completed.

Colony-forming unit (CFU) is defined as a single colony (group of bacterial cells) on an agar plate that in theory arises from a single bacterial cell.

Finely textured beef refers to an edible beef product obtained by removing most of the bone and cartilage from a comminuted beef product from which the bone and cartilage had not been previously removed. These products do not contain more than 0.15% of calcium or any bone particles larger than 1.5 mm in size, with a maximum of 20% of the bone particles larger than 1 mm in size.

Heat treatment is the application of heat. In the food industry the two most commonly used methods of heat treatment for killing food microbes are pasteurization and sterilization.

Mechanically separated beef means an edible beef product that does not contain more than 0.027% of calcium for every one per cent of protein in the product or any bone particles larger than 2 mm in size and that was obtained by removing most of the bone and cartilage from a comminuted beef product from which the bone and cartilage had not been previously removed, as per the *Meat Inspection Regulations*, 1990.

Most probable number (MPN) is a statistical method for estimating small populations of bacteria.

Pasteurization is a heat treatment intended to kill non-spore-forming pathogens and spoilage organisms.

Processed refers to food that has been subjected to a process intended to assure preservation of that food over a period of time. Examples include canned, cooked, frozen, dehydrated, concentrated, pickled or otherwise prepared food.

Raw refers to food that is uncooked or partially-cooked. Raw food may require further processing prior to consumption, for example heat treatment of ground beef.

Ready-to-eat (RTE) fresh-cut produce is defined as fresh fruits or vegetables that have been washed and minimally processed, such as peeled, cored, sliced, chopped and/or shredded, prior to packaging.

Ready-to-eat (RTE) meat is a meat product that has been subjected to a lethality process sufficient to inactivate pathogens and/or their toxins or spores. These types of products do not require further preparation or cooking prior to consumption. Products may need to be washed, thawed or exposed to sufficient heat to warm the product without cooking it.

Serotype refers to a distinctive type of organism, referred to as subspecies, within a specific species of bacteria or virus.

Sterilization is a heat treatment process intended to destroy all living microorganisms.

Trims are pieces of meat, fat and other tissues removed from carcasses during the process of deboning and making specific cuts of meat (i.e. steaks, ribs).

Water activity (a_w) is the amount of water freely available for metabolic activities supporting bio-chemical reactions and microbial growth. This water is not bound to tissues or components.

Executive Summary

The Government of Canada verifies that food produced and/or sold in Canada is safe and meets federal food safety standards. This provides Canadians with confidence in the foods they buy. The Canadian Food Inspection Agency (CFIA) monitors and regulates food products that are produced domestically and moved inter-provincially, or are imported. Within Canada, all food products must comply with the *Food and Drugs Act* and *Regulations*, which set out criteria for safe food and clearly prescribe restrictions on the production, importation, sale, composition and content of food.

The National Microbiological Monitoring Program (NMMP) is one of many tools utilized by the CFIA to meet its objectives. Its monitoring activities focus on specific foods and their related hazards that are most likely to impair the health and safety of Canadians, and are designed to sample and test a broad range of imported and domestic commodities for microbial hazards of concern. The testing carried out under the NMMP covers red meat and poultry products, shell eggs and egg products, dairy products, fresh fruits and vegetables and processed fruit and vegetable products, as well as environmental testing within the manufacturing environments.

It is generally accepted that, when foods are prepared by the consumers, proper precautions are taken in the home to destroy any bacteria that may be present. However, there are ready-to-eat foods that are not further processed by the consumer as well as raw foods that, if not properly cooked, can lead to illness. Most testing under the NMMP is done on these types of foods as the risk of foodborne illness from them is anticipated to be greater.

The results of the 2013/14 NMMP sampling activities demonstrate that the majority of food products available in the Canadian marketplace were safe and compliant with national standards.

During the 2013/14 fiscal year, the overall compliance rate for combined domestic and imported products was 99.3% where domestic products were 99.6% compliant and imported products were 98.4% compliant. These compliance rates were calculated from 13801 tests performed on 5510 domestic and imported products. Specifically, 8982 tests were performed on 3991 domestic products and 4819 tests were performed on 1519 imported products.

Environmental sampling is performed in domestic establishments to verify the operator systems' ability to control the presence of pathogens within the processing environment. The sampling helps the food producer and the CFIA to identify microbial hazards in the

processing environment allowing the food producer to intervene prior to possible product contamination. The results of sampling are also used to verify that food products are produced under sanitary conditions. The food production environment includes not only the surfaces that come into direct contact with the food, such as tools and water that is recirculated during processing but also areas of the production environment that do not come in direct contact with the food like drains and air ducts. Contaminants in these non-food contact areas may be carried to food contact surfaces by various vectors such as humans, dust and water droplets. Thus, in addition to testing food products, wash water samples and surface swabs are taken within the food production environment to monitor the use of sanitary practices. During 2013/14, there were 1986 tests performed on 1895 environmental samples which were assessed as 97.6% compliant.

1. General Introduction

The Canadian Food Inspection Agency (CFIA) is Canada's federal food safety, animal health and plant protection enforcement agency. It is responsible for the administration and enforcement of 13 Acts, including the *Food and Drugs Act*, the *Canada Agricultural Products Act* and the *Meat Inspection Act*. The CFIA delivers 14 inspection programs related to foods, plants and animals across Canada. One of the Agency's roles is to ensure the safety of the Canadian food supply by enforcing standards established by Health Canada. This is achieved through a series of activities that range from the inspection of federally-registered establishments to border inspections, laboratory testing and the carrying out of food safety investigations, risk assessments and recalls on unsatisfactory results.

The Government of Canada oversees the implementation and administration of various measures pertaining to food safety to ensure Canadians have confidence in the quality and safety of the foods they eat. Within Canada, all food products must comply with the *Food and Drugs Act* and *Regulations* that specify the safety of food and prescribe certain restrictions on the production, importation, sale, composition and content of foods and food products. There are three main parties involved in the quality and food safety continuum: the consumer, the industry and the regulatory bodies (CFIA, Health Canada, provincial/territorial governments and municipal authorities).

While the regulatory bodies oversee the development, monitoring and enforcement of food safety regulations, it is the industry that is responsible for implementing systems and practices to ensure the production of safe food. It is the consumer's responsibility for preparing food safely in their home, and this area of food safety lies outside of the CFIA's jurisdiction. There are several ways in which consumers can contribute to the safety of their food. Consumers should ensure that foods are stored and maintained under proper conditions to minimize bacterial growth. Consumers should take steps to prevent cross-contamination between raw and ready-to-eat (RTE) foods while shopping at the grocery store, during transport, meal preparation and storage. Raw foods, such as ground red meat and poultry products, must be cooked sufficiently to ensure that an adequate core temperature is reached in order to kill any pathogens present. More information on safe food handling practices and the prevention of foodborne illnesses can be found on Health Canada's Food and Nutrition for Healthy Canadians website: http://www.healthycanadians.gc.ca/eating-nutrition/index-eng.php.

To ensure all food-related issues are addressed, Canadian food safety standards are supplemented by international standards. In addition to criteria and guidance material generated by the Government of Canada, both the CFIA and Health Canada actively

participate in the Codex Alimentarius Commission that establishes standards, guidelines and codes of practice for the production of safe foods internationally. Under the Codex Alimentarius Commission food is defined as any substance, whether processed, semi-processed or raw intended for human consumption (CAC, 2013). The primary purpose of these standards is to protect the health of consumers, ensure fair trade practices and promote global implementation of food safety standards and codes of practice. Producers are encouraged to follow the international codes of practice developed by the Codex Alimentarius Commission that provide guidance for the safe production of food. The codes address Good Agricultural Practices, Good Manufacturing Practices and Hazard Analysis Critical Control Point programs to control and reduce the potential for contamination with microbial, chemical and physical hazards at all stages of production. They outline basic requirements pertaining to environmental hygiene, hygienic production (including the quality and/or use of water, the use of manure, soil biological control, packing, facility sanitation and personal hygiene), handling, storage and transportation.

During 2013/14, the Agency carried out a variety of microbiological sampling activities such as (i) monitoring by random sampling of the food supply to verify compliance, (ii) risk-based sampling through enhanced sampling of specific food/hazard combinations that are of greater concern to human health and (iii) directed sampling, which focuses on specific food/hazard combination contamination issues or concerns. These activities cover the sampling and testing of domestic and imported foods of both plant and animal origin for various microbial hazards of concern. Results are assessed for compliance and follow-up and enforcement actions are taken when necessary.

This report summarizes the sampling and testing activities performed in the area of microbial hazards in food under the National Microbiological Monitoring Program (NMMP). The purpose of this document is to report on the results obtained through the monitoring activities (which includes risk-based sampling) of the CFIA's NMMP, and does not include the analytical results from directed sampling activities, follow-up activities or food safety investigations.

2. Responsibilities of the CFIA

The CFIA is responsible for the administration and enforcement of 13 Acts and numerous sets of Regulations. The CFIA carries out its responsibilities through the implementation of a variety of compliance verification activities, including inspections, audits, monitoring, grading, sampling, testing and reporting. Inspections of domestic facilities and imported foods are performed regularly. These inspection activities can include the sampling and submission of food for microbial analysis to verify that products were produced in compliance with all relevant Acts and Regulations. In cases of non-compliance, the Agency implements appropriate follow-up actions and risk management steps to protect the health of Canadians.

2.1. Legal Authority

Although there are multiple Acts enforced by the CFIA, the ones most relevant to the NMMP are the *CFIA Act* and the *Food and Drugs Act*. The *CFIA Act* defines the Agency and its responsibilities.

CFIA Act

11. (1) The Agency is responsible for the administration and enforcement of the *Agriculture and Agri-Food Administrative Monetary Penalties Act, Canada Agricultural Products Act, Feeds Act, Fertilizers Act, Fish Inspection Act, Health of Animals Act, Meat Inspection Act, Plant Breeders' Rights Act, Plant Protection Act* and *Seeds Act.*

11. (3) The Agency is responsible for
(*a*) the enforcement of the *Food and Drugs Act* as it relates to food, as defined in section 2 of that Act; and
(*b*) the administration of the provisions of the *Food and Drugs Act* as they relate to food, as defined in section 2 of that Act, except those provisions that relate to public health, safety or nutrition.

The *Food and Drugs Act* clearly prescribes certain restrictions on the production, sale, composition and content of foods and food products. Section 2 provides clear definitions of the various food safety components, such as "food", "unsanitary conditions" and "inspector", and Section 4(1) of the Act (below) describes prohibitions on the sale of food. From the standpoint of microbial hazards, the most important restrictions are those detailed in Sections 4.1 (a), (b), (c) and (e) and Section 7.

Food and Drugs Act

Prohibited sales of food

4. (1) No person shall sell an article of food that:

a) has in or on it any poisonous or harmful substance;

b) is unfit for human consumption;

c) consists in whole or in part of any filthy, putrid, disgusting, rotten, decomposed or diseased animal or vegetable substance;

d) is adulterated; or

e) was manufactured, prepared, preserved, packaged or stored under unsanitary conditions.

Unsanitary manufacture, etc., of food

7. No person shall manufacture, prepare, preserve, package or store for sale any food under unsanitary conditions.

2.2. *Enforcement Actions*

CFIA compliance and enforcement actions occur all along the supply chain and involve numerous stakeholders and jurisdictions. However, ultimately, it is the responsibility of the food producers and importers to ensure all foods intended to be sold in Canada for human consumption comply with all relevant Acts and Regulations. There are a variety of measures the CFIA can use to ensure a return to compliance, and determining which tool is most appropriate depends on several factors including where within the food continuum the non-compliance is detected as well as its degree of severity in terms of potential food safety to the consumer. Enforcement tools available include seizure and detention, confiscation, refusal of entry, recall and/or disposal or destruction of the product, a letter of non-compliance, suspension or cancellation of licence, administrative monetary penalties and/or prosecution.

For example foods deemed to pose a high risk to public health if contaminated, and with an extended shelf-life under proper storage conditions, may be subjected to a "hold and test" regimen. This means when samples from a particular lot are selected and submitted for analysis by the CFIA the manufacturer will retain control of all food produced within that same lot by placing it "on hold" in a storage facility until the analytical results are available. Depending on the situation, the use of a "hold and test" regimen may be voluntary or mandatory. Within the Canadian meat industry, producers of ready-to-eat meat products voluntarily put their lots on "hold and test" as a measure of control over food safety. Alternatively, domestic establishments or importers with recent non-compliance issues may be required by the CFIA to implement a mandatory "hold and test" regimen on all of their products until they can demonstrate a sustained return to compliance. If no pathogens are detected then the lot is released to market, but if

pathogens are detected the product cannot be released unless it can be rendered safe for consumption. For some products this means the product must be destroyed, subjected to a sufficient heat treatment, or diverted for further processing. Using this approach is beneficial in that it ensures only lots of food deemed to be safe for consumption by analytical testing are released to market.

Unfortunately the "hold and test" approach is not always feasible. For example, because fresh fruits and vegetables are not manufactured or processed, and often not grown in Canada, CFIA sampling and testing activities can only occur at the distribution warehouses. Many of these commodities, especially fresh berries, have a very short shelf-life and as such would expire while waiting for test results. Therefore these products are released to market in the absence of analytical results.

Regardless of whether or not the product is subjected to a voluntary "hold and test" approach, when microbial contaminants are detected in food products, a food safety investigation is performed to determine if a violation has occurred and if a risk to human health is present. This may include consultation with Health Canada to determine whether or not the product poses a potential health risk to consumers or sensitive segments of the population (e.g. elderly, immuno-compromised, children, pregnant women).

3. Sampling Plans: Definitions and Terminology

Sampling plans include protocols that detail various components required to define the activities involved in sampling and testing for microbial contaminants. The intent is to obtain a sample that is representative of the commodity being produced. Sampling and testing to assess the compliance of each lot produced is the responsibility of industry, while sampling and testing to assess the compliance of the food safety systems for specific commodities is the responsibility of the CFIA. To accurately assess the microbial quality of the sample, contamination must be prevented and the integrity of the sample must be maintained throughout the sampling and analytical process.

3.1. Types of Sampling Activities

Food sampling and testing are part of the CFIA's daily activities and the majority of samples under the NMMP are tested for multiple organisms. The CFIA's microbiological food testing activities summarized in this report involved two types of sampling to verify industry compliance with food safety standards and guidelines. The most widely used type of sampling implemented by the NMMP during 2013/14 was monitoring sampling, which involves the unbiased and random selection of samples. The analysis of these samples is intended to provide information on the occurrence or level of contamination in a pre-defined type of food, such as processed egg products. Under the NMMP all sampling activities for shell eggs and egg products, dairy products, fresh fruits and vegetables, and processed fruits and vegetables were monitoring sampling. In addition, the bulk of the sampling performed for red meat and poultry products was also monitoring sampling.

To a limited extent, the NMMP also used a sub-type of monitoring sampling referred to as risk-based sampling for the sampling and testing of various types of domestically produced meat products (Appendix A). This is an enhanced monitoring activity designed to provide information on the occurrence or level of contamination in a targeted sample population. This type of sampling is used to monitor areas known to pose a higher risk and sampling is designed using predetermined factors known to contribute to the potential level of risk to the consumer. In 2013/14 all domestic federally registered meat establishments producing precursor materials intended for grinding were subjected to risk-based sampling, and those producing RTE meat products were subjected to product and environmental risk-based sampling.

When monitoring or risk-based programs identify the presence of a risk, an effective control strategy is to use directed or compliance activities to assess the extent and depth of the issue. Directed sampling involves the biased selection of samples and is directed at the product or type of product where a hazard has been found. It is used to investigate any

suspected food safety issues that could pose a potential health risk. This type of sampling may be triggered by consumer complaints, visual inspections of operators or unsatisfactory findings within any of the other types of sampling programs, including industry implemented sampling. Compliance sampling encompasses in-depth sampling directed at specific samples suspected of not being in conformance with specific food safety regulations and guidelines. The product is usually detained until the test results are available.

Data obtained as a result of any of these sampling activities may be used to support the development of risk mitigation activities, which can include public notices, recalls, plant closures or a hold-and-test strategy. When monitoring activities indicate that a contaminant in a given food commodity presents a potential risk, sampling plans may be adjusted, but only to the point that such effort will aid in the understanding of the problem or facilitate regulatory control. Increased sampling from a monitoring perspective permits the study of trends, geographical variation and seasonal prevalence over time, thereby aiding in the design of effective control strategies. However, merely increasing the number of samples taken without a strategy that addresses the benefits is of little value.

The different scopes of sampling performed in Canada are comparable to what is implemented internationally, including in the United States, which is Canada's major trading partner. The terminology used to describe the various sampling activities performed within Canada is in-line with the United States Department of Agriculture's Food Safety and Inspection Service and the Codex Alimentarius Commission.

3.2. Sampling Plan Design

There are two types of sampling plan designs commonly used for the microbial analysis of food: variable and attribute. It is the availability of data that determines what type of sampling plan is most appropriate (ICMSF 7, 2002). A variable sampling plan is used when the underlying distribution of the microorganism within a particular commodity is known, or can be easily determined based on existing data. It employs the use of multiple variables to determine the quality of the commodity on a graduated continuum ranging from 'very good' to 'very bad'. As Canadian manufacturers must continuously monitor and test their processes and products to ensure they maintain quality control and produce safe food, they have extensive proprietary databases of information from which to draw conclusions and utilize variable sampling plans. Since there is no legislative obligation for all industries to share this data with the CFIA on a routine basis, the CFIA does not use variable sampling plans. However, in certain situations this information may be shared with the CFIA as part of the program design.

Where little or no information is available regarding the occurrence and distribution of a microbial hazard within a food commodity, the use of an attribute sampling plan is more effective. Based on the tools and information utilized by the CFIA, attribute sampling plans effectively support the Agency's monitoring activities. In this type of sampling plan, each sample is representative of the microbial quality of the entire lot of product. Each sample is analyzed and assessed according to only two or three assessments of quality.

Attribute sampling plans can be further divided based on the number of categories against which the results are assessed. These are commonly referred to as 2- and 3-class sampling plans. A 2-class plan is one in which a qualitative analysis is performed to determine the presence or absence of the target microorganism. This type of sampling plan classifies the food lot as either acceptable or defective. Based on the analysis of the sample, the entire lot represented by the sample is assessed based on the presence (defective) or absence (acceptable) of the microorganism. A 2-class plan is suitable when there is zero tolerance towards the presence of a microorganism. Under the NMMP, it is used when testing for pathogens that can induce illness when only a few cells (e.g. 10-100) are ingested and their presence in food is not acceptable. For example, when *Salmonella* spp. is detected in a lunch meat sample, the entire associated lot is assessed as unsatisfactory (defective) and not fit for human consumption.

Alternatively, a 3-class attribute plan is one in which a quantitative analysis is performed to determine the level or concentration of the microorganism by quantifying the number of colony forming units (CFU) of the organism present (refer to section 5.4 for more information on CFU). This type of plan offers three attribute classes: acceptable, marginally acceptable and defective. The NMMP uses 3-class plans when the presence of some cells of the organism in question is accepted as is the case with *Listeria monocytogenes* for Category 2A (e.g. refrigerated fresh-cut vegetables) and 2B (e.g. frozen egg, frozen fruit or ice cream) products, according to Health Canada's Listeria Policy (Health Canada, 2008b, Health Canada, 2011). The use of 3-class plans is dependent on the specific food-hazard combination of concern. They may be used for the assessment of indicator organisms (those that do not cause illness) or some pathogens that are not considered to represent a health risk if present in low numbers. For example, within the NMMP this applies to the presence of indicator organisms such as generic *Escherichia coli* in a variety of different food commodities.

The CFIA cannot test all imported or domestically produced lots of food. As such, the Agency employs a randomized strategy to test representative subsamples of these foods. For the microbiological food testing activities summarized in this report, the CFIA implements 2-class and 3-class attribute sampling plans for multiple reasons: (i) it is

logistically impossible for CFIA to test all foods for all microbial hazards at all times, (ii) there are no extensive databases available for each food/hazard combination of interest, (iii) there is little or no information about the conditions under which imported foods are produced and (iv) these sampling activities are used as one of many tools to verify compliance by industry with food safety standards, therefore large numbers of samples are not required.

4. Food Safety Hazards of Concern

There are a variety of microbial hazards inherently present within agricultural environments, domestic herds and the products of animal and plant origin intended for human consumption. During the processes of slaughter or harvesting, microbes from the intestinal tract or growing field may be carried along with the intended food. Subsequently, cross contamination of food products may occur. Handling of these products by improperly trained workers may also be a source of contamination when employees do not practise effective hygienic procedures. As such, CFIA inspectors across Canada monitor domestic food processing establishments and imported foods for a variety of microbial food safety hazards and regulatory requirements.

The microorganisms identified for analysis are known to occur in particular food items and in the associated processing techniques used in the preparation of these food items. Some microorganisms are pathogenic and can cause illness when consumed. Microorganisms that do not cause illness and do not always imply the existence of a food-related health hazard are referred to as indicator organisms. The presence of indicator organisms can expose unsanitary practices and conditions under which pathogenic bacteria could contaminate food products. In addition to the presence of microbial hazards, there are other variables that may either be directly responsible for a food safety concern or used as indicators of food safety. These include the presence of central nervous system tissue and intrinsic factors such as pH and water activity. The following section provides descriptions of the types of analyses performed by the CFIA, highlighting and explaining the food safety issues of concern. The specific descriptions of the pathogens that the Agency tests for include a brief summary of the most common human symptoms associated with infection. The list of symptoms is not meant to be all-inclusive.

4.1. Bacterial and Parasitic Pathogens

Amongst all microorganisms present in food, only a relatively small number are deemed pathogenic (i.e. illness-causing). In addition to pathogenic bacteria, such as *Salmonella* spp., parasites may also be transmitted by food and cause illness. Depending on the pathogen's ability to inflict harm, the ingestion of a few viable cells may be

sufficient to develop an infection and trigger illness. The severity of infection can range from mild diarrhoea, upset stomach and flu-like symptoms to serious illness or death. In some cases it is not the presence of the pathogen itself that is of concern, but the presence of its metabolic toxins. Typically these organisms and their toxins produce mild to moderate reactions amongst the healthy population, and full recovery is reached over a short period of time. However, pathogens may continue to be shed through faeces for several weeks post-recovery. Some infected persons may show no signs or symptoms of illness, while more sensitive individuals within the population (e.g. elderly, immuno-compromised, children, pregnant women) may be at greater risk of experiencing more severe reactions and complications.

***Escherichia coli* O157:H7**

There are many sources of human infection with *Escherichia coli* O157:H7 including undercooked meat and poultry, fermented meat products, non-pasteurized milk and fruit juices, untreated water and the surfaces of leafy greens (Health Canada, 2014). Commonly found in the intestinal tracts of cattle and other ruminants (e.g. sheep), but rarely found in pigs and poultry, *E. coli* O157:H7 may be introduced to the outer surface of the meat and the processing facility during slaughter. Improperly cooked or raw ground beef is the most notable source of foodborne illness related to this organism. Contamination may also occur, although to a lesser extent, through contact with infected persons handling any food type along the production line. Foods of plant origin may also be contaminated through exposure to contaminated manure in the field. The ingestion of a low number of cells (10-100) of *E. coli* O157:H7 can lead to gastrointestinal illness, and in rare instances may result in haemolytic uremic syndrome or kidney disease, which can be fatal (FDA, 2012).

Verotoxigenic *Escherichia coli*

Verotoxigenic *E. coli* (VTEC), also referred to as Shiga-toxigenic *E. coli* (STEC), includes *E. coli* O157:H7 and other non-O157 serogroups, which currently include *E. coli* O26, O103, O111 and O145, that produce verotoxins. Testing is performed on certain commodities in which VTECs are potential pathogens of concern. It is the verotoxins that result in disease, and can induce illness locally or systemically throughout the body. VTECs can cause influenza-like symptoms that may progress to bloody diarrhoea, hemorrhagic colitis, acute and chronic kidney disease, thrombotic thrombocytopenic purpura (blood clotting), neurological sequelae (neurological damage) or death (FDA, 2012).

Listeria monocytogenes

There are more than six species of *Listeria*, of which only *L. monocytogenes* is pathogenic to humans. *L. monocytogenes* is widely distributed in nature, occurring in soil,

sewage, vegetation, stream water, silage, animals and humans (Health Canada, 2012b). *L. monocytogenes* is a hardy organism that is resistant to drying, freezing and high salt concentrations. However, *L. monocytogenes* can be destroyed by thoroughly cooking products. It can grow readily at refrigeration temperatures and in vacuum-packed meat products (Montville *et al*., 2012). As such, foods most commonly associated with outbreaks of listeriosis include deli meats, pâté, soft cheeses, smoked fish and shellfish. Although exposure to *L. monocytogenes* is common, the incidence of listeriosis in healthy adults is relatively rare. The highest incidence occurs amongst pregnant women, the elderly and immuno-compromised individuals. Among pregnant women, symptoms are typically mild. However the passage of the organism through the placenta may cause miscarriage, stillbirth or perinatal septicaemia (blood poisoning) and meningitis (inflammation around the brain) in the newborn baby (Health Canada, 2011). In healthy individuals, infection may result in short term mild gastrointestinal illness but amongst the susceptible population, *L. monocytogenes* can cause influenza-like symptoms and serious effects such as miscarriage, meningitis, septicaemia, or death (Health Canada, 2012b).

***Salmonella* spp.**

There are more than 2500 serotypes of *Salmonella*, of which only a subset cause human illness. Sources of human salmonellosis are foods of animal origin, particularly raw or undercooked meat and poultry, shell eggs and non-pasteurized egg and dairy products, as well as a variety of foods of plant origin, including spices, sprouts, sesame products and vegetables (Health Canada, 2012a). In extreme cases, human *Salmonella* infections can lead to typhoid fever and a condition known as Reiter's Syndrome, which causes chronic joint pain, irritation of the eyes and painful urination (FDA, 2012; Health Canada, 2012a). Highly pathogenic, resistant to cold temperatures and capable of surviving for long periods of time in adverse conditions, *Salmonella* is a food safety concern across all commodities. Contamination of red meat and poultry may occur during slaughter, while fresh produce may be contaminated in the field through the use of improperly composted manure.

***Staphylococcus aureus* and enterotoxins**

Humans are natural carriers of *Staphylococcus aureus*, with the nasal cavity being the main site for colonization. It can also be found in other warm blooded animals, most notably dairy cows. Hence, *S. aureus* is of concern in a variety of dairy products.
S. aureus-related illnesses are caused by metabolic toxins, referred to as enterotoxins, which cause irritation of the lining of the stomach and intestinal tract. The enterotoxins are fast-acting and symptoms may appear within one to seven hours of consuming contaminated food. Symptoms include nausea, vomiting, diarrhoea, dehydration, muscle cramps, changes in blood pressure and pulse rate and occasionally death (FDA, 2012).

The *S. aureus* enterotoxins are stable and cannot be deactivated by freezing, commercial pasteurization, heating, cooking, or high pressure canning processes (Pinchuk *et al.*, 2010; Montville *et al*., 2012).

***Shigella* spp.**

Higher primates and humans are the only known natural carriers of *Shigella* spp. It is easily transmitted through the faecal-oral route with most cases of infection resulting from the ingestion of faecal contaminated food or water. Contamination with *Shigella* spp. is primarily due to poor personal hygienic practices of food handlers, and can occur anywhere along the food continuum (Health Canada, 2012a). Foods most commonly associated with shigellosis outbreaks include leafy green vegetables, commercially prepared salads, dairy products and poultry (FDA, 2012). *Shigella* spp. are easily destroyed by cooking food properly, however leafy greens and salads are typically not cooked. The presence of only 100 cells can lead to widespread foodborne and waterborne outbreaks of shigellosis. Symptoms of *Shigella*-related illness includes diarrhoea, fever and stomach cramps. Illness may lead to serious complications such as reactive arthritis, haemolytic uremic syndrome, kidney failure or death (Mayo Clinic, 2012). *Shigella dysenteriae* produces toxins responsible for more serious bouts of diarrhoea (called dysentery), dehydration and sometimes death (FDA, 2012).

Trichinella spiralis

Trichinellosis, due to the parasitic roundworm *Trichinella spiralis*, is caused primarily through the ingestion of infected raw and undercooked pork. The worm can be destroyed by the use of appropriate processing techniques such as cooking, freezing or curing. Current advice to Canadian consumers is to ensure pork is cooked to a minimum internal temperature of 71ºC (Health Canada, 2010). Because of modern production methods of raising pigs in confinement and high quality feed, *T. spiralis* in Canadian domestic swine populations has become quite rare. However, *Trichinella* infection involving other species of the parasite is endemic in various wildlife hosts in Canada. As such, human infection in Canada is typically associated with the consumption of wild game, particularly walrus or bear (McIntyre *et al*., 2007). Nevertheless, precautions are warranted due to the potential for the introduction of *T. spiralis* into domestic swine herds.

Human infection from *T. spiralis* has severe effects on health. Symptoms include typical gastrointestinal and flu-like symptoms but of greater concern is fluid retention and swelling around the eyes, muscular pain and stiffness, high fever and laboured breathing (Forsythe, 2011). Penetration of the parasite through the intestinal wall and migration to the muscle sites can be an extremely painful and long-enduring disease. With early

diagnosis, treatment often leads to complete recovery, but muscle pain and weakness may persist (McIntyre *et al*., 2007).

Cyclospora

Cyclospora are single-celled parasites that infect the lining of the small intestine and are spread through the discharge of immature parasites in faecal material into the environment. This parasite matures outside of its living host, and enters the host through the consumption of contaminated food or water. Of the many species, *Cyclospora cayetenensis* is the only one that has been observed to cause illness in humans. Cases of cyclosporiasis, the disease caused by *Cyclospora*, are rare and are associated with eating imported fresh produce from tropical and sub-tropical areas such as raspberries and lettuce that are contaminated with *Cyclospora* (FDA, 2012). Symptoms include prolonged, watery and sometimes explosive diarrhea, abdominal cramping and bloating, nausea and fatigue (FDA, 2012). Since people of all ages are susceptible to cyclosporiasis, it is important to wash all fruits and vegetables under clean running water prior to eating them to reduce the chance of illness.

4.2. Indicator Organisms

It is important to note that most microorganisms found in foods are non-pathogenic and do not cause serious illness or disease. Amongst these are indicator organisms which are useful in evaluating the effectiveness of microbial control measures (e.g. hygienic conditions, overall sanitation). The presence of indicator organisms may signal whether or not food has been contaminated, subjected to insufficient heat treatment or produced using contaminated ingredients. However, the use of indicator organisms should not negate the testing for pathogens, such as *E. coli* O157:H7, due to their potential to induce serious illness. There are various types of indicator organisms that can be used to determine quality, of which faecal coliforms and generic *E. coli* are most commonly utilized as indicators of faecal contamination of the food product. Within the production environment, *Listeria* spp. (other than *L. monocytogenes*) is used as an indicator organism to identify unsanitary manufacturing practices where contamination of the food product with *Listeria monocytogenes* is of concern.

Aerobic Colony Count

The Aerobic Colony Count (ACC), also known as the Total Viable Count or Standard Plate Count, is a laboratory method used to determine the total number of bacteria capable of growing in an aerobic (i.e. oxygenated) environment. It is one of the most common tests applied to indicate the quality, and not safety, of food. The significance of ACC can vary according to the type of food product and the processing it has received. For example, ACC results are not applicable to raw RTE foods, such as fresh fruits and vegetables, cultured products or fermented foods since these foods will inherently have a

high count due to the environment or method in which they were produced. However for other food types, including frozen vegetables and powdered milk, elevated ACC levels may occur as a result of the food being past its shelf-life, inadequate processing or contamination due to poor hygiene by personnel or of equipment.

Coliforms

Coliforms are present in the intestinal tracts of humans and animals and widely distributed in nature (soil, water and vegetation). As such, their presence indicates that faecal or environmental contamination may have occurred. These organisms require the same conditions for survival and growth as some pathogens that cause illness (Forsythe, 2011); therefore their presence indicates the potential for viable pathogens to be present. Testing for the presence of coliforms is an economical way to test and identify contaminated foods that have been held under conditions supportive of microbial growth. In a food processing environment, the presence of coliforms is an effective method to determine the relative degree of sanitation, as their numbers increase in direct relation to levels of contamination, and can be an important component of the facility's quality control program.

Faecal coliforms reside in the intestinal tracts of warm-blooded animals and humans. These coliforms may be introduced into the processing environment through poor hygienic practices of food handlers, intestinal contamination during slaughter, improperly composted manure and untreated water supplies (Health Canada, 2014; CAC, 2003). As such, they are useful in determining the level of sanitary control within an establishment. Generic *E. coli* is the primary species in the faecal coliform group, and is considered to be the best indicator of faecal contamination or unsanitary processing (Forsythe, 2011). Although *E. coli* is represented by many serotypes, the majority are not pathogenic.

***Listeria* spp.**

There are more than six species of *Listeria*, of which only *L. monocytogenes* is known to cause illness in humans. The environmental conditions that support the growth of *L. monocytogenes* also support the growth of the other *Listeria* species (ICMSF 7, 2002). Thus, the presence of *Listeria* spp. in the food processing environment indicates a deviation from effective sanitary practices and contamination in the manufacturing environment that could lead to contamination of the food product with *L. monocytogenes* (Health Canada, 2011). Therefore, swabbing and testing food contact surfaces and non-food contact surfaces for *Listeria* spp. is an effective preventative measure for identifying problems with sanitary practices, and allows corrective actions to be taken, before the product becomes contaminated with *L. monocytogenes*.

4.3. Testing Intrinsic Factors for Viability

There are various intrinsic factors (such as pH, water activity, nutrients, fat content) that can be used to determine the viability or growth of microorganisms in any environment. Microorganisms react to different environmental conditions, and have preferential conditions under which they flourish. Although any one factor can create an environment that inhibits growth of the bacteria, the combination of two or more unfavourable factors is more effective in restricting bacterial growth and viability. Testing for these intrinsic factors, also referred to as safety parameters, reveals if microorganisms of concern could survive and grow in that particular food. They can provide useful information regarding the potential for growth of pathogens that may be present and contribute to assessing the risk posed to the consumer. Specifically pH and water activity are used to determine whether or not RTE products are classified as Category 2B products, as defined in the HC Listeria Policy (HC, 2011), by determining their ability to support or inhibit the growth of *L. monocytogenes*.

Salt Content

Salt is one of the oldest methods used for preservation. It restricts bacterial growth by binding to water molecules within the food, therefore reducing the amount of water available for metabolic activities (referred to as water activity; defined below in more detail). When a sufficient amount of salt is used, the water activity is reduced to a level below that required for most microorganisms to grow. As such, salt content may be one of the factors used to assess the level of risk associated with processed products.

pH

The term pH expresses the level of acidity or alkalinity of a substance. Every microorganism has an optimal pH range for growth. Commonly, microbial growth is supported in the slightly acidic to neutral range (i.e. pH of 5.6 to 7.5), and most microorganisms cannot survive below a pH of 4.4 (Montville *et al*., 2012). Acetic acid (i.e. vinegar) is commonly used in the preservation of pickled products. It is the creation of an acidic environment that contributes to the preservation of the food. Knowing the pH of a food helps determine the types of microorganisms capable of surviving in that particular food, and therefore helps narrow the scope of assessment.

Water Activity

Metabolic activities of any organism can only occur in the presence of water which is needed to dissolve nutrients, remove cellular waste and is essential for some metabolic reactions. The amount of water required for these processes varies between organisms. Water activity is a measure of the amount of water freely available for metabolic activities that is not bound in tissues or other components. This differs from moisture content which is the sum of chemically bound water and unbound water. Every

microorganism has an optimal range of water activity for growth. Foodborne pathogens are usually inhibited by water activity of 0.92 or less (Montville *et al*., 2012). As with pH, by measuring water activity, it is possible to determine the types of microorganisms that could be viable in a particular food.

4.4. Non-Microbial Indicators

Not all methods are designed to determine the presence or absence of microorganisms. In some instances, information pertaining to other aspects of food safety may be gained by analysing for a non-microbial indicator. Such tests may be performed to identify manufacturing processes that could support the introduction of potential food safety hazards.

Species Verification as an Indicator of Sanitary and Fraudulent Practices

Species verification is conducted to detect adulteration of meat products claiming to be derived from one species with that from another species. An operator may fraudulently substitute less expensive types of meat for some or all of the more expensive meat declared on the label. Adulteration may also occur due to the improper cleaning of equipment and contamination during processing. From a food safety perspective, species verification is performed to assess the effectiveness of sanitation procedures within the establishment.

Central Nervous System Tissue Screening for BSE

More commonly known as Mad Cow Disease, Bovine Spongiform Encephalopathy (BSE) is a progressive, degenerative neurological disease caused by a misfolded protein (prion), and is resistant to breakdown by heat, enzymes or disinfectants. In cattle, BSE occurs as a result of dietary exposure to feed containing infected meat and bone meal. Presently, there is no test to diagnose BSE in live animals, and it can only be diagnosed through the detection of the abnormal prion in brain tissue collected post mortem. The BSE prion is known to be able to infect humans, causing variant Creutzfeld-Jakob Disease (vCJD; FDA, 2012), through the human consumption of contaminated meat products from BSE-infected cattle. BSE and vCJD are members of a family of diseases known as Transmissible Spongiform Encephalopathies characterised by the degeneration of brain tissue giving it a sponge-like appearance and leading to death (FDA, 2012).

Since it is known that humans may develop vCJD through the consumption of meat products containing the BSE prion, beef products containing ground, finely textured meat are tested for the presence of central nervous system (CNS) tissue. CNS tissue, identified as specified risk material (CFIA, 2008), implies that meat mechanically separated from the vertebral column has been included in the meat product and there is potential for the presence of brain and other nervous system tissues. It is important to note that the

detection of CNS tissue in a meat product does not necessarily mean the BSE prion is present. To proactively avoid the occurrence of vCJD in humans due to the consumption of BSE contaminated meat, CNS tissue is not permitted in meat products (CFIA, 2008).

Phosphatase Test for Pasteurization

Pasteurization of milk and milk products is a key component in ensuring the microbial safety of these foods as they are often sold as RTE products. Pasteurization is a heat process intended to kill pathogens such as *E. coli* O157:H7. Phosphatase is an enzyme present in cow's milk that is inactivated by the pasteurization process. In order to determine if dairy products have been subjected to a pasteurization process or contaminated by raw milk, the food is tested for the presence of phosphatase. However, it should be noted that for some types of cheese, the phosphatase test is not effective (e.g. Blue, Swiss, Camembert) because the phosphatase enzyme is produced by the microorganisms used during fermentation of these types of cheeses.

5. National Microbiological Monitoring Program

The CFIA operates the NMMP to test for the presence of pathogens in foods deemed to pose the greatest risk to consumers by verifying industry compliance with the many Acts and Regulations associated with the production of safe food. The NMMP is designed to sample and test a broad range of imported and domestic commodities for multiple hazards, including red meat and poultry products, shell eggs and egg products, dairy products, fresh fruits and vegetables and processed fruit and vegetable products (Appendix B). Results from this testing enable the CFIA to make decisions concerning the acceptability of food based on its microbial load. Food-hazard combinations deemed to pose the greatest potential health risks, recent outbreaks of foodborne illnesses, emerging food-hazard combinations and historical levels of compliance are taken into consideration when designing the plans.

Under the NMMP, random samples are taken for laboratory analysis to verify compliance with food safety regulations and product standards, utilizing analytical assessment criteria. Sampling is conducted at federally registered establishments, food processors, distribution centers, packing facilities, and importers. Foods tested under the NMMP are domestically produced and destined for interprovincial or international markets, or are imported. Environmental sampling within domestic food processing establishments is also performed to verify the operators' sanitary procedures and ability to control the presence of pathogens within the processing environment.

5.1. Rationale

The NMMP is a risk-based program that provides information to the Government of Canada on the safety of foods available to Canadians. Through its collection of data while verifying compliance of the food industry with safety practices and standards, the NMMP contributes to the following:

1. Demonstrating to Canadians the safety of the foods available in the domestic market.
2. Providing data for the comparative risk associated with domestic and imported sources of foods.
3. Demonstrating the efficacy of the Canadian Food Safety System to international trading partners which supports Canadian industries' access to foreign markets.
4. Providing information on the effectiveness of food safety control measures, as well as the effectiveness of program interventions intended to improve the food safety system.
5. Independently confirming the degree of compliance with Good Manufacturing Practices, Good Hygienic Practices or Hazard Analysis Critical Control Point programs as demonstrated by industry testing.

6. Identifying areas of concern where further control activities, policies and guidelines may be needed.
7. Ensuring domestic producers and importers in violation of Canadian standards are placed on enhanced inspection until there is appropriate compliance.
8. Estimating the prevalence of pathogens in food to verify compliance with food safety standards.

Through the use of clearly defined sampling guidelines and criteria, the results of the microbiological testing of domestic and imported foods are designed to be meaningful and quickly alert authorities of potential food safety issues.

5.2. Product Sampling

Microbial contamination is generally not evenly distributed throughout a commodity. Most foods are not homogeneous by nature; therefore microorganisms establish themselves in pockets where conditions are most favourable for their survival. It is essential that the samples taken for analysis properly represent the commodity as a whole. Therefore, when sampling lots, batches or shipments of food several samples are randomly taken from various points in time and/or space. Each of these is referred to as a subsample, and most commonly five subsamples are taken for each sample. When sampling domestic commodities along the production line, subsamples may be taken at different times during the production day but at the same point within the processing line.

The subsamples are randomly selected and collected using aseptic techniques to prevent contamination during the sampling process. They are transported to the laboratory under conditions that maintain sample integrity and support reliable and accurate analytical results. It is critical that the samples do not become contaminated during these steps. It is also important that the samples are maintained at an appropriate temperature that does not encourage the growth of, nor kills, any potential microorganisms (pathogenic and indicator), and prevents the sample from spoiling.

The sampling activities conducted by the CFIA are designed through the determination of sampling priority, sampling frequency, sample size and method of sample selection. These activities are conducted for regulatory purposes and are intended to verify the implementation and effectiveness of the food safety systems used within food processing establishments. Sampling plans must specify the microbial hazard of concern, the food product to be sampled, number of samples to be collected, point of sampling within the food chain and geographic location, techniques for aseptic sampling, shipping and storage conditions, analytical methodology and assessment criteria.

Bacterial contamination can occur at any point along the farm to fork continuum. Sampling by the CFIA is dependent upon jurisdictional boundaries, manufacturing processes, and origins of the products. For domestic products, CFIA's monitoring plans are designed to allow for the selection of samples during the visual inspection of processing establishments. During processing there are critical control points where kill steps are applied to prevent, eliminate or reduce microbial hazards to acceptable levels. Domestic commodities are sampled at points where processing should render the microorganisms of concern, based on their virulence, as either (i) absent or (ii) at such low levels that by the time the food reaches the consumer there has not been sufficient growth of the microbes to render the food unsafe for consumption. As the CFIA does not have jurisdiction in foreign countries, the sampling of imported food is restricted to ports of entry and distribution facilities. This limits the information pertaining to the exact conditions the food was exposed to during processing and handling. Nevertheless, imported foods are expected to meet the same safety standards as domestic products.

5.3. Environmental Sampling

Bacterial contamination can occur at any point along the production chain. An understanding of certain critical steps during production can provide valuable information as to where contamination may occur and insight on how to prevent it. As such, an effective environmental testing strategy will allow both the food producer and the CFIA to verify the operator systems' ability to control the presence of pathogens within the processing environment and to intervene before contamination of the food occurs. The choice of testing site is highly dependent on the food, the processing facility and the controls that are in place. However, the CFIA does not have the authority to perform environmental sampling in foreign establishments exporting to Canada.

Microorganisms can thrive anywhere ideal conditions exist. Therefore, surfaces and tools that come in direct contact with the food are swabbed and recirculated water used during processing is also tested. Surfaces that do not come in direct contact with the food, including rollers, air ducts and drains may also be tested. These sites may become a source of contamination for food and food contact surfaces through employee movement, dust and air flow. Hence, in addition to the effective sanitation of direct food contact surfaces, establishments must also ensure that bacteria do not become established in other parts of the processing area.

Environmental sampling procedures allow the swabbing of five to ten sites for each sample submitted for analysis, allowing for multiple potential sources of contamination to be assessed. Even if no pathogens are detected in the product, environmental sampling can be used to identify the presence of pathogens within the manufacturing environment,

identify system controls which need to be reviewed and prevent subsequent contamination of products.

Similar to product sampling, environmental samples are collected using aseptic techniques and transported to the laboratory under conditions that maintain the integrity of the sample for analysis. It is critical that the samples do not become contaminated during these steps, and are maintained at an appropriate temperature that does not encourage the growth of, nor kills, the potential pathogen.

At times product and environmental sampling are performed simultaneously (i.e. same establishment, production period and production area). This provides information about the microbial quality of the product and additional timely information about its manufacturing environment at the time of production. From this it may be determined if there is a correlation between sanitary conditions within the establishment and the presence or absence of pathogens in the food product.

5.4. Methodology for Analysis of Pathogens

The CFIA laboratories analyze samples using a variety of conventional microbiological and DNA-based methods designed to meet regulatory standards in order to assess the microbial safety of food. Most methods used for testing are found in Health Canada's Compendium of Analytical Methods (Health Canada, 2008a). Non-compendium or modified versions of compendium methods are also used when appropriate. In order to ensure the laboratory procedures and analytical results are reliable, are internationally recognized (i.e. to maintain the confidence of our trading partners) and will withstand legal scrutiny, CFIA laboratories are accredited by the Standards Council of Canada as complying with internationally recognized standards (ISO 17025).

At the laboratory, for each product or environmental sample, a portion of each subsample is taken and usually pooled for analysis as a single unit. When required, the subsamples may be analyzed individually to provide more information about the distribution and quantity of microorganisms within the sample.

Rapid screening methods are utilized as an effective way to quickly identify compliant samples, thus allowing for their timely release into the market. These methods allow for rapid processing and reporting, and results may be available within 24-72 hours of sample receipt at the laboratory. If results of the screening method indicate the targeted microorganism(s) may be present, the sample is flagged for further testing to confirm its presence.

Potentially positive samples (i.e. presumptive positives) are further tested using a cultural method to determine whether or not the pathogen of concern is present. Cultural methods allow for the isolation and confirmation of specific types of viable microorganisms. In some cases, DNA-based methods are used for confirmatory testing. These methods can accelerate the identification process for pathogens in foods ensuring unsafe food is removed from the marketplace in a timely manner. Results from cultural methods are usually available within two to five days after the confirmation method has commenced.

In some situations it is desirable to know how much contamination has occurred. For this, enumeration methods provide a direct or estimated count of the number of viable organisms present. These counts may be expressed as colony forming units (CFU/mL or CFU/g) or most probable number (MPN/mL or MPN/g). Enumeration results are usually reported within one to five days.

During foodborne illness outbreak investigations, epidemiological evidence is combined with microbial testing of suspect foods to determine the source of contamination. In these situations it is not enough to simply identify the genus (i.e. *Listeria* spp.) or species (i.e. *L. monocytogenes*) of the organism responsible for the infection, but further characterization may be required for source attribution and confirmation. For example, not all colonies of *L. monocytogenes* are of the same genetic composition. Differences that exist in their DNA profiles are used to identify subpopulations of organisms, referred to as strains. Genotyping is the term used to describe the characterization of these strains at the molecular level. Pulsed-Field Gel Electrophoresis (PFGE) technology is one DNA-based subtyping tool utilized by the CFIA for the characterization of foodborne pathogens (sometimes referred to as "DNA fingerprinting").

All DNA "fingerprints" derived from food and clinical testing performed by CFIA and other governmental agencies are entered into a national database system called PulseNet Canada. This database is a virtual electronic network linking provincial and federal public health laboratories, in order to gather and share these DNA "fingerprints" amongst various governmental departments (PHAC, 2014). Contributing to Canada's Foodborne Disease Surveillance, this enables rapid comparison of patterns allowing for the detection of geographically dispersed outbreaks of foodborne bacterial disease at an earlier stage and significantly contributes to the investigation of foodborne illness outbreaks. This analysis is used to make epidemiological linkages between strains isolated from clinical cases with strains identified in a contaminated food source.

5.5. Interpretation of Assessment Criteria

Assessment criteria are used to set clear limits for the presence of contaminants and to ensure a consistent approach in determining if food products are safe for consumption

and produced under conditions compliant with food safety standards. The laboratory test results are compared to criteria specific to the food and microbial organism of concern to determine the microbial quality of the food sample. The assessment criteria used under the NMMP are presented in Appendix C.

For foods and microbial contaminants of top concern to human health, microbiological standards have been established. In Canada, the primary document used to identify assessment criteria based on current regulatory standards and guidelines is Health Canada's Health Products and Food Branch Standards and Guidelines for Microbiological Safety of Food – An Interpretive Summary (HC, 2008b). The Interpretive Summary is founded upon microbiological food safety standards defined in the *Food and Drugs Regulations* and the *Food and Drugs Act* and guidelines which have been developed on the basis of survey data as an aid to the administration of the *Food and Drugs Act*. Additional resources for the determination of microbiological assessment criteria includes Health Canada's Policy on *Listeria monocytogenes* in Ready-to-Eat Foods (HC, 2011) and their Guidance Document on *E. coli* O157:H7 and *E. coli* O157:NM in Raw Beef (HC, 2014).

The structure for defining microbiological assessment criteria based on these standards and guidelines is in line with internationally recognized practices as described by the International Commission on Microbiological Specifications for Foods (ICMSF, 2013), and uses the following terms.

n: The number of sample units to be analyzed. Individually these are referred to as subsamples and collectively they represent one sample.

c: The maximum number of subsamples permitted to lie between the "m" and "M" values. "c" is the acceptance number and when it is exceeded, the microbial load of the sample is deemed to be unacceptable.

m: The numerical value of "m" represents the top limit of acceptable concentrations of microorganisms or amounts of extraneous material, usually per g or mL. In a 2-class plan, "m" separates sample units of acceptable and defective quality; in a 3-class plan, "m" separates sample units of acceptable quality from those of marginally acceptable quality.

M: Only in a 3-class plan, the numerical value of "M" represents lower limit of unacceptable concentrations of microorganisms or amounts of extraneous material, usually per g or mL, that indicate a (potential) health or injury hazard, imminent spoilage or gross insanitation. "M" separates sample units of marginally acceptable quality from

those of defective quality. If any one subsample is determined to be greater than "M", the sample is deemed to be unacceptable.

Table 1: Examples of Microbiological Assessment Criteria Used for 2-Class (*E. coli* O157:H7 & *Listeria monocytogenes*) and 3-Class Plans (generic *E. coli*).

Pathogen	n	c	m	M	Satisfactory	Unsatisfactory
***E. coli* O157:H7**	5	0	0	-	Not Detected	Detected
L. monocytogenes (Category 1 foods)[a]	5	0	0	-	Not Detected	Detected
generic *E. coli*	5	2	10^2	$2x10^3$	≤m/g or if c is not exceeded	>M/g in one or more sample units or if c is exceeded

[a] Categorization of Ready-to-Eat (RTE) Foods is based on Health Canada's *Listeria* Policy (HC, 2011).

Standards and guidelines are expressed in terms of 2-class plans or 3-class plans depending on the degree of hazard involved (Table 1). Two-class plans are typically used where there is zero tolerance for the presence of pathogens in food which may induce serious illness when only a few cells are consumed. Thus the assessment criteria used by the CFIA for pathogens, such as *E. coli* O157:H7, clearly state that the presence of such organisms in food is unacceptable (c=0, m=0). In such cases, when the pathogen is detected in the sample the entire associated lot of food is considered to be unsatisfactory for human consumption and appropriate actions are immediately taken to mitigate the risk to consumers.

Three-class plans are used when there are varying degrees of acceptable within the limits (Table 1), and the CFIA typically uses this when testing for the presence of indicator organisms in food. Although indicator organisms, such as generic *E. coli*, do not pose a health risk, their presence is used as a measure of sanitary quality. For example, very low levels of generic *E. coli* (≤100 CFU/g) are considered acceptable as they are commonly present in the food source and environment. These levels (defined by "m") are innate to the processing environment and pose no health risk, therefore when present in any or all of the subsamples, the sample is assessed as satisfactory and no action is required. For example, if generic *E. coli* was detected at 100 CFU/g in each of the 5 subsamples, the sample would be assessed as satisfactory. Slightly elevated levels of indicator organisms are also acceptable (values that lie between "m" and "M"), however only in a limited frequency (defined by "c") as they are an indication that a minor failure in sanitary controls has occurred within the processing establishment. In such circumstances, the

food is considered to be marginally acceptable. Contrarily, if multiple subsamples (greater than "c") contain marginally acceptable levels of the microorganism then the sample is assessed as unsatisfactory. This is considered to be a warning that the sanitary controls are not functioning as effectively as they could be, and the probability of introducing pathogenic levels of microorganisms is becoming a concern. For example, if three of the 5 ("n" value) subsamples contained generic *E. coli* at levels between 100 and 2000 CFU/g (the "m" and "M" values respectively) the sample would be assessed as unsatisfactory because the "c" value of 2 was exceeded. Contrarily if only one or two of the subsamples contained generic *E. coli* at levels between 100 and 2000 CFU/g the sample would be assessed as satisfactory. The presence of indicator organisms at high levels (defined by "M") is an indication of gross contamination or major non-compliance issues in the processing environment. When these levels are detected in any one of the subsamples, the sample and associated lot are deemed to be unsatisfactory and unfit for human consumption. For example, if any one subsample contained more than 2000 CFU/g of generic *E. coli*, the sample would be assessed as unsatisfactory. Although it does not directly pose a health risk, high levels of indicator organisms are the result of system failures that could also lead to the presence of pathogens in the food. Appropriate follow-up actions are taken to ensure the processing environment returns to a state of compliance.

Table 2: Assessment Criteria Used to Identify Investigative Samples Intended to Trigger Proactive Action to Prevent Contamination of Foods with Unacceptable Levels of Pathogens.

Pathogen	n	c	m	M	Satisfactory	Investigative	Unsatisfactory
generic *E. coli* (raw ground beef)	5	0	100	-	≤100/g	>100/g	not applicable
L. monocytogenes (Category 2 foods)[a]	5	0	100	-	Not Detected	Detected: ≤100/g in all sub samples tested	Detected and >100/g in any sub sample tested
***Listeria* spp.** (environmental testing)	10	0	0	-	Not Detected	*Listeria* spp. other than *L. mono* detected	*L. monocytogenes* detected

[a] Categorization of Ready-to-Eat Foods is based on Health Canada's *Listeria* Policy (HC, 2011). Investigative assessment is based on CFIA risk management approach.

The above examples are typical of 2-class and 3-class plans, however there are some exceptions. Although *L. monocytogenes* is classified as a pathogenic organism, Health Canada's Policy on *Listeria monocytogenes* in Ready-to-Eat Foods (HC, 2011) indicates the presence of *L. monocytogenes* at low levels in some RTE foods is permissible in the absence of risk to the consumer. As such, RTE foods are classified into three categories based upon health risk. Various intrinsic and external factors are used to determine the category into which RTE foods are classified, such as processing (e.g. frozen foods, heat treatments), duration of the shelf-life, pH and water activity. Category 1 products support the growth of *L. monocytogenes* and if contaminated could potentially exceed 100 CFU/g by the end of their stated shelf-life. Therefore, since this poses a health risk, the presence of *L. monocytogenes* is not tolerated in Category 1 products (Table 1; c=0, m=0). Contrarily, *L. monocytogenes* is permitted at low levels in Category 2 products, which are divided into two sub-categories. Category 2A products support the growth of *L. monocytogenes*, however due to various factors, growth throughout the stated shelf-life would be limited (i.e. <100 CFU/g at the "best before" date displayed on the package) while Category 2B products do not support the growth of *L. monocytogenes* (HC, 2011). Therefore, in Category 2 products the detection of *L. monocytogenes* at low levels (<100 CFU/g; c=0, m=100) is permitted. However, if any one of the subsamples exceeds 100 CFU/g, the sample is unsatisfactory and not fit for consumption. Hence, samples of Category 2 products may contain up to 100 CFU/g of *L. monocytogenes* in any or all of their subsamples and not pose a health risk to the general public. However it is acknowledged that the presence of *L. monocytogenes*, even at low levels, indicates the contamination of food with a potentially pathogenic microorganism. Therefore the CFIA has decided to take a cautionary approach with Category 2 RTE products and assesses these as investigative (Table 2). This assessment triggers a follow-up inspection at the establishment to identify any deviations within the control processes, as well as ensuring a return to full compliance in order to avoid the food becoming contaminated with higher levels of *L. monocytogenes* that may then pose a health risk.

"Investigative" assessments are at times also used under the NMMP when indicator organisms are detected in manufacturing environments or are present at elevated levels in foods that are expected to be thoroughly cooked by the consumer, and if cooked properly, do not pose a health risk (Appendix C). This assessment indicates a minor deviation from sanitary practices has occurred and although no further assessment or follow-up action may be performed on the food, a visual inspection and follow-up activities may be carried out at the establishment in order to prevent future potential contamination of the food being produced with pathogenic organisms. One example is the assessment criteria used in the analysis of generic *E. coli* in raw ground beef (Table 2). Although the "m" value is set at 100 CFU/g and there is no "M" value defined, if any subsamples are assessed as containing >100 CFU/g of generic *E. coli* the sample is assessed as investigative and not

unsatisfactory. In this situation the presence of generic *E. coli* is an indication of sanitary practices and since it is expected that the consumer will thoroughly cook the ground beef, there is no associated health risk. However, if high levels of generic *E. coli* are detected this is interpreted as being an indication of failures in the sanitary practices which could result in the contamination of ground beef with pathogenic *E. coli* O157:H7. Therefore, the investigative result is used to trigger a follow-up inspection at the meat processing establishment to identify and ensure the correction of any deviations in sanitary practices in order to return the facility back to a state of compliance.

This risk management approach is also applied when *Listeria* spp. other than *L. monocytogenes* are detected in the environmental samples taken within food processing establishments. Although *L. monocytogenes* is the only *Listeria* spp. that poses a risk to human health, the presence of other *Listeria* spp. indicates contamination from a source that could also potentially introduce *L. monocytogenes*. Therefore, when *Listeria* spp. other than *L. monocytogenes* are detected in environmental samples, they are assessed as investigative in order to trigger further investigation within the establishment with the intention of preventing future contamination with *L. monocytogenes*.

All other food safety tests performed are assessed in the same manner as pathogens or indicator organisms. Whether there is zero tolerance or a gradient of acceptable levels is dependent on the interpretation of the results and the implied level of risk to the consumer. For example, for pH and water activity there is a range of values that is used to determine the potential risk for conditions which may support the survival or growth of microorganisms.

Since each sample analyzed is representative of the microbial quality of the entire lot, when a sample is deemed to be compliant the entire lot is assessed as being compliant, it is labeled as “Satisfactory” and no food safety actions are required. With some food/hazard combinations if the sample is determined to be moderately satisfactory it is assessed as “Investigative”, since it is an indication of a minor deviation from sanitary practices. Although there is no immediate risk to human health, further investigation at the manufacturing establishment may be performed. When analytical results determine the sample does not meet microbial food safety standards and is therefore out of compliance, it is labeled as “Unsatisfactory” (Appendix C). Further assessment is then performed to determine whether or not there is a potential health risk and based on these findings appropriate follow-up actions are taken to protect consumers.

5.6. Statistical Considerations

For the information collected from the sampling and testing of foods to be scientifically sound, and for accurate conclusions to be drawn from the results, both the design of the sampling program and the analysis of the data must be statistically supported.

Statistical Design

Statistical development of the sampling design must be utilized in order to ensure the information gathered supports its purpose. Considerations must be taken into account when determining the sampling technique, the number of samples, the location of sampling, as well as the frequency of sampling, as these factors determine what conclusions may be deduced from the results. The activities under the NMMP are intended to verify compliance by domestic and foreign food industries with Canadian standards. For verification purposes, a limited number of samples are collected randomly throughout the food population using variable sampling plans and collectively are sufficient to represent the current state of the entire food safety system. To support its purpose, these activities and the analysis of the data are performed on an annual basis. However, to actively monitor the microbial quality of food requires the continuous sampling and testing of each food product utilizing attribute sampling plans, and this is performed by industry. Monitoring activities provide more detailed information about the food safety system implemented within a single establishment on a continuous basis, and is a valuable tool that provides constant and timely feedback used by the food manufacturing establishments since they are ultimately responsible for the production of safe food. Nevertheless, variable sampling plans and smaller sample numbers can still be used to verify the effectiveness of industry practices.

Statistical Analysis

From a statistical perspective, in order to accurately report on rates of compliance by specific industries or companies, or the prevalence of a specific pathogen in one type of food, extensive sampling and testing must be conducted. This is required to be able to provide a calculated value with a high degree of confidence that this value is truly representative. For example, from April 2009 to March 2010 CFIA performed a targeted survey in which 4250 samples of fresh leafy vegetables were collected and tested for *Salmonella* spp. (CFIA, 2014c). Of these, *Salmonella* spp. was detected in two samples and from this the prevalence of *Salmonella* spp. in leafy vegetables was calculated to be 0.05%. Most pathogens in food have prevalence rates of <1%, therefore to accurately determine the prevalence of all pathogens of concern in all food products would require the annual sampling and testing of tens of thousands of samples, which is not logistically feasible.

Hence, with the analysis of approximately 9000 samples each year, the primary intent of the NMMP sampling and testing activities is to verify industry compliance with Canadian standards. The main body of this report focuses on the assessment of results obtained through sampling and testing activities conducted over a 12 month period. Therefore, caution must be used when interpreting the results of this data, as it represents the state of compliance within each industry, and Canada's national food safety system, during that particular time period.

However, by combining the data gathered under the NMMP over several consecutive years we are able to demonstrate an estimated rate of prevalence. This can be performed periodically to understand the current state of food safety within Canada, but does not contain enough data to be able to repeat this analysis for monitoring on an annual basis purposes. Hence, this report also includes a summary of the types of analyses performed on each food group over a seven-year time period (2007/08 to 2013/14) with the intention of providing a best estimate of prevalence within the Canadian market. This was accomplished by calculating the Estimated Prevalence and True Prevalence of each microorganism analyzed within each food group. The Estimated Prevalence is defined as the percentage of samples in which the pathogenic hazard of concern was detected (# positive). However, for indicator organisms, such as ACC, coliforms, generic *E. coli* and *S. aureus*, the estimated prevalence is defined as the percentage of samples in which the level of contamination indicates a notable deviation from sanitary practices. This includes samples assessed as investigative and unsatisfactory. For example, when generic *E. coli* is detected in ground beef at levels $\leq$100 CFU/g, the sample is assessed at satisfactory and not considered to be a positive sample in the determination of estimated prevalence. This is because these levels are within the limits of control attainable by current industry practices and do not pose a health risk.

Estimated Prevalence = (# positive samples / total # of samples tested) x 100

Note that within these tables, the reported number of samples analyzed for 2011/12, 2012/13 and 2013/14 may slightly differ from what is documented in NMMP's published annual reports. These discrepancies are caused by the manner in which data is entered into the database and the fields which are selected to extract and summarize the data. Although the data analyzed and presented in the NMMP annual reports have been checked for accuracy prior to compilation, assessment and reporting, resource constraints do not permit for a similar review of all the data points associated with the entire seven year period used to calculate the estimated prevalence.

Regardless of the total number of samples analyzed, there is always a certain degree of uncertainty when calculating the estimated prevalence. Therefore, to provide a more

meaningful estimate of the prevalence, the true prevalence range is presented. The True Prevalence provides with 95% confidence a range within which the actual prevalence may lie. The following calculations were used to determine the upper and lower limits of the true prevalence range.

True Prevalence

$$95\%\ \text{Lower} = \frac{1}{1+\frac{z^2_{\alpha/2}}{n}}\left(\hat{p} + \frac{z^2_{\alpha/2}}{2n} - z_{\alpha/2}\sqrt{\frac{\hat{p}(1-\hat{p})}{n} + \frac{z^2_{\alpha/2}}{4n^2}}\right)$$

$$95\%\ \text{Higher} = \frac{1}{1+\frac{z^2_{\alpha/2}}{n}}\left(\hat{p} + \frac{z^2_{\alpha/2}}{2n} + z_{\alpha/2}\sqrt{\frac{\hat{p}(1-\hat{p})}{n} + \frac{z^2_{\alpha/2}}{4n^2}}\right)$$

where,

$\hat{p}$ = estimated prevalence = # positive samples / total # of samples tested, and

$z_{\alpha/2}$ = 1.96 is the 95th percentile for the standard normal distribution.

It is important to note that the fewer the number of samples analyzed the greater the range in the True Prevalence, due to increased uncertainty from the lack of data, as depicted in Figure 1. It is equally important to note that even when the pathogen is not detected resulting in an estimated prevalence of zero, the true prevalence range is still calculated to express the probability that the pathogen may be present, despite the absence of detection, within the population being tested.

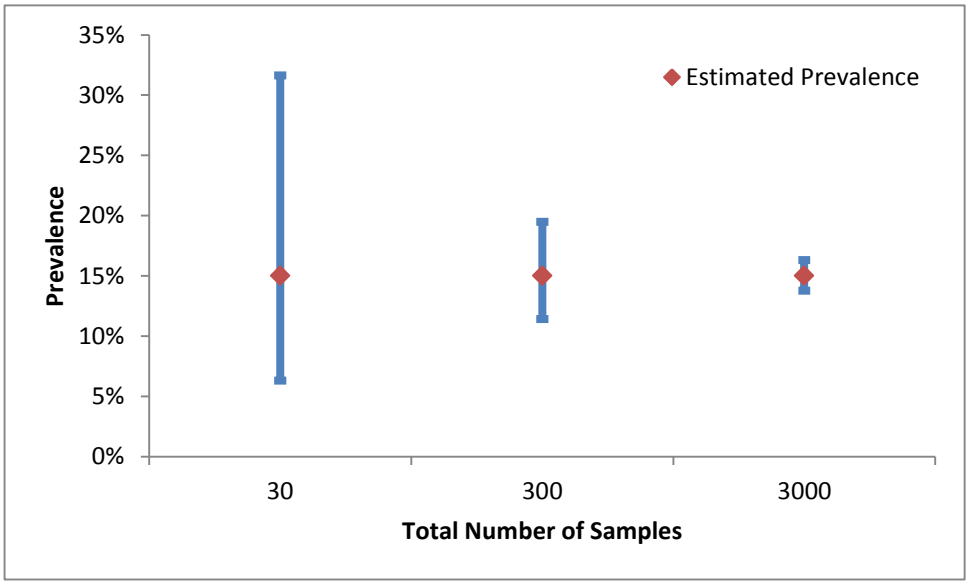

Figure 1: How the Number of Samples Affects the Calculated True Prevalence Range.

6. Results of the National Microbiological Monitoring Program

The results of all product and environmental sampling and testing performed from April 1, 2013 to March 31, 2014 under the NMMP are described in the following sections. Information pertaining to each commodity group (red meat and poultry products, shell eggs and egg products, dairy products, fresh fruits and vegetables, and processed fruit and vegetable products) is presented separately, with subsections designated to specific food types and environmental sampling. The tables provide in detail the number of samples within each food group that were analyzed for each microbial hazard. The information is presented separately for domestic and imported food and includes the number of tests performed, the number of samples assessed as satisfactory, investigative and unsatisfactory, compliance rates and the country of origin. The percent compliance is based on the total number of samples that are deemed acceptable, which includes the samples assessed as satisfactory and investigative. Investigative samples are included since they are indicators of minor deviations and do not exceed the level which is used to determine non-compliance. The percent compliance is calculated as follows:

% Compliance = (Total # Samples - # Unsatisfactory)/ Total # Samples x 100

The beginning of each section provides a high level summary of the published sampling and testing activities performed under the NMMP from 2011/12 to 2013/14. The objective is to demonstrate the trends and consistencies in tests and sample numbers and industry compliance over this three year period. In addition, each section also includes the calculated estimated prevalence for each microorganism routinely tested using NMMP sampling results collected over a seven year period (2007/08 to 2013/14). The analyses performed in each fiscal year reflect the hazards of concern associated with that food group at that point in time. In addition, the Estimated Prevalence and True Prevalence based on the cumulative results over this time period were calculated, providing the most extensive report and comprehensive summary on microbial prevalence in food using Canadian data.

In addition to this report, Annual Reports for 2011/12 and 2012/13 have been published and are available through the CFIA website (CFIA, 2014a). Table 3 provides an overview of these three years of data. This summary indicates the number of samples, the number of tests, and the compliance rates have been consistent during this time period. During 2011/12, 2012/13 and 2013/14 activities performed under the NMMP deemed the food products within the Canadian market to be 98.7%, 99.4% and 99.3% compliant, respectively, with microbial food safety standards. The slightly lower level of compliance

in 2011/12 was due to the low level of compliance within the processed products, which resulted from a high incidence of mould in imported tomato products. Likewise, during 2011/12, 2012/13 and 2013/14, domestic food production environments were deemed to be 97.5%, 97.7% and 97.6% compliant, respectively. Although slightly lower than the compliance rates of the food products, the ability to control for the presence of microorganisms in the production environment is highly challenging yet an essential step in preventing the cross contamination of food. In many situations the environmental samples are tested for indicator organisms, not pathogenic organisms, which tend to be more prevalent. However, the consistency and high levels of compliance for both the food products and production environments over this time period demonstrates that Canadians may be confident that the food safety system in Canada is highly effective and stable.

Table 3: Summary of NMMP Published Data

Fiscal Year	# Tests	# Samples	# Unsatisfactory	% Compliance
Food Products				
2011/12	14307	5234	68	98.7
2012/13	13237	4980	31	99.4
2013/14	13801	5510	38	99.3
Environmental				
2011/12	2398	1878	47	97.5
2012/13	2563	1892	44	97.7
2013/14	1986	1895	45	97.6

7. Red Meat and Poultry Products

Improperly prepared meat has historically been implicated in a significant proportion of the human illnesses associated with foodborne diseases. Typically originating from the animals being slaughtered and processed, contamination can be spread across many portions of food by contaminated surfaces and equipment (CAC, 2005). In addition, if certain cuts of meat are consumed raw or undercooked, the internal temperature of the meat may not be sufficiently high enough to kill all pathogens, if present. For this reason, the CFIA predominantly focuses its testing activities on meat products that are typically not cooked by the consumer prior to consumption (e.g. RTE meat products), as well as those that could be consumed in a partially cooked state, such as beef. Every domestic establishment slaughtering, processing or packaging meat products intended for interprovincial trade or export must be federally registered and therefore monitored by CFIA inspectors. In addition to the continuous inspection of processes and procedures, random samples are taken for laboratory analysis to verify compliance with all applicable food safety regulations and product standards.

Table 4: Summary of NMMP Published Data for Domestic and Imported Meat Products and Environmental Testing in Domestic Federally Registered Establishments

Fiscal Year	# Tests	# Samples	# Unsatisfactory	% Compliance
Meat Products				
2011/12	4729	2693	16	99.4
2012/13	4183	2528	7	99.7
2013/14	5210	3079	5	99.8
Overall Products	**14122**	**8300**	**28**	**99.7**
Environmental				
2011/12	1160	1062	11	99.0
2012/13	1236	1004	9	99.1
2013/14	1048	1010	13	98.7
Overall Environmental	**3444**	**3076**	**33**	**98.9**

Comparing the data presented in NMMP's published reports, it is seen that meat products and environmental testing have been highly compliant with national food safety standards over the past three years. Domestic and imported meat products were deemed to be 99.4%, 99.7% and 99.8% compliant in 2011/12, 2012/13 and 2013/14, respectively (Table 4). While environmental testing performed within domestic establishments producing RTE meat products showed similar levels of compliance of 99.0%, 99.1% and 98.7% in 2011/12, 2012/13 and 2013/14, respectively. The consistency and levels of

compliance assure consumers that meat products available on the market are very safe for consumption, keeping in mind that the products deemed to present the highest risk to consumers were selected for testing.

Due to consumer practices and food safety awareness, it is expected that some meat products, such as raw chicken, will be thoroughly cooked prior to consumption, which should destroy any pathogens present. Hence, at this point in time the NMMP does not oversee the sampling and testing of raw poultry products for microbial hazards, and therefore results are not available for presentation in this section. However, due to the absence of Canadian data, in 2013 CFIA initiated a pilot project to determine the prevalence of *Salmonella* spp. and *Campylobacter* spp. in raw poultry at various points throughout the food chain.

7.1. *Ready-To-Eat Meat Products*

Canada's Meat Inspection Regulations (MIR, 1990) defines ready-to-eat as "a meat product that has been subjected to a process sufficient to inactivate vegetative pathogenic microorganisms or their toxins and control spores of foodborne pathogenic bacteria so that the meat product does not require further preparation before consumption except washing, thawing or exposing the product to sufficient heat to warm the product without cooking it." Based on this, RTE meat products include all species of meat subjected to an adequate heat treatment or other kill step, thus decreasing the number of bacteria and minimizing the chance of pathogenic strains surviving. Most RTE meat products are subjected to a combination of treatments intended to destroy pathogens, for example heat treatment, fermentation, addition of spices and/or smoking. Dried meat products, such as salamis and hams, do not receive heat treatment but are instead cured. These products are required to be free of pathogens, such as *E. coli* O157:H7. They require no further cooking by the consumer prior to consumption, and include products consumed "as-is" or warmed to a palatable temperature. RTE meats have been associated with outbreaks of foodborne disease due to recontamination from raw or undercooked products while being handled in processing establishments, catering establishments and in the home kitchen.

During 2013/14, RTE meat products were sampled and tested for the following pathogens of concern: *E. coli* O157:H7 (on fermented RTE products containing beef only), *L. monocytogenes* and *Salmonella* spp. The results summarized in Table 5 include all CFIA testing (monitoring and risk-based sampling results). There were 1505 tests performed on 1056 domestic products determined to be 99.7% compliant. The 0.3% non-compliance was due to three Category 1 samples in which *L. monocytogenes* was detected (<5 CFU/g; Table 6). Although deemed to be compliant, five Category 2 type samples were assessed as investigative due to the detection of low levels ($\leq$5 CFU/g) of

L. monocytogenes. In addition, 268 tests were performed on 133 imported RTE meat products. These imported products were 100% compliant, with one Category 2 product from Italy assessed as investigative due to low levels of *L. monocytogenes* (<5 CFU/g). The majority of Canada's imported RTE meat products came from the United States (>71%) and France (>14%; Figure 2).

Combining these results, a total of 1773 analytical tests were performed on 1189 RTE meat products with a compliance rate of 99.7%. Overall, *L. monocytogenes* was detected in nine samples, however only three posed potential health risks due to their product categories (three Category 1 products). *Salmonella* spp. was not detected in any of the 444 domestic or 133 imported samples analyzed. Likewise, *E. coli* O157:H7 was not detected in any of the fermented products containing beef (five domestic and two imported) that were analyzed.

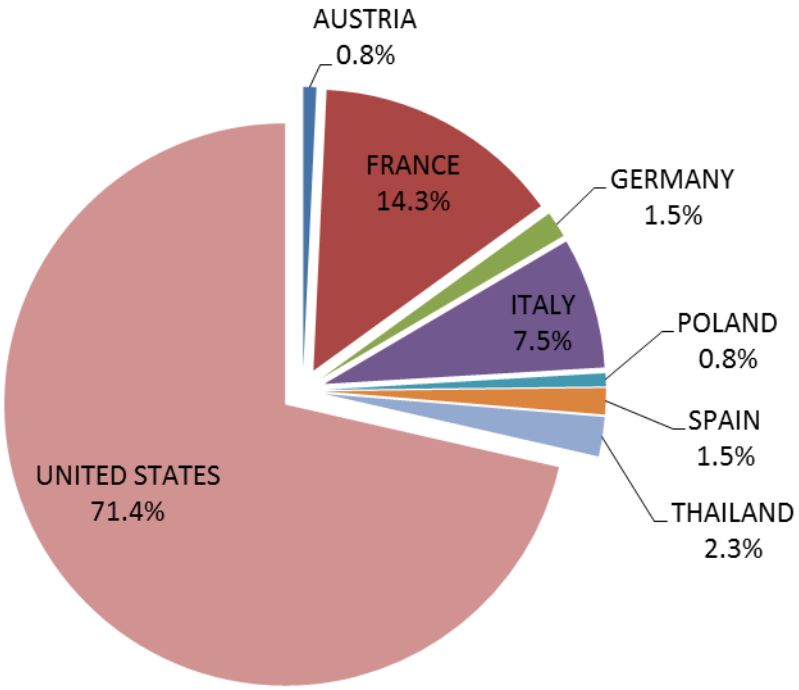

Figure 2: Percent Distribution of Imported Ready-To-Eat Meat Products Analyzed by Country of Origin

Table 5: Assessment of Domestic and Imported Ready-To-Eat Meat Products by Pathogen

Pathogen	# Tests	# Samples	# Satisfactory	# Investigative [a]	# Unsatisfactory	% Compliance
Domestic						
L. monocytogenes [b,c]	1056	1056	1048	5	3	99.7
Salmonella spp.	444	444	444	n/a	0	100
E. coli O157:H7	5	5	5	n/a	0	100
Overall [d]	**1505**	**1056**	**1048**	**5**	**3**	**99.7**
Imported						
L. monocytogenes [b]	133	133	132	1	0	100
Salmonella spp.	133	133	133	n/a	0	100
E. coli O157:H7	2	2	2	n/a	0	100
Overall [d]	**268**	**133**	**132**	**1**	**0**	**100**
Total Overall	**1773**	**1189**	**1180**	**6**	**3**	**99.7**

[a] n/a = not applicable. The assessment (Investigative) does not apply to the corresponding microbial hazard.
[b] Investigative = low levels of *L. monocytogenes* were detected in Category 2 products; Unsatisfactory = *L. monocytogenes* was detected in Category 1 products.
[c] The number of domestic samples tested for *L. monocytogenes* exceeds the number of samples tested for *Salmonella* spp. because samples taken under the Risk-based sampling were only subjected to *L. monocytogenes* testing.
[d] The overall number of tests is equal to the sum of tests for each pathogen. All other "overall" values may not equal the sum of the values due to the fact that individual samples may be subjected to multiple tests and may test positive for more than one pathogen.

Table 6: *Listeria monocytogenes* Detected in Domestic and Imported Ready-To-Eat Meat Products.

Assessment [a]	Product Category	Product Type	Country of Origin	Date Sampled (y/m/d)	PFGE AscI Pattern	PFGE ApaI Pattern
Unsatisfactory	1	Chicken Breast	Canada	2014-02-26	LMACI.0004	LMAAI.0013
Investigative	2B	Chicken Breasts; frozen, seasoned pre-cooked boneless, skinless	Canada	2013-07-04	LMACI.0004	LMAAI.0013
Investigative	2B	Toscano Salami	Italy	2013-08-09	LMACI.0036	LMAAI.0563
Unsatisfactory	1	Regular Salami	Canada	2014-02-19	LMACI.0060	LMAAI.0204
Unsatisfactory	1	Pizza Submarine	Canada	2013-09-04	LMACI.0340	LMAAI.1153
Investigative	2B	Chicken Nuggets	Canada	2013-09-24	LMACI.0351	LMAAI.1160
Investigative	2B	Pizza Pockets	Canada	2013-07-30	LMACI.0364	LMAAI.0393
Investigative	2B	Whole Prosciutto Ham	Canada	2013-12-09	LMACI.0622	LMAAI.0223
Investigative	2B	Cured Pork Sausage	Canada	2013-10-21	LMACI.0708	LMAAI.0665

[a] Investigative = low levels of *L. monocytogenes* were detected in Category 2 products; Unsatisfactory = *L. monocytogenes* was detected in Category 1 products. All samples were enumerated as $\leq$ 5 CFU/g.

The *L. monocytogenes* detected in the nine samples were further tested to identify its PFGE patterns (Table 6). Of these, two contained *L. monocytogenes* of the same PFGE pattern (LMACI.0004 / LMAAI.0013). Although these two samples were chicken products they were taken at different points in time (July 2013 and February 2014) and not from the same processing establishment. Therefore, they were not subject to a common source of contamination. The remaining products contained *L. monocytogenes* with PFGE patterns not present in other products, making them distinct due to differences in their DNA.

Using data gathered over a seven year period the estimated prevalence for each microbial hazard tested was calculated (Table 7), and individually determined to be less than 0.8%. In 2009 the number of samples taken for analysis was increased in response to the Canadian 2008 Listeria outbreak. This was one of several tools implemented by CFIA to increase the monitoring of foods deemed to be of a higher risk in causing listeriosis in humans. In addition to the current testing for *Salmonella* spp., *L. monocytogenes* and *E. coli* O157:H7 in RTE meats, historical testing for generic *E. coli* and *S. aureus* has also been performed. In 2011 the latter two tests were discontinued because (i) there were very few positives being detected, (ii) the United States had ceased performing these analyses in RTE meat products, and (iii) prioritization of sampling and testing activities based on risk to human health. During the four years of this seven year period in which generic *E. coli* and *S. aureus* were tested (2007/08 to 2010/11), 4700 samples were analyzed and only five were assessed as investigative or unsatisfactory, resulting in estimated prevalence rates of 0.06% and 0.04%, respectively. Due to the number of samples analyzed the true prevalence range, based on levels indicative of notable deviations from sanitary practices, was calculated as 0.02-0.19% for generic *E. coli* and 0.01-0.16% for *S. aureus*.

Since *L. monocytogenes* and *Salmonella* spp. pose a high risk to human health, testing for these pathogens in RTE meats has been continuously performed since 2007/08. In that seven year period, 8428 and 6480 samples were analysed for *L. monocytogenes* and *Salmonella* spp., respectively. Prior to 2011/12 there was zero tolerance for *L. monocytogenes* in RTE meat products. However, starting in 2011/12, products could be classified as Category 1 or Category 2 as per the HC Listeria Policy (HC, 2011) which indicates low levels of *L. monocytogenes* (<100 CFU/g) in Category 2 products does not pose a health risk. Taking a precautionary approach, samples of Category 2 products in which *L. monocytogenes* is detected, but <100 CFU/g, are assessed as investigative by the CFIA. Using the number of investigative and unsatisfactory results for *L. monocytogenes*, the prevalence rate has been estimated to be 0.74% with a true prevalence range of 0.57-0.94%. In addition, the prevalence rate for *Salmonella* spp. is estimated to be 0.09% with a true prevalence range of 0.04-0.20%. During this period, 223 RTE fermented meat

products containing beef were tested for *E. coli* O157:H7. Since no *E. coli* O157:H7 was detected, the estimated prevalence is calculated to be 0.0%, however this must be interpreted with caution due to the limited number of samples analyzed. The low number of samples also affected the true prevalence range of 0-1.69%, making it quite broad. For this particular hazard, significantly more products need to be tested to gain a more accurate estimate of its prevalence in these types of products within Canada and will continue to be monitored over time.

Table 7: Estimated Prevalence and True Prevalence Range (at 95% Confidence Interval [CI]) of generic *E. coli*, *E. coli* O157:H7, *Salmonella* spp., *Listeria monocytogenes* and *Staphylococcus aureus* in Ready-to-Eat Meat Product Samples Analyzed Over a Seven-Year Time Period.

Fiscal Year	Number of Samples Analyzed for Each Hazard				
	generic *E. coli*	*E. coli* O157:H7	*Salmonella* spp.	*Listeria monocytogenes*	*Staphylococcus aureus*
2007/2008	668	65	668	668	668
2008/2009	892	41	892	895	892
2009/2010	1607	53	1607	1610	1607
2010/2011	1532	42	1532	1537	1532
2011/2012	1	10	594	1293	0
2012/2013	0	4	610	1236	0
2013/2014	0	8	577	1189	0
Total Number	**4700**	**223**	**6480**	**8428**	**4699**
Number Positive	**3**	**0**	**6**	**62**	**2**
Estimated Prevalence	**0.06%**	**0.00%**	**0.09%**	**0.74%**	**0.04%**
True Prevalence at 95% CI	**0.02-0.19%**	**0-1.69%**	**0.04-0.20%**	**0.57-0.94%**	**0.01-0.16%**

7.2. *Precursor Materials and Raw Ground Beef/Veal*

In addition to the traditional trimmings from cuts (e.g. pieces of meat remaining after steaks and roasts are removed) and boneless chucks, which are typically used as the primary ingredients in raw ground beef products, this fiscal year precursor materials such as coarse ground beef, hearts, head meat, and cheek meat were added to CFIA's monitoring program. Although these types of materials are not extensively used and may not be present in all ground meat products, their potential to introduce pathogens into ground meat products has been identified and therefore verification of their processing controls has been implemented.

The production of ground meat products involves the pooling of meat from multiple animals prior to grinding. During the grinding process bacteria present on the surface of the intact cuts and trims can easily be distributed throughout the meat. The grinding process minces and mixes the meat increasing the surface area available for microorganisms to grow. For ground meat products this is the most likely point in production for cross contamination to occur, and all establishments producing raw ground beef or veal are sampled under monitoring activities.

Precursor materials and ground products are tested for *E. coli* O157:H7 as well as generic *E. coli*. Although generic *E. coli* does not pose a health risk, it is used as an indication of sanitary control in the plant. In 2013/14, a total of 2948 analytical tests were performed on 810 domestic precursor material and 664 domestic ground beef/veal samples (Table 8). Of the domestic samples, seven precursor material and 28 ground product samples were assessed as investigative due to the presence of elevated levels of generic *E. coli* (>100 CFU/g). However, no *E. coli* O157:H7 was detected and the domestic precursor material and ground products were 100% compliant. Due to extensive domestic production, comparatively small amounts of these products are imported and as such, few imported products were selected for analyses: fifteen samples of precursor materials and twelve samples of ground meat. No generic *E. coli* or *E. coli* O157:H7 was detected in any of the imported products, however due to the limited number of samples the 100% compliance rate should be interpreted with caution.

As depicted in Figure 3, 99.2% of the domestic and imported precursor materials were assessed as satisfactory, due to the absence of generic *E. coli* and *E. coli* O157:H7, and 0.8% as investigative due to elevated levels of generic *E coli*. Conversely, 95.9% of the domestic and imported raw ground beef/veal products were assessed as satisfactory and 4.1% as investigative due to elevated levels of generic *E. coli*. *E. coli* O157:H7 was not detected in any of the samples, therefore all samples were deemed to be compliant.

Table 8: Compliance Rates of Domestic and Imported Precursor Material (PM) and Raw Ground Meat (Beef/Veal)

Product Type	# Tests [a]	# Samples	# Satisfactory	# Investigative [b]	# Unsatisfactory [b]	% Compliance
Domestic PM	1620	810	803	7	0	100
Domestic Ground Meat	1328	664	636	28	0	100
Imported PM [c]	30	15	15	0	0	100
Imported Ground Meat [c]	24	12	12	0	0	100
Overall	**3002**	**1501**	**1466**	**35**	**0**	**100**

[a] All samples were tested for generic *E. coli* and *E. coli* O157:H7, therefore the number of tests is twice the number of samples.
[b] Investigative = generic *E. coli* >100 CFU/g detected; Unsatisfactory = *E. coli* O157:H7 detected.
[c] Due to small sample numbers, the significance of these results should be interpreted with caution.

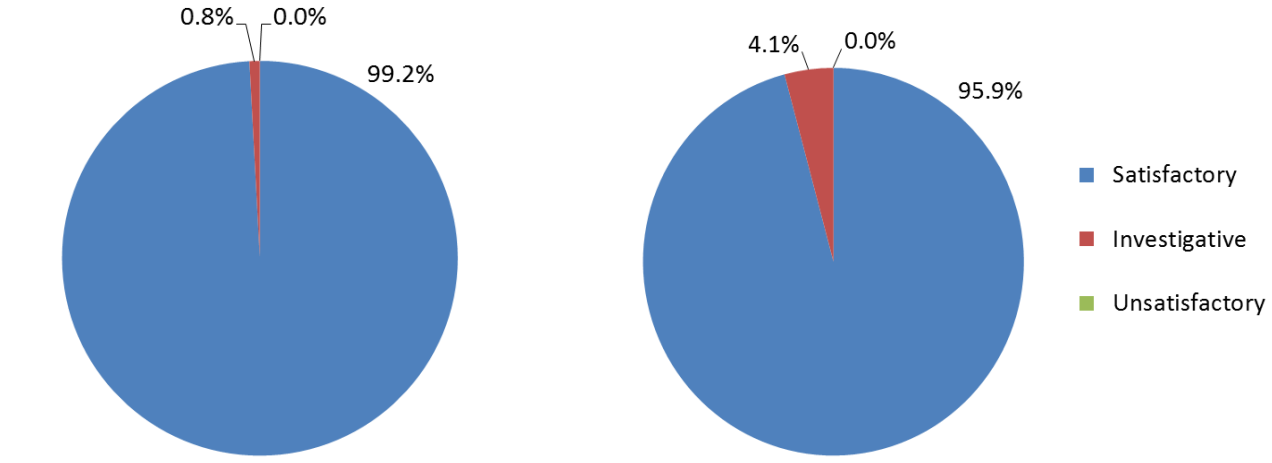

Figure 3: Microbial Assessment (%) of Domestic and Imported Raw (A) Precursor Material and (B) Ground Beef/Veal

Overall, 3002 tests were performed on 1501 precursor material and raw ground beef/veal products, and determined to be 100% compliant. Due to large Canadian production, the majority of samples collected were produced domestically. However samples originating from the United States, Australia, New Zealand and Uruguay were also analyzed (Table 9).

Table 9: **Number of Imported Precursor Material and Raw Ground Beef/Veal Samples Analyzed by Country of Origin**

Product Type	Country of Origin	# Samples	% Compliance [a]
Precursor Material	AUSTRALIA	8	100
Precursor Material	NEW ZEALAND	4	100
Precursor Material	UNITED STATES	2	100
Precursor Material	URUGUAY	1	100
Ground Meat	NEW ZEALAND	1	100
Ground Meat	UNITED STATES	11	100

[a] Due to small sample numbers, the significance of these results should be interpreted with caution.

Elevated levels of generic *E. coli* (>100 CFU/g) are used to indicate a breakdown in sanitation procedures within processing establishments. During 2013/14, no elevated levels of generic *E. coli* were detected in any of the imported samples. However, as previously mentioned, elevated levels (>100 CFU/g) were detected in seven domestic precursor materials and 28 domestic ground beef/veal samples. The detection of generic *E. coli* ranged from 100 CFU/g to 61 000 CFU/g (Table 10), with 28 of the 35 samples assessed as containing less than 1000 CFU/g. Since generic *E. coli* does not represent a health risk and the end product is expected to be thoroughly cooked by the consumer (HC, 2013), these samples were assessed as investigative but deemed to be compliant. The elevated levels of generic *E. coli* indicate the presence of a sanitary issue that needs to be corrected. Typically, as the degree of sanitary non-compliance increases, the level of generic *E. coli* detected in the food increases. Of the 35 samples identified, two samples contained relatively high levels (18 000 and 61 000 CFU/g) of generic *E. coli* as compared to the majority of the samples (n=28; 80%) which contained less than 1000 CFU/g. Hence, it may be interpreted that 5.7% (2/35) of the investigative samples, or 0.1% (2/1501) of the total number of samples, were produced in facilities with heightened sanitary issues.

Table 10: Levels [a] of generic *E. coli* Detected in Domestic Raw Precursor Material (PM) and Ground Beef/Veal Samples

Product Type	Date Sampled (y/m/d)	Level (CFU/g)
Beef Trim (PM)	2013-10-09	200
Beef Trim (PM)	2013-05-01	250
Beef Trim (PM)	2013-09-30	400
Finely Textured Beef (PM)	2014-03-04	110
Finely Textured Beef (PM)	2013-09-19	180
85% Ground Beef (with soya)	2013-08-08	180
Beef Burger (with spices)	2013-05-27	180
Ground Beef	2013-07-23	110
Ground Beef, Raw	2013-12-17	140
Ground Beef	2014-02-18	160
Ground Beef	2013-05-27	280
Ground Beef	2013-10-23	310
Ground Beef, Raw	2013-09-25	410
Ground Beef	2013-08-20	520
Ground Beef	2013-05-23	1500
Ground Beef, Fresh	2013-08-07	4600
Hamburger Patties	2013-04-16	240
Lean Ground Beef	2013-09-25	>100
Lean Ground Beef	2013-10-02	190
Lean Ground Beef	2013-12-04	330
Lean Ground Beef	2014-02-25	480
Lean Ground Beef	2013-06-25	680
Lean Ground Beef	2013-10-30	960
Lean Ground Beef	2013-11-06	4900
Lean Ground Beef	2013-06-25	18000
Lean Ground Beef	2013-08-15	61000
Medium Ground Beef	2013-10-03	>100
Medium Ground Beef	2013-08-20	103
Medium Ground Beef, Frozen	2014-02-03	170
Medium Ground Beef	2013-05-07	720
Medium Ground Beef	2013-12-10	2500
Medium Ground Beef	2013-09-11	5300
Veal Trim (PM)	2014-01-08	110
Veal Trim (PM)	2013-07-31	200
Uncooked Breaded Formed Veal Cutlets	2013-10-17	190

[a] Elevated levels (>100 CFU/g) of generic *E. coli* were detected.

Table 11: **Estimated Prevalence and True Prevalence Range (at 95% Confidence Interval [CI]) of generic *E. coli* and *E. coli* O157:H7 in Precursor Material and Ground Beef/Veal Samples Analyzed Over a Seven-Year Time Period.**

Fiscal Year	Number of Samples Analyzed for Each Hazard	
	generic *E. coli*	*E. coli* O157:H7
Precursor Materials		
2007/2008	36	37
2008/2009	389	384
2009/2010	311	308
2010/2011	288	289
2011/2012	277	277
2012/2013	259	259
2013/2014	827	827
Total Number	**2387**	**2381**
Number Positive	**48**	**14**
Estimated Prevalence	**2.01%**	**0.59%**
True Prevalence at 95% CI	**1.52-2.66%**	**0.35-0.98%**
Ground Beef/Veal		
2007/2008	361	355
2008/2009	622	613
2009/2010	564	561
2010/2011	574	572
2011/2012	615	615
2012/2013	636	636
2013/2014	679	679
Total Number	**4051**	**4031**
Number Positive	**176**	**15**
Estimated Prevalence	**4.34%**	**0.37%**
True Prevalence at 95% CI	**3.76-5.02%**	**0.23-0.61%**

Since 2007/08 over 2300 samples of precursor materials have been tested for generic *E. coli* and *E. coli* O157:H7 (Table 11). From this data the estimated prevalence of generic *E. coli*, based on levels indicating a deviation from proper sanitary procedures, has been calculated as 2.01% with a true prevalence range of 1.52-2.66%. As well the estimated prevalence of *E. coli* O157:H7 in precursor material has been calculated as 0.59% with a true prevalence range of 0.35-0.98%. During this same time period over 4000 samples of ground beef and veal were also tested for generic *E. coli* and *E. coli* O157:H7. This data indicates an estimated prevalence of 4.34% for generic *E. coli* and 0.37% for *E. coli* O157:H7 along with true prevalence ranges of 3.76-5.02% and 0.23-0.61%, respectively. For both food types the prevalence of generic *E. coli* was greater than that for *E. coli* O157:H7. However, generic *E. coli* is used as an indicator of sanitary control and does not create an immediate food safety concern. Contrarily, *E. coli* O157:H7 does pose a

concern to consumer health but has an estimated prevalence of less than 0.6% in both of these food types.

7.3. *Raw Mechanically Separated and Finely Textured Beef*

The CFIA tests mechanically separated beef and finely textured beef to verify the absence of CNS tissue. The presence of CNS tissue implies that bones from the vertebral column have been included in the meat product and there is potential for the presence of brain tissue. If a product in distribution is found to contain CNS tissue, it will be recalled. If the product is not in the markets, it may be sent for edible rendering (e.g. extraction of fats and oils) or disposal.

In Canada, there are three producers of mechanically separated beef and finely textured beef. During 2013/14, 38 samples were tested, of which three were considered to be adulterated due to the presence of central nervous system (CNS) tissue. From 2007/08 to 2013/14, a total of 276 mechanically separated and finely textured beef samples were analyzed for the presence of CNS tissue. In this time frame 11 samples tested positive resulting in an estimated prevalence of 3.99% and a true prevalence range of 2.24-6.99% (Table 12).

Table 12: **Estimated Prevalence and True Prevalence Range (at 95% Confidence Interval [CI]) of Central Nervous System Tissue in Mechanically Separated and Finely Textured Beef Samples Analyzed Over a Seven-Year Time Period.**

Fiscal Year	Number of Samples Analyzed
	Central Nervous System Tissue
2007/2008	27
2008/2009	49
2009/2010	41
2010/2011	43
2011/2012	38
2012/2013	40
2013/2014	38
Total Number	**276**
Number Positive	**11**
Estimated Prevalence	**3.99%**
True Prevalence at 95% CI	**2.24-6.99%**

7.4. *Raw Meat: Pork and Wild Boar*

The results of routine monitoring of Canadian pork indicate the risk of *T. spiralis* infection is virtually nonexistent. However, precautions must remain in effect due to the presence of

T. spiralis in wildlife and the potential for sporadic transfer to domestic herds, and government testing for *T. spiralis* supports the Canadian pork industry's continued access to international markets. The analytical methodology for testing *T. spiralis* in pork allows for tissues from up to 100 animals to be pooled and submitted for analysis. In 2013/14, 332 samples representing 31,617 animals (market hogs, breeder hogs and wild boars) were tested. *T. spiralis* was not detected in any of the samples analyzed. Since 2007/08 over 216,000 animals within the federally regulated system have been sampled (Table 13) and none have tested positive for *T. spiralis*. From this, the estimated prevalence of *T. spiralis* is 0% with a true prevalence range of 0-0.17%, supporting the perception that there is little to no risk to consumers.

Table 13: Estimated Prevalence and True Prevalence Range (at 95% Confidence Interval [CI]) of *Trichinella spiralis* in Raw Pork and Wild Boar Samples Analyzed Over a Seven-Year Time Period.

Fiscal Year	Number of Samples (Animals) Analyzed	
	Trichinella spiralis	
2007/2008	266	(30,092)
2008/2009	318	(30,950)
2009/2010	318	(30,041)
2010/2011	312	(29,567)
2011/2012	318	(32,721)
2012/2013	338	(31,784)
2013/2014	332	(31,617)
Total Number	**2202**	(216,772)
Number Positive	**0**	
Estimated Prevalence	**0.00%**	
True Prevalence at 95% CI	**0-0.17%**	

7.5. *Species Verification*

CFIA uses species verification as both a food safety indicator and an indication of fraud. From a food safety perspective, it is used as an indication of sanitary control within an establishment. The CFIA tests imported meat products with label claims indicating they are composed of a single or a combination of specific species. Selected products are those that have been ground to the point where it is impossible to determine through visual examination what species has been used. This sampling includes raw ground meat products, RTE products and other products which have received heat treatment. Domestic establishments producing such products are subject to visual inspections by CFIA inspectors and domestic samples are taken under directed sampling activities for investigative purposes only. However, imported samples are subject to verification sampling since the conditions of manufacturing in foreign establishments are unknown.

In 2013/14, a total of 65 species verification tests were performed on 19 imported meat products, of which 89.5% were compliant. The two non-compliant samples came from France and Germany (Table 14). Since species verification does not measure microbial contamination, no estimated prevalence was calculated.

Table 14: Number of Imported Single Species Meat Products Analyzed by Country of Origin

Country of Origin	# Samples	# Satisfactory	# Unsatisfactory	% Compliance[c]
FRANCE	2	1	1[a]	50.0[c]
GERMANY	1	0	1[b]	0[c]
SPAIN	1	1	0	100
UNITED STATES	15	15	0	100
Total	**19**	**17**	**2**	**89.5**[c]

[a] Only pork was detected in a product labelled as duck.
[b] Pork and poultry were detected in a product labelled as pork.
[c] Due to small sample numbers, the significance of these results should be interpreted with caution.

7.6. *Environmental Testing in RTE Meat Establishments*

As with the RTE meat products, monitoring and risk-based environmental sampling are carried out at domestic federally registered establishments. For both monitoring and risk-based cases, environmental sampling is linked to the product sampling, meaning both product and environmental samples are taken at the same time. In 2013/14, 1010 environmental samples representing approximately 10,000 food contact surfaces from 219 domestic federally registered establishments producing RTE meat products were analyzed for *Listeria* spp. and *L. monocytogenes*.

Of the 1010 environmental samples analyzed (Figure 4), 1.3% (n=13) were assessed as unsatisfactory due to the detection of *L. monocytogenes*. Overall, 98.7% were compliant with 97.2% of the environmental samples assessed as satisfactory and 1.5% (n=15) as investigative due to the presence of other *Listeria* spp.

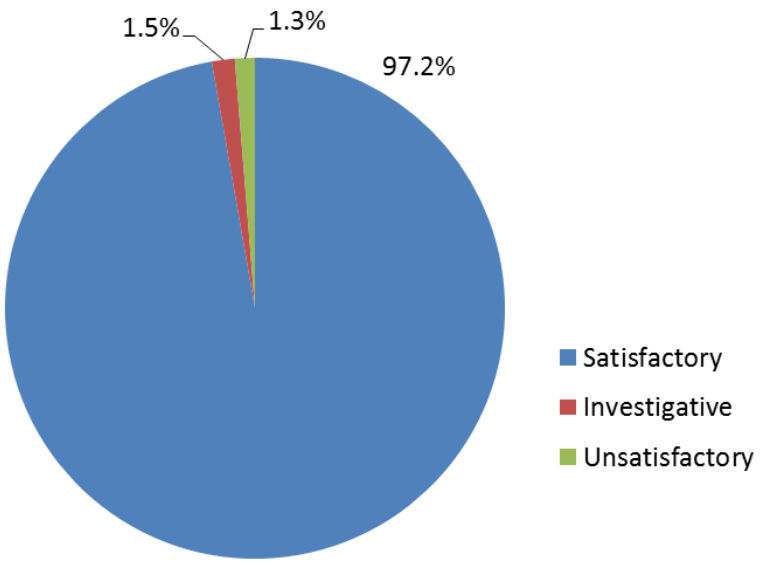

Figure 4: **Environmental Analysis (%) of Domestic Federally Registered Meat Establishments Producing Ready-To-Eat Meat Products**

In the absence of *L. monocytogenes*, the presence of other *Listeria* spp. results in an investigative assessment since these species do not induce illness in humans but do indicate a lack of sanitary control. Contrarily, the presence of *L. monocytogenes* is not tolerated in the production environment and its detection results in an unsatisfactory assessment. When *Listeria* spp. or *L. monocytogenes* is detected, the establishment is required to implement corrective actions to remove the bacteria from the production environment in order to prevent the contamination of products with *L. monocytogenes*. Additionally, when *L. monocytogenes* is detected a food safety investigation is performed to determine whether or not the associated product poses a health risk to consumers and appropriate action is taken.

The *L. monocytogenes* detected in the thirteen environmental samples were further tested to identify its PFGE patterns (Table 15). Of these, two contained *L. monocytogenes* of the same PFGE pattern LMACI.0001/ LMAAI.0001 and three contained the PFGE pattern LMACI.0004/ LMAAI.0013. However, all five samples were taken from different processing establishments at different points in time, and therefore were not as a result of a common source of contamination. The remaining environmental samples contained *L. monocytogenes* with PFGE patterns not present in others, making them distinct due to differences in their DNA. It is noted that two processing establishments did have one investigative (*Listeria* spp. present) and one unsatisfactory (*L. monocytogenes* present) test result. However, they were taken at different points in time and not related to a common source of contamination within each establishment.

Table 15: Detection of *Listeria* spp. [a] and *Listeria monocytogenes* on Food Contact Surfaces in Domestic Federally Registered Meat Establishments Producing Ready-To-Eat Meat Products

Assessment	Date Sampled (y/m/d)	Species	PFGE AscI Pattern	PFGE ApaI Pattern
Investigative	2013-04-16	*Listeria* spp.	n/a	n/a
Investigative	2013-05-07	*Listeria* spp.	n/a	n/a
Investigative	2013-05-14	*Listeria* spp.	n/a	n/a
Investigative	2013-05-29	*Listeria* spp.	n/a	n/a
Investigative	2013-07-19	*Listeria* spp.	n/a	n/a
Investigative	2013-07-23	*Listeria* spp.	n/a	n/a
Investigative	2013-08-01	*Listeria* spp.	n/a	n/a
Investigative	2013-08-27	*Listeria* spp.	n/a	n/a
Investigative	2013-09-10	*Listeria* spp.	n/a	n/a
Investigative	2013-09-26	*Listeria* spp.	n/a	n/a
Investigative	2013-10-02	*Listeria* spp.	n/a	n/a
Investigative	2013-10-09	*Listeria* spp.	n/a	n/a
Investigative	2013-11-18	*Listeria* spp.	n/a	n/a
Investigative	2013-11-18	*Listeria* spp.	n/a	n/a
Investigative	2014-02-04	*Listeria* spp.	n/a	n/a
Unsatisfactory	2013-09-19	*Listeria monocytogenes*	LMACI.0001	LMAAI.0001
Unsatisfactory	2014-03-18	*Listeria monocytogenes*	LMACI.0001	LMAAI.0001
Unsatisfactory	2013-07-04	*Listeria monocytogenes*	LMACI.0004	LMAAI.0013
Unsatisfactory	2013-09-18	*Listeria monocytogenes*	LMACI.0004	LMAAI.0013
Unsatisfactory	2014-02-26	*Listeria monocytogenes*	LMACI.0004	LMAAI.0013
Unsatisfactory	2013-07-10	*Listeria monocytogenes*	LMACI.0015	LMAAI.0024
Unsatisfactory	2013-05-29	*Listeria monocytogenes*	LMACI.0016	LMAAI.0648
Unsatisfactory	2013-06-17	*Listeria monocytogenes*	LMACI.0045	LMAAI.0287
Unsatisfactory	2014-03-18	*Listeria monocytogenes*	LMACI.0337	LMAAI.0489
Unsatisfactory	2013-11-19	*Listeria monocytogenes*	LMACI.0364	LMAAI.0393
Unsatisfactory	2013-06-17	*Listeria monocytogenes*	LMACI.0478	LMAAI.1130
Unsatisfactory	2013-10-21	*Listeria monocytogenes*	LMACI.0708	LMAAI.0665
Unsatisfactory	2014-01-06	*Listeria monocytogenes*	LMACI.0811	LMAAI.0287

[a] In the absence of *Listeria monocytogenes*, which is the only *Listeria* spp. known to cause human illness, *Listeria* spp. are not further identified and these samples are assessed as Investigative.

From 2007/08 to 2013/14, a total of 5758 composite samples representing over 55 000 environmental swabs taken from food contact surfaces of establishments producing RTE meat products were analyzed for *Listeria monocytogenes* (Table 16). This environmental sampling was initiated just prior to the start of 2009/10 in response to the Canadian 2008 Listeria outbreak, as a means of enhancing CFIA's monitoring activities for the potential contamination of RTE meat products with *L. monocytogenes*. Of these, 82 samples tested positive for *L. monocytogenes* resulting in a calculated estimated prevalence of 1.42% with a true prevalence range of 1.15-

1.76%. Comparing these results to calculations presented for RTE meat products (0.74% estimated prevalence with a true prevalence range of 0.57-0.94%; Table 7) it may be concluded that domestic establishments have effective procedures in place to minimize the contamination of their meat products with *L. monocytogenes*.

Table 16: **Estimated Prevalence and True Prevalence Range (at 95% Confidence Interval [CI]) of *Listeria* spp. and *Listeria monocytogenes* on Food Contact Surfaces in Domestic Federally Registered Meat Establishments Producing Ready-To-Eat Meat Products Analyzed Over a Seven-Year Time Period.**

Fiscal Year	Number of Samples [a] Analyzed for Each Hazard	
	Listeria spp.	*Listeria monocytogenes*
2007/2008	0	0
2008/2009	0	148
2009/2010	0	1254
2010/2011	0	1272
2011/2012	1039	1069
2012/2013	1000	1005
2013/2014	995	1010
Total Number	**3034**	**5758**
Number Positive	**105**	**82**
Estimated Prevalence	**3.46%**	**1.42%**
True Prevalence at 95% CI	**2.87-4.17%**	**1.15-1.76%**

[a] Each sample analyzed is a composite of up to10 swabs sampling different surfaces.

In 2011, in support of the HC Listeria Policy (HC, 2011), testing for *Listeria* spp. was added to these sampling and testing activities. Although these species do not induce illness in humans they thrive in environments that are also capable of supporting *L. monocytogenes*. Therefore, monitoring for their presence is a proactive approach to identifying conditions under which *L. monocytogenes* could thrive, and implementing corrective actions before the establishment of *L. monocytogenes* within the manufacturing environment. Over the three years, this testing has been performed on more than 3000 composite samples, representing over 30,000 food contact surfaces, of which 105 tested positive for *Listeria* spp. other than *L. monocytogenes*. From this data, *Listeria* spp. has a calculated estimated prevalence of 3.46% and a true prevalence range of 2.87-4.17% in domestic establishments producing RTE meat products. In these types of manufacturing environments the prevalence of *Listeria* spp. was greater than that for *L. monocytogenes*. However, *Listeria* spp. is used as an indicator of sanitary control and does not indicate an immediate food safety concern. Monitoring for both microorganisms in these environments will continue to be performed.

7.7. *Linked Product and Environmental Testing in RTE Meat Establishments*

Within the domestic RTE meat establishments, environmental swabs and product samples were taken simultaneously for both monitoring and risk-based sampling. While the RTE meat products were tested for *L. monocytogenes* and other pathogens, the environmental swabs were only tested for *Listeria* spp. and *L. monocytogenes*. Therefore, when comparing the results of linked product and environmental samples, only the presence/absence of *Listeria* spp. and *L. monocytogenes* can be addressed.

Of the 1010 environmental swabs analyzed, 26 did not have corresponding product analyzed for various reasons including the product being unfit for analysis upon arrival at the lab. Therefore, 984 environmental-product pairs were tested of which three pairs contained environmental swabs and RTE meat product that tested positive for *L. monocytogenes* (Table 17). In fifteen pairs, *Listeria* spp. was detected in the environmental swabs while *L. monocytogenes* was not detected in the product. A further ten pairs had *L. monocytogenes* detected in the environmental swabs, while it was not detected in the RTE meat product. In contrast, five pairs showed RTE meat products that tested positive for *L. monocytogenes*, though it was not detected in the environmental swabs. *L. monocytogenes* was not detected in the remaining 951 environmental-product pairs.

Table 17: The Number of Linked Environmental and RTE Meat Product Sample Pairs by Category of Analysis

Product Analytical Results for *L. monocytogenes*	**Environmental Analytical Results**		
	***Listeria* spp. – Not Detected (including *L. mono*)**	***Listeria* spp. - Detected & *L. mono* - Not Detected**	***L. mono* - Detected** [a]
Not Detected	951	15	10
Detected	5	0	3

[a] When *L. monocytogenes* is detected no further analysis is conducted to determine if other *Listeria* spp. are present.

8. Shell Eggs and Egg Products

Typically, shell eggs are either cooked in-shell or the internal edible portion is removed from the shell and further cooked by the consumer. Since the internal edible portion of the egg is protected by the external shell, cross contamination typically takes place during preparation in the consumers' home. Therefore, CFIA does not perform routine microbiological testing of shell eggs in domestic shell egg grading stations. However, because domestic shell egg grading stations are federally registered, they are subject to routine inspections and environmental testing to verify the adequacy of sanitary practices. In contrast, CFIA routinely tests imported shell eggs for *Salmonella* spp. since it is unable to inspect foreign establishments.

In Canada, eggs are graded, sized and packed at egg grading stations. Therefore, environmental testing at these stations is a valuable tool to monitor the sanitary conditions under which eggs are processed and the potential for their microbial contamination prior to being shipped to market. Within these stations, surface swabs from food contact or non-food contact surfaces along the production lines designated for ungraded and graded eggs are tested for *Salmonella* spp. In addition, egg wash water and water from basket washers, which is commonly recirculated for use, are also sampled and tested for ACC.

Under the NMMP, domestic and imported processed egg products are tested for ACC, coliforms, *L. monocytogenes* and *Salmonella* spp. In domestic egg product processing establishments, environmental sampling primarily includes the random selection and swabbing of food contact surfaces or non-food contact surfaces prior to the start of production or during production. The samples taken prior to production are tested for *Salmonella* spp., while samples taken during production are tested for *Salmonella* spp. and *L. monocytogenes*. Periodically, egg wash water and water from basket washers from these establishments may be submitted and analysed for ACC.

Comparing the data presented in NMMP's published reports it is seen that shell eggs, egg products and associated environmental testing have been highly compliant with national food safety standards over the past three years (Table 18). In 2011/12, 2012/13 and 2013/14, shell eggs and egg products were deemed to have very high compliance rates of 99.4%, 100% and 99.5%, respectively. The consistency and high levels of compliance (>99%) assure consumers that shell eggs and egg products available on the Canadian market are very safe for consumption. Environmental testing performed within domestic egg grading stations and egg product processing establishments over this time period showed compliance levels of 95.3%, 95.5% and 95.9% in 2011/12, 2012/13 and 2013/14, respectively. These lower rates of compliance are due to the frequent detection of high levels of ACC in the wash water samples. Although the environmental sampling was of a lower compliance rate than the products, its consistency indicates a stable and controlled system.

Table 18: Summary of NMMP Published Data for Imported Shell Eggs, Domestic and Imported Egg Products and Environmental Testing in Domestic Federally Registered Egg Grading Stations and Processed Egg Processing Establishments

Fiscal Year	# Tests	# Samples	# Unsatisfactory	% Compliance
Shell Eggs & Egg Products				
2011/12	1675	659	4	99.4
2012/13	1466	602	0	100
2013/14	1523	631	3	99.5
Overall [a] Products	**4664**	**1892**	**7**	**99.6**
Environmental [b]				
2011/12	1186	764	36	95.3
2012/13	1197	758	34	95.5
2013/14	813	760	31	95.9
Overall [a] Environmental	**3196**	**2282**	**101**	**95.6**

[a] The overall number of tests is equal to the sum of tests for each pathogen. All other "overall" values may not equal the sum of the values due to the fact that individual samples may be subjected to multiple tests and may test positive for more than one pathogen.

[b] The number of tests displayed for 2011/12 and 2012/13 are as they are reported in the corresponding annual reports and may be proportionally greater than that reported in 2013/14 due to the manner in which the tests were calculated (i.e. whether or not the analyses of each of the ten subsamples were counted as one or ten analyses).

8.1. *Shell Eggs*

The United States is the sole exporter of shell eggs to Canada. In 2013/14, a total of 302 imported samples were subjected to 302 tests for *Salmonella* spp. No *Salmonella* spp. was detected. Results of the environmental testing performed in domestic shell egg grading stations are discussed below in section 8.3.

From 2007/08 to 2013/14, a total of 2156 imported shell eggs were tested for *Salmonella* spp. (Table 19). Of these, only one sample tested positive resulting in a calculated estimated prevalence of 0.05% with a true prevalence range of 0.01-0.26%.

Table 19: **Estimated Prevalence and True Prevalence Range (at 95% Confidence Interval [CI]) of *Salmonella* spp. on Imported Shell Eggs Analyzed Over a Seven-Year Time Period.**

Fiscal Year	Number of Samples Analyzed
	***Salmonella* spp.**
2007/2008	247
2008/2009	304
2009/2010	337
2010/2011	348
2011/2012	330
2012/2013	291
2013/2014	299
Total Number	**2156**
Number Positive	**1**
Estimated Prevalence	**0.05%**
True Prevalence at 95% CI	**0.01-0.26%**

8.2. *Egg Products*

Egg products include all frozen, liquid, or dried egg products which are subjected to the process of breaking and pasteurization (Manitoba Egg Farmers, 2011). Some are made available directly to the public at retail, while others are used by the foodservice and food manufacturing industries.

In 2013/14, in addition to the domestic and imported egg products tested for ACC, coliforms, *L. monocytogenes* and *Salmonella* spp., some domestic egg product samples (n=54) were taken at the same time as environmental swabs, and analyzed for *L. monocytogenes* and *Salmonella* spp. In total, 1177 tests were performed on 318 domestic egg products, of which 99.1% were deemed compliant (Table 20). In addition, since the United States is Canada's only source of imported egg products, and due to limited import volumes, 11 egg products from the United States were subjected to 44 tests, all of which were 100% compliant. Overall, 1221 tests were performed on 329 domestic and imported egg products with a 99.1% compliance rate. Three domestic samples were assessed as unsatisfactory because of elevated levels of indicator organisms (ACC and coliforms) and not because of pathogenic organisms, *L. monocytogenes* and *Salmonella* spp. No *Salmonella* spp. was detected in any of the domestic or imported samples. *L. monocytogenes* was detected in one domestic sample (Category 2B product) but did not pose a health risk and was assessed as investigative.

Table 20: **Compliance Rates of Domestic and Imported Processed Egg Products**

Pathogen	# Tests	# Samples	# Satisfactory	# Investigative [c]	# Unsatisfactory	% Compliance
Domestic [a]						
ACC	269	269	267	n/a	2	99.3
Coliforms	269	269	268	n/a	1	99.6
L. monocytogenes	318	318	317	1	0	100
Salmonella spp.	318	318	318	n/a	0	100
Overall [b]	**1177**	**318**	**314**	**1**	**3**	**99.1**
Imported [d]						
ACC	11	11	11	n/a	0	100
Coliforms	11	11	11	n/a	0	100
L. monocytogenes	11	11	11	0	0	100
Salmonella spp.	11	11	11	n/a	0	100
Overall [b]	**44**	**11**	**11**	**0**	**0**	**100**
Total Overall	**1221**	**329**	**325**	**1**	**3**	**99.1**

[a] The number of domestic samples tested for *L. monocytogenes* and *Salmonella* spp. exceeds the number of samples tested for ACC and coliforms because only these two analyses were performed on product samples taken simultaneously with environmental samples.
[b] The overall number of tests is equal to the sum of tests for each pathogen. All other "overall" values may not equal the sum of the values due to the fact that individual samples may be subjected to multiple tests and may test positive for more than one pathogen.
[c] n/a = not applicable. The assessment (Investigative) does not apply to the corresponding microbial hazard.
[d] Due to small sample numbers, the significance of these results should be interpreted with caution.

Table 21: Levels of ACC and Coliforms Detected in Domestic Processed Egg Products

Product Type	Date Sampled (y/m/d)	Indicator Organism	Level (CFU/g)
Dried Whole Egg	2013-05-23	Coliform count	45
Salt Yolk	2013-10-01	Aerobic colony count	>50000
Salt Mix	2013-10-04	Aerobic colony count	610000

The 0.9% non-compliance in processed egg products was due to two domestic samples with unacceptable aerobic colony counts (ACC) and one domestic sample with an unacceptable level of coliforms (Table 21). Although these organisms do not pose a direct health risk, within these processed products, the levels detected indicate inadequate hygiene or processing during manufacturing to render the final product safe for consumption, therefore these samples were assessed as unsatisfactory. In addition, although deemed to be compliant, one Category 2B sample (frozen salt yolk) was assessed as investigative due to the detection of low levels of *L. monocytogenes* (<5 CFU/g; PFGE pattern: LMACI.0014 / LMAAI.0183).

Table 22: Estimated Prevalence and True Prevalence Range (at 95% Confidence Interval [CI]) of ACC, Coliforms, *Salmonella* spp. and *L. monocytogenes* in Domestic and Imported Processed Egg Products Analyzed Over a Seven-Year Time Period.

Fiscal Year	Number of Samples Analyzed for Each Hazard			
	ACC	Coliforms	*Salmonella* spp.	*Listeria monocytogenes*
2007/2008	327	326	327	325
2008/2009	341	341	341	336
2009/2010	332	332	332	332
2010/2011	367	367	367	367
2011/2012	339	339	344	340
2012/2013	271	270	319	319
2013/2014	280	280	329	329
Total Number	**2257**	**2255**	**2359**	**2348**
Number Positive	**16**	**15**	**1**	**2**
Estimated Prevalence	**0.71%**	**0.67%**	**0.04%**	**0.09%**
True Prevalence at 95% CI	**0.44-1.15%**	**0.40-1.09%**	**0.01-0.24%**	**0.02-0.31%**

From 2007/08 to 2013/14, approximately 2300 domestic and imported processed egg products were analyzed for ACC, coliforms, *Salmonella* spp., and *L. monocytogenes* (Table 22). From the 2257 samples analyzed for ACC, 16 displayed elevated levels resulting in an estimated prevalence of 0.71% with a true prevalence range of 0.44-1.15%. Similarly, of the 2255 samples analyzed for coliforms, 15 displayed elevated levels resulting in an estimated prevalence of 0.67% and a true prevalence rage of 0.40-1.09%. As previously stated, these indicator organisms do not pose a direct health risk, but are used to verify effective hygiene and manufacturing processes (i.e. pasteurization) are in place to render the final product safe for consumption. During this time period, 2359 samples were analyzed for *Salmonella* spp., of which only one tested positive. As a result, the estimated prevalence was 0.04% with a true prevalence range of 0.01-0.24%. Likewise, among the 2348 samples tested for *L. monocytogenes*, only two were deemed to be unsatisfactory due to the presence of this pathogen. Hence, the estimated prevalence was 0.09% with a true prevalence range of 0.02-0.31%. Prior to 2011/12, there was zero tolerance for *L. monocytogenes* in processed egg products. However, starting in 2011/12 products could be classified as Category 1 or Category 2 as per the HC Listeria Policy (HC, 2011). Although the Policy states that low levels of *L. monocytogenes* (<100 CFU/g) in Category 2 products do not pose a health risk, these samples are assessed as investigative by CFIA. Overall, in the processed egg products both pathogens displayed estimated prevalence rates of less than 0.1%, while the indicator organisms had estimated prevalence rates closer to 0.7%.

8.3. *Environmental Testing in Domestic Shell Egg Grading Stations and Egg Product Processing Establishments*

Within domestic shell egg grading stations and egg product processing establishments, there are four points in the production environment which are sampled in order to verify sanitary controls. These are: water used to wash the eggs, water used to wash the baskets containing the eggs, food contact surfaces and non-food contact surfaces. In 2013/14, a total of 813 tests were performed on 760 environmental samples, including wash water and surface swabs (Table 23). The overall compliance rate was 95.9% with 31 samples deemed unsatisfactory.

At domestic shell egg grading stations, surface swabs are taken on food contact surfaces within the production areas designated for the graded eggs and may also be taken on food contact or non-food contact surfaces in the areas designated for ungraded eggs. In total, 361 tests for *Salmonella* spp. were performed on 361 environmental swab samples (Table 23), representing approximately 3600 surfaces within shell egg grading establishments. Of these, 97.8% were compliant, due to the detection of *Salmonella* spp. in eight samples.

Table 23: Compliance Rates of Environmental Samples from Domestic Shell Egg Grading Stations and Egg Product Processing Establishments

Sample Type	# Tests	# Samples	# Satisfactory	# Unsatisfactory	% Compliance
Shell Egg Environmental Swabs	361	361	353	8	97.8
Egg Product Environmental Swabs	107 [b]	54	51	3	94.4 [a]
Basket Washer/Egg Wash Water	345	345	325	20	94.2
Overall	**813**	**760**	**729**	**31**	**95.9**

[a] Due to small sample numbers, the significance of these results should be interpreted with caution.
[b] Due to the location of sampling environmental swabs taken in egg product processing establishments were tested either for *Salmonella* spp. and *L. monocytogenes*, or only for *Salmonella* spp.

In domestic egg product processing establishments, surface swabs are taken on food contact surfaces and non-food contact surfaces along the manufacturing line, both prior to production and during production. Samples taken prior to production were tested for *Salmonella* spp., while samples taken during production were tested for *Salmonella* spp. and *L. monocytogenes*. A total of 107 tests were performed on 54 samples (Table 23), representing approximately 540 surfaces within the processing establishments. Of these, three samples tested positive for *Salmonella* spp. for an overall compliance rate of 94.4%. *L. monocytogenes* was not detected in any of the samples.

A variety of *Salmonella* spp. were detected on food contact and non-food contact surfaces in both grading stations and processing establishments (Table 24). However, the same species were not found in both types of establishments. *Salmonella* Agona, Braenderup, Heidelberg, Infantis and Johannesburg were detected in egg grading stations, while *Salmonella* Cerro, Enteritidis and Ohio were detected in egg product processing establishments. The food contact surfaces sampled on October 22, 2013 and March 11, 2014 that tested positive for *Salmonella* Heidelberg were from the same shell egg grading station, indicating a possible recurrent or systemic environmental hygiene issue that was investigated and corrected by the establishment.

Table 24: *Salmonella* Serotypes Detected on Food Contact and Non-Food Contact Surfaces in Domestic Shell Egg Grading Stations and Egg Product Processing Establishments

Environmental Location	Date Sampled (y/m/d)	*Salmonella* Serotype
Shell Egg Grading Station		
Non-Food Contact Surface	2013-07-10	*Salmonella* Agona, *Salmonella* Braenderup
Non-Food Contact Surface	2013-07-10	*Salmonella* Braenderup
Food Contact Surface	2013-10-22	*Salmonella* Heidelberg
Food Contact Surface	2014-02-25	*Salmonella* Heidelberg
Food Contact Surface	2014-03-11	*Salmonella* Heidelberg
Food Contact Surface	2013-06-25	*Salmonella* Infantis
Non-Food Contact Surface	2014-03-13	*Salmonella* Johannesburg
Non-Food Contact Surface	2013-08-20	*Salmonella* Johannesburg
Egg Product Processing Establishment		
Food Contact Surface	2013-11-07	*Salmonella* Cerro
Non-Food Contact Surface	2013-09-30	*Salmonella* Enteritidis
Non-Food Contact Surface	2013-09-09	*Salmonella* Ohio

In addition, 345 wash water samples from egg grading stations and processing establishments were subjected to 345 tests for ACC, and determined to be 94.2% compliant (Table 23). Of these, 20 contained high levels of ACC indicating inadequate sanitary practices, ranging from 110 000 to 2 700 000 CFU/g (Table 25). Although not a health concern, the presence of high levels of ACC indicates inadequate practices to ensure the microbial quality of the wash water is controlled.

From 2007/08 to 2013/14, 2691 environmental swabs were taken in domestic shell egg grading stations and tested for *Salmonella* spp., which was detected in 91 samples (Table 26). This data resulted in a calculated prevalence of 3.38% and a true prevalence range of 2.76-4.13%. During this seven-year time period, environmental swabs were also taken in domestic egg product processing establishments and tested for *Salmonella* spp. In total, 371 samples were tested and in nine *Salmonella* spp. was detected (Table 26). The estimated prevalence was calculated to be

2.43% with a true prevalence range of 1.28-4.55%. In 2011, in response to the recommendation to strengthen national surveillance and early detection of foodborne illness made in the Weatherill Report following the Canadian 2008 Listeria outbreak (GoC, 2011) and in support of the HC Listeria Policy (HC, 2011), the testing of *L. monocytogenes* in domestic establishments producing egg products was implemented. Over the three years this activity has been conducted, a total of 144 environmental swabs have been analyzed and *L. monocytogenes* has not been detected in any of them. Hence, the estimated prevalence of 0% and a true prevalence range of 0-2.60%.

Table 25: Levels of ACC Detected in Wash Water Samples from Domestic Egg Grading Stations and Processed Egg Product Establishments

Date Sampled (y/m/d)	Level (CFU/g)
2013-07-03	110,000
2014-01-28	120,000
2013-07-17	130,000
2013-12-19	150,000
2013-12-17	150,000
2013-05-28	160,000
2014-01-22	170,000
2013-09-26	240,000
2013-07-16	275,000
2013-10-31	280,000
2013-07-15	290,000
2013-09-24	460,000
2013-12-11	890,000
2013-12-04	1,100,000
2013-09-24	1,200,000
2014-02-12	1,300,000
2013-05-23	1,500,000
2013-06-19	2,100,000
2014-01-08	2,100,000
2013-07-16	2,700,000

Table 26: Estimated Prevalence and True Prevalence Range (at 95% Confidence Interval [CI]) of *Salmonella* spp. and *L. monocytogenes* on Environmental Swabs, Taken at Domestic Shell Egg Grading Stations and Egg Product Processing Establishments, Analyzed Over a Seven-Year Time Period.

Fiscal Year	Number of Samples Analyzed for Each Hazard		
	Salmonella [a] **spp.**	***Salmonella*** [b, c] **spp.**	***Listeria monocytogenes*** [b, c]
2007/2008	424	52	0
2008/2009	385	50	0
2009/2010	403	58	0
2010/2011	365	52	0
2011/2012	371	51	38
2012/2013	382	54	53
2013/2014	361	54	53
Total Number	**2691**	**371**	**144**
Number Positive	**91**	**9**	**0**
Estimated Prevalence	**3.38%**	**2.43%**	**0%**
True Prevalence at 95% CI	**2.76-4.13%**	**1.28-4.55%**	**0-2.60%**

[a] *Salmonella* spp. on food contact and non-food contact surfaces in shell egg grading stations.
[b] *Salmonella* spp. and *L. monocytogenes* on food contact and non-food contact surfaces in egg product processing establishments.
[c] Due to small sample numbers, the significance of these results should be interpreted with caution.

In addition to the environmental swabs, wash water samples have been taken and analyzed for ACC. Over this seven year time period, 2341 samples have been analyzed and 216 were unsatisfactory due to high levels of ACC (Table 27). From this data, the estimated prevalence is calculated to be 9.23% with a true prevalence range of 8.12-10.47%. Although high levels of ACC do not pose a health risk to consumers, the high rate of prevalence found in these wash water samples suggests the recirculated water used to wash shell eggs and egg baskets poses a potential source of contamination and will continue to be monitored.

Table 27: Estimated Prevalence and True Prevalence Range (at 95% Confidence Interval [CI]) of ACC in Wash Water Samples, Taken at Domestic Shell Egg Grading Stations and Egg Product Processing Establishments, Analyzed Over a Seven-Year Time Period.

Fiscal Year	Number of Samples Analyzed
	Aerobic Colony Count
2007/2008	303
2008/2009	345
2009/2010	403
2010/2011	321
2011/2012	325
2012/2013	313
2013/2014	331
Total Number	**2341**
Number Positive	**216**
Estimated Prevalence	**9.23%**
True Prevalence at 95% CI	**8.12-10.47%**

8.4. *Linked Product and Environmental Testing from Egg Product Processing Establishments*

Within the domestic egg product processing establishments, environmental swabs and product samples were taken simultaneously. The product samples were tested for *Salmonella* spp. and *L. monocytogenes.* The environmental swabs taken prior to production were tested for *Salmonella* spp., and those taken during production were tested for *L. monocytogenes* in addition to *Salmonella* spp. This provides information about the microbial quality of the product and its manufacturing environment at the time of production. From this it may be determined if there is a correlation between sanitary conditions within the establishment and the presence or absence of pathogens in the food product.

Of the 54 environmental swabs analyzed, 5 did not have corresponding product analyzed for various reasons including the product being unfit for analysis upon arrival at the lab. Therefore, 49 environmental-product pairs were tested for *Salmonella* spp. and *L. monocytogenes*. Of these two pairs contained environmental swabs that tested positive for *Salmonella* spp. (Table 28). No *L. monocytogenes* was detected in any of the environmental-product pairs and no *Salmonella* spp. was detected in any of the corresponding product samples. In addition, due to the limited number of samples, a correlation between the detection of *Salmonella* spp. and *L. monocytogenes* in the processing environment, and the detection of these pathogens in the corresponding egg products, was not established.

Table 28: The Number of Linked Environmental and Processed Egg Product Sample Pairs by Category of Analysis [a]

Product Analytical Results	Environmental Analytical Results	
	Not Detected	Detected
Not Detected	47	2 [b]
Detected	0	0

[a] Both the product and environmental swabs were tested for *Salmonella* spp. and *L. monocytogenes*.
[b] *Salmonella* spp. was detected in two environmental swabs.

9. Dairy Products

Most milk and dairy products contain the proper nutrients to support the growth of pathogenic organisms however most of these products are subject to pasteurization and extensive aging processes that render them free from microbial hazards. Section B.08.002.2 under Canada's Food and Drug Regulations (FDR, 2014) prohibits the sale of unpasteurized milk except when used for cheese or when sold to a processor that will pasteurize it during its food manufacturing process. The sale of raw milk has been strictly prohibited under the FDR since 1991. For this reason, routine sampling to monitor for contaminants is performed on liquid milk products and cheeses.

Although some of these products depend on the use of non-harmful microorganisms to produce their unique tastes and textures, such as cheese and yogurt, the presence of harmful bacteria is typically the result of inadequate processes or contamination after pasteurization. There are other types of products which are subjected to heat treatments, freezing, etc., and domestic establishments producing such products (i.e. canned milk, frozen dairy products, milk based powders) are subject to visual inspections by CFIA inspectors. Therefore, these types of products are submitted under directed sampling activities for investigative purposes only.

Dairy samples are analyzed for coliforms, generic *E. coli*, *Salmonella* spp., *L. monocytogenes*, and *S. aureus.* The pasteurization of milk is an effective treatment which kills *E. coli* O157:H7, therefore this testing is only performed on dairy products made from raw milk, and phosphatase testing is performed only when claims of pasteurization need to be confirmed. In addition, environmental samples (food contact surface swabs) are taken in domestic cheese processing establishments, simultaneously with cheese samples, and analyzed for *L. monocytogenes*.

Table 29: Summary of NMMP Published Data for Domestic and Imported Dairy Products and Environmental Testing in Domestic Cheese Processing Facilities

Fiscal Year	# Tests	# Samples	# Unsatisfactory	% Compliance
Dairy Products				
2011/12	2944	714	21	97.1
2012/13	3319	759	12	98.4
2013/14	3012	724	22	97.0
Overall Products	**9275**	**2197**	**55**	**97.5**
Environmental				
2011/12	52	52	0	100 [a]
2012/13	130	130	1	99.2
2013/14	125	125	1	99.2
Overall Environmental	**307**	**307**	**2**	**99.3**

[a] Due to small sample numbers, the significance of these results should be interpreted with caution.

NMMP's published data shows a consistent level of compliance for dairy products and environmental samples over the past three years (Table 29). Domestic and imported dairy products were deemed to be 97.1%, 98.4% and 97.0% compliant in 2011/12, 2012/13 and 2013/14, respectively, with an overall average of 97.5%. It should be noted that the vast majority of non-compliant samples were imported cheeses and not domestic dairy products. In addition, over this time period environmental testing performed in domestic cheese processing facilities were 100%, 99.2% and 99.2% compliant in 2011/12, 2012/13 and 2013/14, respectively. An average compliance rate of 99.3% implies domestic cheese processing facilities have highly effective and controlled procedures ensuring hygienic conditions for the production of cheese products that are safe for consumption.

9.1. *Fluid Milk Products*

Fluid milk products include all grades of milk, chocolate milk, coffee creams and specialty products. Due to the extensive volume of milk production within Canada, imported fluid milk represents approximately 1% of what is consumed by Canadians (Catford *et al*, 2014). Therefore all samples routinely collected under this program for microbial analysis were domestically produced. During 2013/14, a total of 78 domestic fluid milk products were sampled at domestic dairy producers and analyzed for generic *E. coli* and *L. monocytogenes*. A total of 156 analytical tests were performed and were deemed to be 100% compliant (Table 30). No generic *E. coli* was detected in any of the samples and all levels of *L. monocytogenes* were within acceptable compliance limits as per the HC Listeria Policy (HC, 2011).

Table 30: **Compliance Rates of Domestic Fluid Milk Products**

Product Type	# Tests	# Samples	# Satisfactory	# Unsatisfactory	% Compliance
Skim Milk	6	3	3	0	100
1% Milk	18	9	9	0	100
2% Milk	56	28	28	0	100
Homogenized (3.25%) Milk	4	2	2	0	100
Chocolate Milk	32	16	16	0	100
Cream[a]	26	13	13	0	100
Specialty Milk[b]	14	7	7	0	100
Overall	**156**	**78**	**78**	**0**	**100**

[a] Cream includes 10%, 18% and whipping cream.
[b] Specialty milk includes omega-3 fortified milk, egg nog, organic milk and goat milk.

Table 31: **Estimated Prevalence and True Prevalence Range (at 95% Confidence Interval [CI]) of generic *E. coli* and *L. monocytogenes* in Domestic Fluid Milk Samples Analyzed Over a Seven-Year Time Period.**

Fiscal Year	Number of Samples Analyzed [a] for Each Hazard	
	generic *E. coli*	*Listeria monocytogenes*
2007/2008	110	85
2008/2009	1	1
2009/2010	0	0
2010/2011	86	86
2011/2012	97	97
2012/2013	90	90
2013/2014	79	79
Total Number	**463**	**438**
Number Positive	**0**	**0**
Estimated Prevalence	**0.00%**	**0.00%**
True Prevalence at 95% CI	**0-0.82%**	**0-0.87%**

[a] Due to small sample numbers, the significance of these results should be interpreted with caution.

Since 2007/08, routine testing of domestic fluid milk products was implemented over five fiscal years, but not performed in 2008/09 and 2009/10 (Table 31). During these two time periods, directed sampling was performed when deemed necessary through visual inspection of the dairy. Routine monitoring was discontinued in 2008/09 due to very few positives being detected, but reinstated in 2010/11 in order to maintain the Canadian Dairy Industry's access to international markets. In the five years fluid milk products were monitored under the NMMP, a total of 463 samples were tested for generic *E. coli*. Unlike raw meat products, which are not subjected to

heat treatment, in fluid milk products are pasteurized and therefore there is zero tolerance for the presence of generic *E. coli*. No generic *E. coli* was detected resulting in an estimated prevalence of 0% and a true prevalence range of 0-0.82%. Similarly, 438 samples were tested for *L. monocytogenes*, which was not detected in any of the samples. Hence an estimated prevalence of 0% and a true prevalence range of 0-0.87%. Due to the small number of samples collected, fluid milk products will continue to be monitored for these two organisms.

9.2. *Cheese Products*

The other most commonly consumed dairy product is cheese. Cheese is a manufactured product for which the probability of microbial contamination is a result of handling and fermentation practices. As such, domestic and imported cheeses are sampled and analyzed for generic *E. coli*, *Salmonella* spp., *L. monocytogenes*, and *S. aureus*. In addition, *E. coli* O157:H7 testing is performed on cheeses claimed to be made from raw milk, and phosphatase testing is performed to verify claims of pasteurization when deemed appropriate. Testing for *S. aureus* enterotoxins in approximately 100 domestic cheese samples was also performed. In 2007 this was initiated as a pilot project for information gathering purposes, and therefore samples were limited in number and restricted to domestic cheese. The continued implementation of testing for *S. aureus* enterotoxins is now being assessed.

Domestic samples consisted primarily of traditional cheeses, such as cottage cheese, cheddar, mozzarella, brie and cheese slices, the bulk of which were produced with pasteurized milk. In addition, some domestic producers also manufacture "non-traditional" cheeses with methods that do not use bacteria to coagulate the cheese. These types of cheeses, including paneer and channa, were also selected for analysis and were also made from pasteurized milk. In total, 338 domestic pasteurized milk cheeses were subjected to 1427 tests (Table 32). This included 331 domestic traditional cheeses and 7 domestic non-traditional cheeses. The traditional cheeses made with pasteurized milk were 98.8% compliant and the domestic non-traditional cheeses were 100% compliant. Overall, the domestic cheeses made with pasteurized milk were 98.8% compliant, with four deemed to be unsatisfactory. One sample was deemed to have high levels of generic *E. coli*, one sample had high levels of *S. aureus*, one sample was positive for *L. monocytogenes*, and one sample was positive for *S. aureus* enterotoxins (Table 35). No *Salmonella* spp. was detected in any of the domestic cheeses made with pasteurized milk.

Table 32: Assessment of Domestic and Imported Pasteurized Milk Cheeses by Analysis

Product Type / Analysis	# Tests	# Samples	# Satisfactory	# Unsatisfactory	% Compliance
Domestic Traditional Cheese - Pasteurized Milk					
generic *E. coli*	330	330	329	1	99.7
Salmonella spp.	330	330	330	0	100
L. monocytogenes	330	330	329	1	99.7
S. aureus	330	330	329	1	99.7
S. aureus enterotoxins [a]	78	78	77	1	98.7
Phosphatase	1	1	1	0	100
Overall [a]	**1399**	**331**	**327**	**4**	**98.8**
Domestic Non-Traditional Cheese Products – Pasteurized Milk					
generic *E. coli*	7	7	7	0	100
Salmonella spp.	7	7	7	0	100
L. monocytogenes	7	7	7	0	100
S. aureus	7	7	7	0	100
Overall [a]	**28**	**7**	**7**	**0**	**100**
Imported Traditional Cheese – Pasteurized Milk					
generic *E. coli*	134	134	131	3	97.8
Salmonella spp.	134	134	134	0	100
L. monocytogenes	134	134	131	3	97.8
S. aureus	134	134	134	0	100
Phosphatase	3	3	2	1	66.7
Overall [a]	**539**	**134**	**128**	**6**	**95.5**
Total Overall	**1966**	**472**	**462**	**10**	**97.9**

[a] The overall number of tests is equal to the sum of tests for each pathogen. All other "overall" values may not equal the sum of the values due to the fact that individual samples may be subjected to multiple tests and may test positive for more than one pathogen.

A variety of cheeses imported from 20 countries were also tested (Figure 5), with France being a significant source of foreign cheeses, almost half of the samples collected were from France. Of these imported cheeses, 134 were made from pasteurized milk and subjected to 539 tests, with 95.5% deemed to be compliant (Table 32). Six imported cheeses were assessed as non-compliant: one sample from Italy, one from the United States and one from France contained high levels of generic *E. coli*; two samples from Italy were unsatisfactory due to the presence of *L. monocytogenes* and another sample from Italy was unsatisfactory as a result of *L. monocytogenes* and phosphatase testing. No *Salmonella* spp. or *S. aureus* was detected in any of the imported cheeses made with pasteurized milk. Overall, the domestic and imported cheeses made with pasteurized milk were 97.9% compliant.

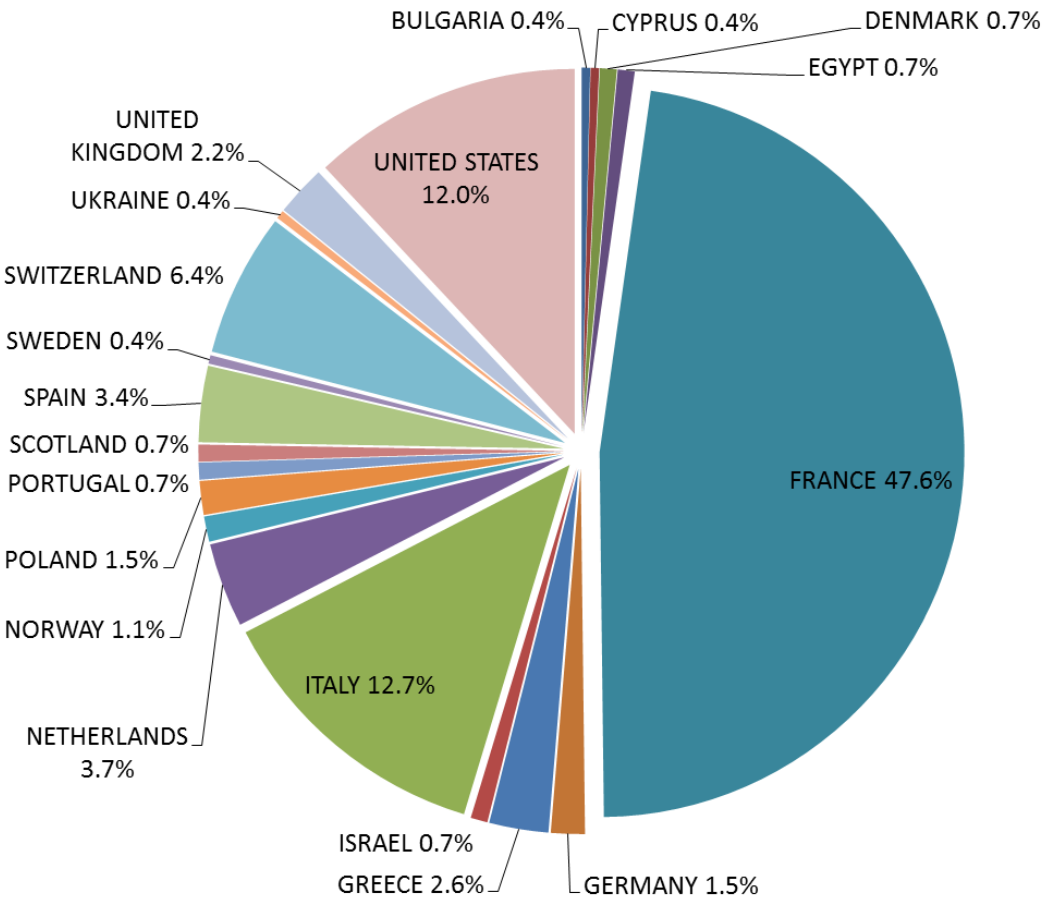

Figure 5: Percent Distribution of Imported Cheese Samples Analyzed by Country of Origin

In addition to cheeses made from pasteurized milk, domestic and imported cheeses made from raw milk were also sampled and tested. Of these there were 46 domestic cheeses made with raw milk, subjected to 246 tests and deemed to be 95.7% compliant (Table 33). There were two unsatisfactory samples; one due to the detection of *L. monocytogenes* and another due to the detection of *S. aureus* enterotoxins. No *Salmonella* spp., *E. coli* O157:H7, *S. aureus* or unacceptable levels of generic *E. coli* was detected in any of the domestic cheeses made with raw milk. Additionally, 128 imported raw milk cheeses were subjected to 640 tests and assessed to be 92.2% compliant. There were ten unsatisfactory samples, all of which were from France: three samples had high levels of generic *E. coli*, one had high levels of *S. aureus*, and one sample contained *Salmonella* spp. While the remaining five contained unacceptable levels of multiple organisms: three had high levels of generic *E. coli* and *S. aureus*, and two samples had high levels of generic *E. coli* and contained *L. monocytogenes*. No *E. coli* O157:H7 was detected in any of the imported raw milk cheeses. Overall, the domestic and imported raw milk cheeses were 93.1% compliant.

Table 33: Assessment of Domestic and Imported Raw Milk Cheeses by Analysis

Product Type / Analysis	# Tests	# Samples	# Satisfactory	# Unsatisfactory	% Compliance
Domestic Traditional Cheese - Raw Milk					
generic *E. coli*	46	46	46	0	100
E. coli O157:H7	46	46	46	0	100
Salmonella spp.	46	46	46	0	100
L. monocytogenes	46	46	45	1	97.8
S. aureus	47	44	44	0	100
S. aureus enterotoxins	15	15	14	1	93.3
Overall [a]	**246**	**46**	**44**	**2**	**95.7**
Imported Traditional Cheese – Raw Milk					
generic *E. coli*	128	128	120	8	93.8
E. coli O157:H7	128	128	128	0	100
Salmonella spp.	128	128	127	1	99.2
L. monocytogenes	128	128	126	2	98.4
S. aureus	128	128	124	4	96.9
Overall [a]	**640**	**128**	**118**	**10**	**92.2**
Total Overall	**886**	**174**	**162**	**12**	**93.1**

[a] The overall number of tests is equal to the sum of tests for each pathogen. All other "overall" values may not equal the sum of the values due to the fact that individual samples may be subjected to multiple tests and may test positive for more than one pathogen.

As mentioned above the 262 imported cheeses were from 20 different countries, but predominantly from France (Figure 5). Of these, the sixteen imported cheese samples deemed to be unsatisfactory were from the top three importing countries: France, Italy, and the United States (Table 34). Due to the fact that so few samples were analyzed, the results indicating percent compliance by country of origin must be interpreted with caution. Of the 20 countries, products originating from 17 were 100% compliant. Amongst these no more than 8 samples from each of 15 countries were analyzed. Therefore, the compliance rate of cheese producers within these countries cannot be reliably assessed. Products from the top importers sampled, France, Italy, and the United States, were assessed as 91.2%, 87.5% and 96.9% compliant, respectively. Again, due to the limited number of samples these compliance rates need to be interpreted with caution, and do not reliably reflect the state of food safety compliance within the cheese manufacturing industries of these countries. It may only be reasonably deduced that 93.9% of the imported cheeses complied with Canadian food safety standards.

Table 34: **Number of Imported Cheese Samples Analyzed by Country of Origin**

Country of Origin	# Samples	# Satisfactory	# Unsatisfactory	% Compliance[a]
BULGARIA	1	1	0	100
CYPRUS	1	1	0	100
DENMARK	2	2	0	100
EGYPT	2	2	0	100
FRANCE	125	114	11	91.2
GERMANY	4	4	0	100
GREECE	7	7	0	100
ISRAEL	2	2	0	100
ITALY	32	28	4	87.5[a]
NETHERLANDS	10	10	0	100
NORWAY	3	3	0	100
POLAND	4	4	0	100
PORTUGAL	2	2	0	100
SCOTLAND	2	2	0	100
SPAIN	8	8	0	100
SWEDEN	1	1	0	100
SWITZERLAND	17	17	0	100
UKRAINE	1	1	0	100
UNITED KINGDOM	6	6	0	100
UNITED STATES	32	31	1	96.9
Total	**262**	**246**	**16**	**93.9**

[a] Due to small sample numbers, the significance of these results should be interpreted with caution.

Combining the data for domestic and imported cheeses, and comparing cheeses made with pasteurized milk vs raw milk (Table 35), shows that similar levels of indicator organisms and pathogens are found. However, the data seems to indicate that cheeses made from raw milk may be more likely to be contaminated, as the cheeses made with raw milk were 93.1% compliant compared to the cheeses made with pasteurized milk which were 97.9% compliant. In this particular data set generic *E. coli* and *S. aureus* were detected more frequently in cheeses made from raw milk than those made from pasteurized milk. As a result, based on the data analyzed and obtained through randomized sampling to represent the population, it can be concluded that cheeses made from raw milk are more likely to be contaminated. This theory is supported by the absence of a heat treatment step (pasteurization) to kill microorganisms that may be present in the milk. In addition, since generic *E. coli* is used as an indicator of sanitary practices, it cannot be concluded that its presence in the cheese was specifically due to its presence in the raw milk or if the cheese was contaminated within the processing environment.

Table 35: Levels of Indicator Organisms and Other Positive Results Detected in Domestic and Imported Cheese Samples Made From Pasteurized and Raw Milk

Product Type	Country of Origin	Date Sampled (y/m/d)	generic *E. coli* (CFU/g)	*S. aureus* (CFU/g)	Other Parameters Detected
Cheese Made with Pasteurized Milk					
Fresh Mozzarella – Semi-hard	United States	2013-10-11	<5 – 5500		
Pecorino – Hard, sheep milk	Italy	2013-11-21	50 - 4600		
Swiss Cheese – Semi-hard	Canada	2014-03-14	290 - 470		
Semi-soft, cow milk	France	2013-08-08	150 - >15000		
Soft, cow milk	Canada	2014-03-12		180 - 1700	
Gorgonzola	Italy	2013-07-25			*L. monocytogenes*
Shredded Dairy Product	Canada	2013-06-13			*L. monocytogenes*
Gorgonzola	Italy	2013-07-04			Phosphatase, *L. mono*
Gorgonzola	Italy	2013-07-26			*L. monocytogenes*
Triple Crème Goat Brie	Canada	2013-05-08			*S. aureus* enterotoxins
Cheese Made with Raw Milk					
Semi-soft, cow milk	France	2013-07-09	<50-5800	500 - 17000	
Hard, goat milk	France	2013-11-13	<50-10000		
Munster – Soft, cow milk	France	2013-04-16	<50 - 10000	500 - 51000	
Semi-soft, cow milk	France	2013-11-13		16000 - 90000	
Soft, cow milk	France	2013-11-20	500 - 12000	28000 - 110000	
Soft, cow milk	France	2013-10-03	<=500 - >16000		
Soft, cow milk	France	2013-10-03	7500 - 40000		*L. monocytogenes*
Semi-hard, cow milk	France	2013-10-24	6000 - 17000		
– Soft, cow milk	France	2013-10-23	9200 - >16000		*L. monocytogenes*
Old Cheddar	Canada	2014-01-28			*L. monocytogenes*
– Semi-soft, Sheep & Goat Milk	France	2013-08-06			*Salmonella* spp.
Raclette au poivre	Canada	2013-05-22			*S. aureus* enterotoxins

Table 36: Details of Serotype and Pulse Field Gel Electrophoresis (PFGE) Patterns for Domestic and Imported Cheese Samples with Confirmed *Salmonella* spp. and *Listeria monocytogenes*

Common Name	Country of Origin	Date Sampled	Species	PFGE AscI Pattern	PFGE ApaI Pattern
(Semi-soft raw sheep and goat milk cheese)	France	2013-08-06	*Salmonella enterica* subsp. *diarizonae*	n/a	n/a
Gorgonzola (Pasteurized milk)	Italy	2013-07-25	*Listeria monocytogenes*	LMACI.0021	LMAAI.0114
Soft raw cow milk cheese with a washed rind	France	2013-10-03	*Listeria monocytogenes*	LMACI.0146	LMAAI.0260
Soft raw cow milk cheese with a washed rind	France	2013-10-23	*Listeria monocytogenes*	LMACI.0146	LMAAI.0260
Shredded Dairy Product (Pasteurized milk)	Canada	2013-06-13	*Listeria monocytogenes*	LMACI.0152	LMAAI.1121
Gorgonzola cheese (Pasteurized milk)	Italy	2013-07-04	*Listeria monocytogenes*	LMACI.0353	LMAAI.0510
Gorgonzola (Pasteurized milk)	Italy	2013-07-26	*Listeria monocytogenes*	LMACI.0779	LMAAI.1133
Old Cheddar (Raw milk)	Canada	2014-01-28	*Listeria monocytogenes*	LMACI.0815	LMAAI.0119

Serotyping and DNA fingerprinting (PFGE patterns) was performed on the *Salmonella* spp. and *Listeria monocytogenes* detected in the cheese samples (Table 36). There was one imported cheese sample from France that tested positive for *Salmonella* spp., specifically *Salmonella enterica.* This cheese was made from raw sheep and goat milk. *L. monocytogenes* was detected in three cheese samples from Italy and two from France. The three cheeses from Italy were produced from pasteurized milk, and did not share a common PFGE pattern. Both cheeses from France were made from raw cow milk and although they shared the same PFGE pattern (LMACI.0146 / LMAAI.0260), these cheeses were produced by different establishments. In addition there were two domestic cheeses, one made from pasteurized milk and the other from raw milk that tested positive for *L. monocytogenes*. Other than the two cheeses from France, all other *L. monocytogenes* isolates had different PFGE patterns.

Since 2007/08, approximately 3000 cheeses made from pasteurized milk have been routinely tested for generic *E. coli*, *Salmonella* spp., *L. monocytogenes* and *S. aureus* while 456 samples were tested for *S. aureus* enterotoxins (Table 37). Over this time period no *Salmonella* spp. was detected, resulting in an estimated prevalence of 0% and a true prevalence range of 0-0.12%. *L. monocytogenes* was detected in 14 samples for an estimated prevalence of 0.47% and a true prevalence range of 0.28-0.79%. *S. aureus* was detected at elevated levels in 6 samples, for an estimated prevalence of 0.19% and a true prevalence range of 0.09-0.41%. *S. aureus* enterotoxins were detected in 6 of the 456 samples, with an estimated prevalence of 1.32% and a true prevalence range of 0.60-2.84%. As an indicator organism generic *E. coli*, at levels indicative of sanitary problems, had a prevalence of 0.47% and a true prevalence range of 0.29-0.77%.

During the same time period, approximately 1000 cheeses made from raw milk were tested for the same organisms as the cheeses made from pasteurized milk: generic *E. coli*, *Salmonella* spp., *L. monocytogenes* and *S. aureus*, as well as 114 samples for *S. aureus* enterotoxins (Table 38). As with the cheeses made from pasteurized milk, *Salmonella* spp. displayed the lowest estimated prevalence which was calculated to be 0.10% with a prevalence range of 0.02-0.57%. For the raw milk cheeses, *S. aureus* and *L. monocytogenes* were the most prevalent with estimated prevalence of 3.05% and 1.68%, respectively as well as true prevalence ranges of 2.14-4.31% and 1.02-2.76%. These values were higher than the estimated prevalence for *S. aureus* and *L. monocytogenes* in pasteurized milk cheeses (0.19% and 0.47%, respectively). Also, compared to the pasteurized cheeses, raw milk cheeses displayed a lower estimated prevalence of *S. aureus* enterotoxins (0.88%), however due to the smaller number of samples the true prevalence range was broader (0.16-4.80%). The indicator organism, generic *E. coli* had a higher estimated prevalence of 2.43% and a broader true prevalence, 1.64-3.59%, in the raw milk cheeses as compared to the pasteurized milk cheese. Raw milk cheeses were also tested for *E. coli* O157:H7 which was not detected in any of the samples and had an estimated prevalence of 0% with a true prevalence range of 0-0.39%.

Overall, generic *E. coli*, *L. monocytogenes* and *S. aureus* were more prevalent in raw milk cheese than in pasteurized milk cheese. *Salmonella* spp. had the lowest prevalence rate in both types of cheese (excluding comparison to E. coli O157:H7 which was only tested in raw milk cheese).

Table 37: Estimated Prevalence and True Prevalence Range (at 95% Confidence Interval [CI]) of generic *E. coli*, *Salmonella* spp., *L. monocytogenes*, *Staphylococcus aureus*, and *S. aureus* enterotoxins in Domestic and Imported Cheese Samples Made from Pasteurized Milk Analyzed Over a Seven-Year Time Period.

Fiscal Year	Number of Samples Analyzed for Each Hazard				
	generic *E. coli*	*Salmonella* spp.	*Listeria monocytogenes*	*Staphylococcus aureus*	*S. aureus* enterotoxins
Cheese Made with Pasteurized Milk					
2007/2008	425	425	210	426	1
2008/2009	454	454	454	454	50
2009/2010	466	466	464	463	88
2010/2011	406	406	406	406	83
2011/2012	462	462	463	460	86
2012/2013	505	504	505	502	70
2013/2014	470	470	471	470	78
Total Number	**3188**	**3187**	**2973**	**3181**	**456**
Number Positive	**15**	**0**	**14**	**6**	**6**
Estimated Prevalence	**0.47%**	**0.00%**	**0.47%**	**0.19%**	**1.32%**
True Prevalence at 95% CI	**0.29-0.77%**	**0-0.12%**	**0.28-0.79%**	**0.09-0.41%**	**0.60-2.84%**

Table 38: Estimated Prevalence and True Prevalence Range (at 95% Confidence Interval [CI]) of generic *E. coli*, *E. coli* O157:H7, *Salmonella* spp., *L. monocytogenes*, *Staphylococcus aureus*, and *S. aureus* enterotoxins in Domestic and Imported Cheese Samples Made from Raw Milk Analyzed Over a Seven-Year Time Period

Fiscal Year	Number of Samples Analyzed for Each Hazard					
	generic *E. coli*	*E. coli* O157:H7	*Salmonella* spp.	*Listeria monocytogenes*	*Staphylococcus aureus*	*S. aureus* enterotoxins
Cheese Made with Raw Milk						
2007/2008	125	125	125	30	125	0
2008/2009	133	133	133	133	133	21
2009/2010	124	124	124	124	124	12
2010/2011	133	133	133	133	133	20
2011/2012	147	147	147	147	147	20
2012/2013	151	151	151	151	151	26
2013/2014	174	174	174	174	172	15
Total Number	**987**	**987**	**987**	**892**	**985**	**114**
Number Positive	**24**	**0**	**1**	**15**	**30**	**1**
Estimated Prevalence	**2.43%**	**0.00%**	**0.10%**	**1.68%**	**3.05%**	**0.88%**
True Prevalence at 95% CI	**1.64-3.59%**	**0-0.39%**	**0.02-0.57%**	**1.02-2.76%**	**2.14-4.31%**	**0.16-4.80%**

9.3. *Environmental Testing in Cheese Manufacturing Establishments*

In addition to testing domestic traditional cheeses, the manufacturers were also subjected to environmental testing. Environmental sampling allows for early identification and prevention of *L. monocytogenes* contamination in the finished products. When environmental samples were collected, cheese products manufactured within the same production period were also taken for analysis. Each environmental sample represents 5 to 10 different food contact surfaces within the production environment, and is analyzed for *L. monocytogenes*. In 2013/14, a total of 125 environmental samples were tested and deemed to be 99.2% compliant. One environmental sample was deemed unsatisfactory due to the presence of *L. monocytogenes* (LMACI.0039/ LMAAI.0462).

The sampling and testing of food contact surfaces in cheese manufacturing establishments, was implemented in 2011 to strengthen national surveillance activities regarding *Listeria* in response to the Weatherill Report (GoC, 2011) and as recommended by the HC Listeria Policy (HC, 2011). During the three years of surveillance, a total of 309 environmental samples have been analyzed, in which *L. monocytogenes* was detected in three (Table 39). Using this limited information the estimated prevalence has been calculated as 0.97% with a true prevalence range of 0.33-2.82%. Due to the importance of this monitoring in the early detection of potential foodborne illness and the lack of data, this monitoring activity will continue to be implemented.

Table 39: Estimated Prevalence and True Prevalence Range (at 95% Confidence Interval [CI]) of *Listeria monocytogenes* on Cheese Manufacturing Environmental Samples Analyzed Over a Three-Year Time Period

Fiscal Year	Number of Samples Analyzed [a]
	Listeria monocytogenes
2007/2008	0
2008/2009	0
2009/2010	0
2010/2011	0
2011/2012	52
2012/2013	131
2013/2014	126
Total Number	**309**
Number Positive	**3**
Estimated Prevalence	**0.97%**
True Prevalence at 95% CI	**0.33-2.82%**

[a] Due to small sample numbers, the significance of these results should be interpreted with caution.

9.4. *Linked Product and Environmental Testing in Cheese Manufacturing Establishments*

Within the domestic cheese manufacturing establishments, environmental swabs and product samples were taken simultaneously. This provides timely information about the microbial quality of the product and its manufacturing environment at the time of production. From which it may be determined if a correlation exists between the sanitary conditions of the manufacturing environment and the probability of pathogenic contamination of the product. The analytical results of these environmental swabs and cheese products are included in the data presented in sections 9.2 and 9.3 above. Of the 125 environmental swabs and 384 domestic cheeses analyzed there were 121 environmental-product pairs tested for *L. monocytogenes* (Table 40). Of these, one pair contained environmental swabs that tested positive for *L. monocytogenes*, but was not detected in the product, and two pairs contained cheese products that tested positive for *L. monocytogenes*, but was not detected in the environment. *L. monocytogenes* was not detected in the remaining 118 environmental-product pairs. At this point, there appears to be no link between the detection of *L. monocytogenes* in the environment and the detection of *L. monocytogenes* in the corresponding product. However, due to the limited amount of information, more data needs to be gathered and analyzed over time to make a firm conclusion.

Table 40: The Number of Linked Environmental and Cheese Product Sample Pairs by Category of Analysis

Product Analytical Results for *L. monocytogenes*	**Environmental Analytical Results for *L. monocytogenes***	
	Not Detected	Detected
Not Detected	118	1
Detected	2	0

10. Fresh Fruits and Vegetables

Fresh produce is susceptible to microbial contamination throughout the food chain continuum, starting in the field/green house and through to the consumers' home. Many fruits and vegetables are grown in the ground or close to the soil, and some have surface features (e.g. the layering of leaves, netted surface on cantaloupes, and the adhesion of multiple parts to form individual raspberries or blackberries) that make the removal of soil and microorganisms difficult. Combined with the fact that fruits and vegetables are typically consumed raw and are not subject to any processing techniques that can destroy microbial pathogens, fresh produce presents concerns in terms of foodborne illness to consumers.

Under the NMMP, a select variety of fresh fruits and vegetables grown under various conditions are tested, including those grown using organic and conventional farming methods, in fields and greenhouses. Due to seasonal limitations, the bulk of domestically-produced samples are collected during the months of July to October. However, both domestic produce grown in greenhouses and imported produce are available year round and are sampled accordingly. It is estimated that imported fruits and vegetables account for approximately 90% and 75%, respectively, of the produce available for consumption in Canada (Catford *et al*., 2014). Therefore, overall more imported produce than domestic produce was sampled and analyzed.

Table 41: Summary of NMMP Published Data for Domestic and Imported Fresh Fruits and Vegetables

Fiscal Year	# Tests	# Samples	# Unsatisfactory	% Compliance
2011/12	4155	993	7	99.3
2012/13	3910	995	8	99.2
2013/14	3757	982	5	99.5
Overall Products	**11822**	**2970**	**20**	**99.3**

From the data presented in NMMP's published reports, it is seen that domestic and imported fresh fruits and vegetables have maintained a high level of compliance over the past three years. In 2011/12, 2012/13 and 2013/14, domestic and imported produce were deemed to be 99.3%, 99.2% and 99.5% compliant with national food safety standards, respectively (Table 41). The consistency and high level of compliance indicates standard practices within the fresh fruit and vegetable industry are capable of minimizing microbial contamination of produce and are being implemented in an effective and consistent manner. However, it should be noted that there is a diverse array of fresh produce on the market in terms of quantity and variety, and as such, it is impossible to equally represent all types of produce in these annual monitoring surveys. Therefore, each year the scope of sampling has been limited to monitoring the highest risk pathogens on the most susceptible and widely consumed types of produce based on current

information, such as foodborne illness outbreaks. From this, in general, products such as herbs, sprouts, and vegetables typically consumed raw and/or in salads, as well as melons and berries are tested for generic *E. coli*, *E. coli* O157:H7, *Salmonella* spp. and *Shigella* spp. The sampling and analyses of fruits and vegetables includes both whole and RTE fresh-cut produce, which is defined as fruits and vegetables that have been washed and/or minimally processed (peeled, cored, chopped, sliced) and are intended to be consumed raw. Due to the occasional outbreak of *L. monocytogenes* linked to RTE fresh-cut produce, this analysis is also performed. In addition, in 2011/12, as a result of increased international awareness around *E. coli* strains other than *E. coli* O157:H7 causing human illness, VTEC testing was added to the leafy vegetables, sprouts, herbs, green onions.

10.1. *Fresh Vegetables and Ready-To-Eat Fresh-Cut Vegetables*

The sampling of domestic and imported vegetables was primarily composed of herbs, onions, peppers, lettuce, spinach and tomatoes, since they have been identified internationally as being of greatest concern in terms of food safety. In 2009, leafy greens and tomatoes were listed in the top ten riskiest foods regulated by the US FDA (CSPI, 2009), and spinach, lettuce, tomatoes, and peppers were identified as produce of high concern based on an assessment of foodborne illness outbreak data in the United States from 1998 to 2008 (Painter *et al*., 2013). In 2013, the European Food Safety Authority included leafy greens, tomatoes and herbs in their list of top five groups of food/pathogen combinations of concern (EFSA, 2013). In addition, the Food and Agriculture Organization of the United Nations (FAO) and the World Health Organization (WHO) ranked leafy vegetables and herbs as a level one priority, as well as green onions and tomatoes as a level two priority, and onions as a level three priority (FAO/WHO, 2008).

During 2013/14, under the NMMP, similar types and numbers of domestic and imported vegetables were tested (Figure 6). The majority of sampling was limited to produce identified as being of high concern: herbs, lettuce, spinach, onions, peppers and tomatoes. However, some sampling was conducted on other types of vegetables in order to provide a broad range of produce representing what is available and chosen by consumers: beans, bok choy, lemon grass, peas, sprouts, and other leafy greens such as chard, dandelion leaves, and watercress. Although limited in diversity, a number of RTE fresh-cut vegetables were also selected for analysis and included sliced mushrooms, baby carrots, diced onions, celery sticks, coleslaw, chopped lettuce and kale. The results associated with these products with minimal sample numbers must be interpreted with caution, as the analysis of 1, 10 or 20 samples of one particular product is not sufficient to represent the general microbial condition of that type of produce as it is presented in markets across the country. In addition to produce intended for local markets, (i.e. for sale to the general public), institutional sized bags of vegetables (e.g. salad, shredded lettuce and spinach) destined for restaurants, hospitals or institutions were also sampled.

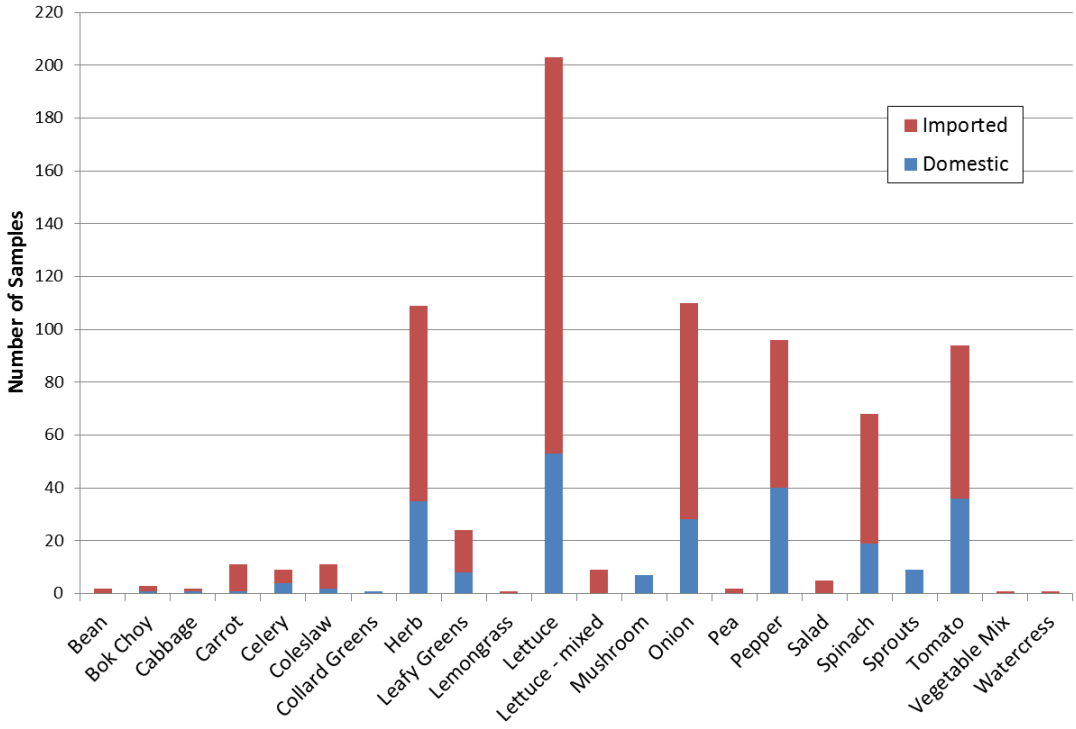

Figure 6: **Number and Types of Domestic and Imported Vegetables (Fresh and Ready-To-Eat Fresh-Cut) Analyzed**

In total, 693 domestic and imported fresh vegetables were subjected to 2588 tests and deemed to be 99.6% compliant. Amongst the 223 domestic fresh vegetables, 22 were tested for VTEC and two for *L. monocytogenes*. However, only one sample of spinach was assessed as unsatisfactory due to the presence of *Salmonella* spp. (Table 42). No generic *E. coli*, *E. coli* O157:H7, *L. monocytogenes*, *Shigella* spp. or VTEC was detected in any of the domestic fresh vegetable samples, and the overall compliance rate was 99.6%. In addition, 470 imported fresh vegetables were sampled and analyzed, of which 68 were tested for VTEC. Only two herb samples were determined to be unsatisfactory due to high levels of generic *E. coli*. The compliance rate of the imported fresh vegetables was the same as for the domestic fresh vegetables, at 99.6% (Table 42). *E. coli* O157:H7, *Salmonella* spp., *Shigella* spp. and VTEC were not detected in any of the imported fresh vegetable samples.

Table 42: Assessment of Domestic and Imported Fresh Vegetables by Pathogen

Product Type / Pathogen	# Tests	# Samples	# Unsatisfactory	# Investigative [a]	% Compliance
Domestic Fresh Vegetables					
generic *E. coli*	221	221	0	n/a	100
E. coli O157:H7	199	199	0	n/a	100
L. monocytogenes	2	2	0	0	100
Salmonella spp.	201	201	1	n/a	99.5
Shigella spp.	199	199	0	n/a	100
VTEC	22	22	0	n/a	100
Overall [b]	**844**	**223**	**1**	**0**	**99.6**
Imported Fresh Vegetables					
generic *E. coli*	470	470	2	n/a	99.6
E. coli O157:H7	402	402	0	n/a	100
Salmonella spp.	402	402	0	n/a	100
Shigella spp.	402	402	0	n/a	100
VTEC	68	68	0	n/a	100
Overall [b]	**1744**	**470**	**2**	n/a	**99.6**
Total Overall	**2588**	**693**	**3**	**0**	**99.6**

[a] n/a = not applicable. The assessment (Investigative) does not apply to the corresponding microbial hazard.
[b] The overall number of tests is equal to the sum of tests for each pathogen. All other "overall" values may not equal the sum of the values due to the fact that individual samples may be subjected to multiple tests and may test positive for more than one pathogen.

In addition to the whole fresh vegetables, 85 RTE fresh-cut vegetables were subjected to 414 analyses and deemed to be 98.8% compliant (Table 43). There was no generic *E. coli*, *E. coli* O157:H7, *L. monocytogenes*, *Salmonella* spp. or *Shigella* spp. detected in any of the 22 domestic RTE fresh-cut vegetables analyzed, and were therefore assessed as 100% compliant. Of the 63 samples of imported RTE fresh-cut vegetables one fresh cut salad was assessed as unsatisfactory due to the presence of *L. monocytogenes*. Therefore imported RTE fresh-cut vegetables were assessed as 98.4% compliant. No generic *E. coli*, *E. coli* O157:H7, *L. monocytogenes*, *Salmonella* spp., or *Shigella* spp. were detected in any of the domestic and imported RTE fresh-cut vegetables sampled. However, because of the small number of samples analyzed these results should be interpreted with caution.

Table 43: Assessment of Domestic and Imported Ready-To-Eat (RTE) Fresh-Cut Vegetables by Pathogen

Product Type / Pathogen	# Tests	# Samples	# Unsatisfactory	# Investigative [a]	% Compliance
Domestic RTE Fresh-Cut Vegetables					
generic *E. coli*	22	22	0	n/a	100
E. coli O157:H7	22	22	0	n/a	100
L. monocytogenes	21	21	0	0	100
Salmonella spp.	22	22	0	n/a	100
Shigella spp.	22	22	0	n/a	100
Overall [b]	**109**	**22**	**0**	**0**	**100**
Imported RTE Fresh-Cut Vegetables					
generic *E. coli*	63	63	0	n/a	100
E. coli O157:H7	63	63	0	n/a	100
L. monocytogenes	53	53	1	0	98.1
Salmonella spp.	63	63	0	n/a	100
Shigella spp.	63	63	0	n/a	100
Overall [b]	**305**	**63**	**1**	**0**	**98.4**
Total Overall	**414**	**85**	**1**	**0**	**98.8**

[a] n/a = not applicable. The assessment (Investigative) does not apply to the corresponding microbial hazard.
[b] The overall number of tests is equal to the sum of tests for each pathogen. All other "overall" values may not equal the sum of the values due to the fact that individual samples may be subjected to multiple tests and may test positive for more than one pathogen.

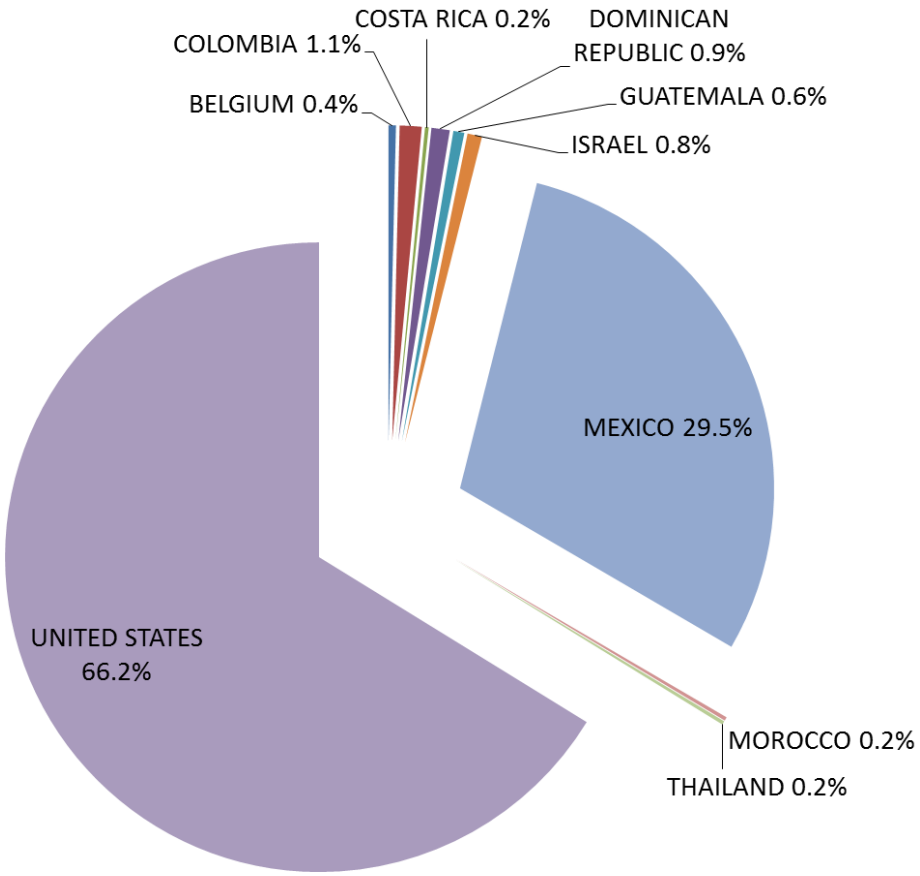

Figure 7: **Percent Distribution of Imported Vegetables (Fresh and Ready-To-Eat Fresh-Cut) Analyzed by Country of Origin**

During this fiscal year, the 533 imported fresh vegetables and RTE fresh-cut vegetables analyzed were from ten different countries, and more than 95% of these were from the United States and Mexico (Figure 7). The produce from the United States and Mexico were 99.7% and 99.4% compliant, respectively. Of the remaining eight countries, no more than six samples for each were sampled and analysed, and seven of them were assessed as 100% compliant (Table 44). However, the calculated compliance rates by country of origin must be interpreted with caution. Due to the limited number of samples analyzed from each country, it is not possible to determine the level compliance of the vegetable industry within each of these countries. However it may be stated that the imported produce was 99.4% compliant with Canadian food safety standards.

Table 44: Number and Compliance Rates of Imported Vegetables (Fresh and Ready-To-Eat Fresh-Cut) Analyzed by Country of Origin

Country of Origin	# Samples	# Satisfactory	# Unsatisfactory	% Compliance[a]
BELGIUM	2	2	0	100
COLOMBIA	6	6	0	100
COSTA RICA	1	1	0	100
DOMINICAN REPUBLIC	5	4	1	80.0[a]
GUATEMALA	3	3	0	100
ISRAEL	4	4	0	100
MEXICO	157	156	1	99.4
MOROCCO	1	1	0	100
THAILAND	1	1	0	100
UNITED STATES	353	352	1	99.7
Total	**533**	**530**	**3**	**99.4**

[a] Due to small sample numbers, the significance of these results should be interpreted with caution.

In 2013/14 there were two imported herbs assessed as unsatisfactory due to high levels of generic *E. coli*: coriander from the Dominican Republic and basil from Mexico (Table 45). Elevated levels of generic *E. coli* (>100 CFU/g) are used to indicate faecal contamination and inadequate sanitation procedures along the food continuum. Although generic *E. coli* does not represent a health risk to the consumer, fresh fruits and vegetables are typically consumed raw and when subjected to faecal contamination, are at risk of contamination with pathogenic organisms that do induce human illness. Therefore, in fresh fruits and vegetables, high levels of generic *E. coli* are not acceptable and result in the sample being assessed as unsatisfactory. In addition to these, there was one RTE fresh cut salad from the United States that tested positive for *L. monocytogenes* and one sample of domestic spinach that was positive for *Salmonella* Typhimurium (Table 46).

Table 45: Levels of generic *E. coli* Detected in Imported Fresh Vegetable Samples

Common Name	Country of Origin	Date Sampled (y/m/d)	Indicator Organism	Level [a] (CFU/g)
Coriander	Dominican Republic	2013-06-18	generic *E. coli*	40-460
Basil	Mexico	2013-06-18	generic *E. coli*	1925

[a] High levels or multiple elevated levels (>100 CFU/g in 3-5 subsamples) of generic *E. coli* were detected. Generic *E. coli* does not represent a health risk, however the extent of contamination indicates a serious deviation in sanitary procedures and since the product is consumed raw by the consumer, these samples were assessed as Unsatisfactory.

Table 46: Details of Serotype and Pulse Field Gel Electrophoresis (PFGE) Patterns for Domestic and Imported Vegetable Samples with Confirmed *Salmonella* spp. and *Listeria monocytogenes*

Common Name	Country of Origin	Date Sampled (y/m/d)	Species	PFGE AscI Pattern	PFGE ApaI Pattern
Spinach	Canada	2013-09-17	*Salmonella* Typhimurium var Copenhagen	n/a	n/a
Salad	United States	2014-03-04	*Listeria monocytogenes*	LMACI.0009	LMAAI.0234

From the data gathered over the past seven years, the estimated prevalence of all the microbial hazards in fresh and RTE fresh-cut vegetables was calculated to be less than 0.2%, with the exception of a 0.85% estimated prevalence for *L. monocytogenes* in RTE fresh-cut vegetables. From approximately 5200 samples of fresh vegetables, generic *E. coli* has an estimated prevalence of 0.18% with a true prevalence range of 0.10-0.33% (Table 47). While *E. coli* O157:H7, *Salmonella* spp. and *Shigella* spp. have an estimated prevalence of 0.02%, 0.04% and 0.0% with a true prevalence range of 0-0.11%, 0.01-0.14% and 0-0.07%, respectively. In addition, VTEC was analyzed in 175 fresh vegetables and found to have an estimated prevalence of 0% with a prevalence range of 0-2.15%. However it is the limited number of samples and absence of the VTEC, which results in such a broad true prevalence range.

Comparatively, the 668 RTE fresh-cut vegetables analysed displayed an estimated prevalence of 0% and a true prevalence range of 0-0.57% for generic *E. coli*, *E. coli* O157:H7, *Salmonella* spp. and *Shigella* spp. (Table 48). Although these displayed lower estimated prevalence values and greater true prevalence ranges than the fresh vegetables, these values must be interpreted with caution. It is the limited number of samples analyzed and the lack of detection of the organisms, which contribute to these values. These factors must also be considered when interpreting the estimated and true prevalence values calculated from 590 RTE fresh-cut vegetables for *L. monocytogenes* which were calculated to be 0.85% and 0.36-1.97%, respectively.

Table 47: Estimated Prevalence and True Prevalence Range (at 95% Confidence Interval [CI]) of generic *E. coli*, *E. coli* O157:H7, *Salmonella* spp., *Shigella* spp., and VTEC on Fresh Vegetable Samples Analyzed Over a Seven-Year Time Period

Commodity/ Fiscal Year	Number of Samples Analyzed for Each Hazard				
	generic *E. coli*	*E. coli* O157:H7	*Salmonella* spp.	*Shigella* spp.	VTEC
Fresh Vegetables					
2007/2008	621	622	622	620	0
2008/2009	1346	1346	1346	1346	0
2009/2010	713	709	714	709	0
2010/2011	723	723	723	668	0
2011/2012	690	611	611	610	52
2012/2013	710	625	626	624	32
2013/2014	690	600	603	600	91
Total Number	**5493**	**5236**	**5245**	**5177**	**175**
Number Positive	**10**	**1**	**2**	**0**	**0**
Estimated Prevalence	**0.18%**	**0.02%**	**0.04%**	**0%**	**0%**
True Prevalence at 95% CI	**0.10-0.33%**	**0-0.11%**	**0.01-0.14%**	**0-0.07%**	**0-2.15%**

Table 48: Estimated Prevalence and True Prevalence Range (at 95% Confidence Interval [CI]) of generic *E. coli*, *E. coli* O157:H7, *Salmonella* spp., *Shigella* spp., and *Listeria monocytogenes* on RTE Fresh-Cut Vegetable Samples Analyzed Over a Seven-Year Time Period

Commodity/ Fiscal Year	Number of Samples Analyzed for Each Hazard				
	generic *E. coli*	*E. coli* O157:H7	*Salmonella* spp.	*Shigella* spp.	*Listeria monocytogenes*
RTE Fresh-Cut Vegetables					
2007/2008	62	62	62	62	34
2008/2009	105	105	105	105	101
2009/2010	119	119	119	119	118
2010/2011	106	106	106	106	105
2011/2012	100	100	100	100	79
2012/2013	91	91	91	91	79
2013/2014	85	85	85	85	74
Total Number	**668**	**668**	**668**	**668**	**590**
Number Positive	**0**	**0**	**0**	**0**	**5**
Estimated Prevalence	**0%**	**0%**	**0%**	**0%**	**0.85%**
True Prevalence at 95% CI	**0-0.57%**	**0-0.57%**	**0-0.57%**	**0-0.57%**	**0.36-1.97%**

10.2. *Fresh Fruits and Ready-To-Eat Fresh-Cut Fruits*

Due to their international recognition as fruits of greatest concern in terms of food safety, melons and berries were the primary domestic and imported fruits sampled during 2013/14. In 2008, the FAO/WHO performed a global ranking of fresh fruits and vegetables known to be associated with pathogens causing illness, in order to prioritize issues to be addressed. From this analysis berries and melons were the highest ranked fruits as a level two priority along with mangoes as a level three priority (FAO/WHO, 2008). Likewise, in 2013 raspberries and melons were the only fruits ranked in the top five priority groups of foods of non-animal origin most often linked to foodborne illness in the European Union by the European Food Safety Authority (EFSA, 2013).

As with the fresh vegetables, all fresh fruits were tested for generic *E. coli*, *E. coli* O157:H7, *Salmonella* spp. and *Shigella* spp., except for whole cantaloupe which cannot be tested for generic *E. coli* due to difficulty extracting this particular microorganism from its netted rind. In addition, the RTE fresh-cut fruit was also tested for *L. monocytogenes*. The selection of domestic and imported whole fruit included cantaloupe, honeydew melon, raspberries, blackberries, strawberries, blueberries, papaya, and mango (Figure 8). Although very limited in availability, a few RTE fresh-cut fruits were also selected for analysis and included sliced apples, cantaloupe, honeydew melon and mixed melon pieces. It should be noted that these results are derived from minimal sample numbers and must be interpreted with caution. The analysis of 1, 10 or 20 samples of one particular product is not sufficient to draw conclusions about the general microbial condition of that type of produce as it is presented in markets across the country.

In 1996 and 1997, there were multiple outbreaks of cyclosporiasis across North America linked to the consumption of berries from Guatemala contaminated with a parasite called *Cyclospora* (Bern *et al*., 1999). Similar outbreaks in Ontario in 1998 and 1999 led the Canadian government to create an Import Policy for Fresh Guatemalan Raspberries and Blackberries, which restricted the entry of fresh Guatemalan raspberries and blackberries into Canada (CFIA, 2012b). The policy stipulated that farmed berries harvested from mid-March to mid-August could not be imported into Canada, and no fresh wild berries would be permitted at any time of year. Following the implementation of improved farming practices to prevent the occurrence of *Cyclospora* in cultivated blackberry fields within Guatemala, as well as international audits of these practices, the policy was revised. In 2012, the restriction on importing farmed, fresh Guatemalan blackberries was lifted, however the restrictions on farmed raspberries and wild berries remains in effect. Therefore, to verify the implementation of effective practices on blackberry farms in Guatemala, the CFIA implemented a monitoring sample plan to test Guatemalan blackberries for *Cyclospora*.

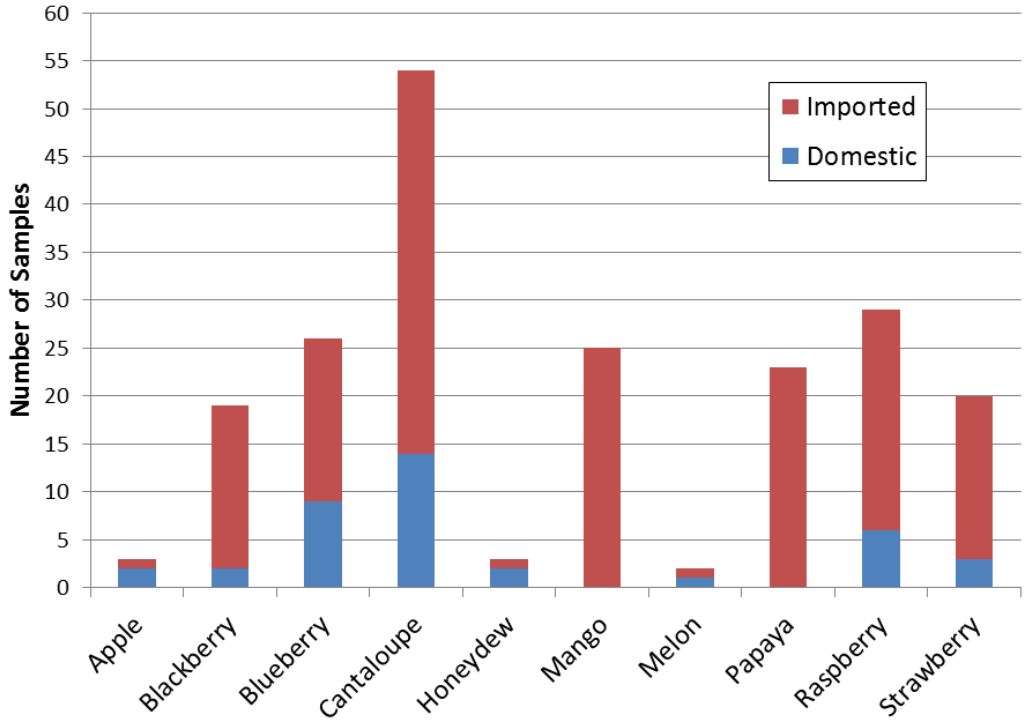

Figure 8: Number and Types of Domestic and Imported Fresh Fruits and Ready-To-Eat Fresh-Cut Fruits Analyzed

Table 49: Assessment of Domestic and Imported Fresh Fruit by Pathogen

Product Type / Pathogen	# Tests	# Samples	# Unsatisfactory	% Compliance
Domestic Fresh Fruit				
generic *E. coli*	20	20	0	100
E. coli O157:H7	33	33	0	100
Salmonella spp.	33	33	0	100
Shigella spp.	33	33	0	100
Overall [a]	**119**	**33**	**0**	**100**
Imported Fresh Fruit				
generic *E. coli*	121	121	0	100
E. coli O157:H7	160	160	0	100
Salmonella spp.	160	160	0	100
Shigella spp.	160	160	0	100
Cyclospora spp.	4	4	0	100
Overall [a]	**601**	**164**	**0**	**100**
Total Overall	**720**	**197**	**0**	**100**

[a] The overall number of tests is equal to the sum of tests for each pathogen. All other "overall" values may not equal the sum of the values due to the fact that individual samples may be subjected to multiple tests and may test positive for more than one pathogen.

A total of 204 fresh and RTE fresh-cut fruits were subjected to 755 analytical tests, with an overall compliance of 99.5%. Amongst these, 33 domestic fresh fruit and 164 imported fresh fruit were subjected to 720 analyses and deemed to be 100% compliant (Table 49). No generic *E. coli*, *E. coli* O157:H7, *Salmonella* spp., or *Shigella* spp. was detected in any of these fruit. In addition, no *Cyclospora* was detected in any of the blackberries imported from Guatemala that were sampled.

As with the RTE fresh-cut vegetables, there is a limited selection and volume of RTE fresh-cut fruits available for sampling. This year six domestic RTE fresh-cut fruits and one imported RTE fresh-cut fruit were analyzed (Table 50). Subjected to 30 analytical tests, the domestic RTE fresh-cut fruits were 83.3% compliant, due to the detection of *L. monocytogenes* (LMACI.0024 / LMAAI.1188) in domestic fresh-cut cantaloupe. The one imported RTE fresh-cut fruit was compliant with all analyses. No generic *E. coli*, *E. coli* O157:H7, *Salmonella* spp., or *Shigella* spp. was detected in any of the domestic or imported RTE fresh-cut fruit.

Table 50: Assessment of Domestic and Imported Ready-To-Eat (RTE) Fresh-Cut Fruit by Pathogen

Product Type / Pathogen	# Tests	# Samples	# Unsatisfactory	# Investigative [a]	% Compliance
Domestic RTE Fresh-Cut Fruit					
generic *E. coli*	6	6	0	n/a	100
E. coli O157:H7	6	6	0	n/a	100
L. mono	6	6	1	0	83.3
Salmonella spp.	6	6	0	n/a	100
Shigella spp.	6	6	0	n/a	100
Overall [b]	**30**	**6**	**1**	**0**	**83.3**
Imported RTE Fresh-Cut Fruit					
generic *E. coli*	1	1	0	n/a	100
E. coli O157:H7	1	1	0	n/a	100
L. mono	1	1	0	0	100
Salmonella spp.	1	1	0	n/a	100
Shigella spp.	1	1	0	n/a	100
Overall [b]	**5**	**1**	**0**	**0**	**100**
Total Overall	**35**	**7**	**1**	**0**	**85.7**

[a] n/a = not applicable. The assessment (Investigative) does not apply to the corresponding microbial hazard.
[b] The overall number of tests is equal to the sum of tests for each pathogen. All other "overall" values may not equal the sum of the values due to the fact that individual samples may be subjected to multiple tests and may test positive for more than one pathogen.

The imported fruits were from 12 different countries (Figure 9), with products from the United States and Mexico accounting for over 75% of the samples tested. All imported products were compliant with Canadian food safety regulations, but will continue to be monitored to ensure Canadians are provided with imported fruits that are safe for consumption.

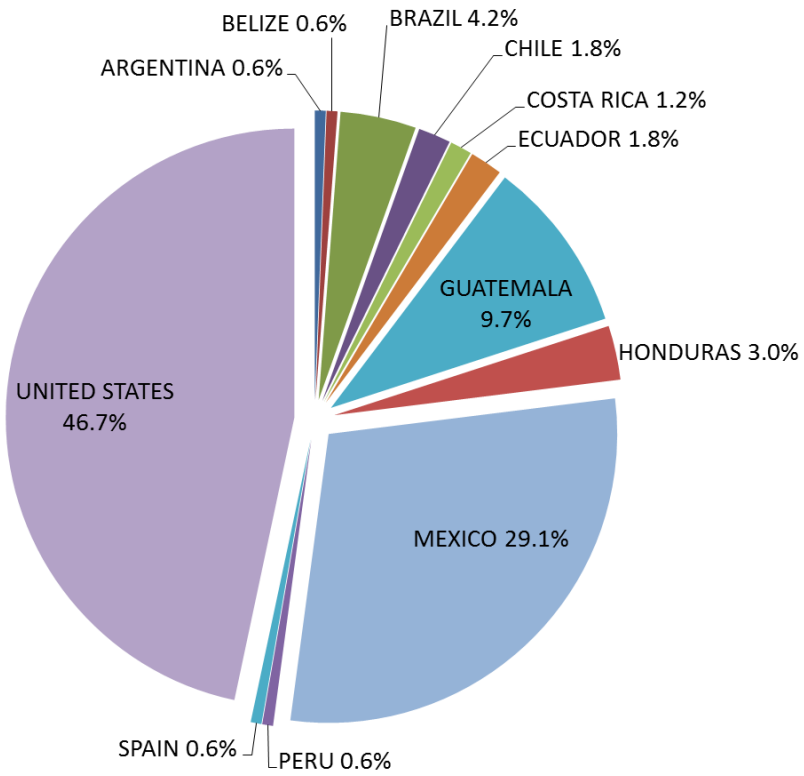

Figure 9: Percent Distribution of Imported Fruits (Fresh and Ready-To-Eat Fresh-Cut) Analyzed by Country of Origin

From the data gathered over the past seven years, the estimated prevalence of all the microbial hazards in fresh and RTE fresh-cut fruit was calculated to be no greater than 0.11%, with the exception of *L. monocytogenes* in RTE fresh-cut fruit which was calculated as 1.45%. From approximately 2000 samples of fresh fruit, *E. coli* O157:H7, *Salmonella* spp. and *Shigella* spp. have the estimated prevalence values of 0%, 0.05%, and 0.05%, and true prevalence ranges of 0-0.20%, 0.01-0.29%, and 0.01-1.29%, respectively (Table 51). Since testing for generic *E. coli* was not performed on whole cantaloupe, fewer samples were analyzed (n=918) resulting in an estimated prevalence of 0.11% and a greater true prevalence range of 0.02-0.62%.

When looking at the estimated and true prevalence values for the RTE fresh-cut fruit it cannot be emphasized enough how much small sample numbers affect these calculations.

With only 74 RTE fresh-cut fruits analyzed over this seven-year period, this category of fruit displayed an estimated prevalence of 0% and a true prevalence range of 0-4.87% for generic *E. coli*, *E. coli* O157:H7, *Salmonella* spp. and *Shigella* spp. (Table 52). Likewise, the analysis of *L. monocytogenes* in 69 RTE fresh-cut fruits displayed an estimated prevalence of 1.45% and a broad true prevalence range of 0.26-7.76%. Typically with such small numbers, the true prevalence range would not be calculated since it offers little value in assessing the level of compliance to Canadian food safety standards within this industry. However, it is offered here in order to provide a rough comparison to the fresh-cut fruits as was done with the fresh and RTE fresh-cut vegetables. Again, extreme caution must be taken when assessing these results, since it is the limited number of samples analyzed and the lack of detection of the organisms, which contribute to these values. Therefore, the sampling and testing of RTE fresh-cut fruit will continue.

Table 51: Estimated Prevalence and True Prevalence Range (at 95% Confidence Interval [CI]) of generic *E. coli*, *E. coli* O157:H7, *Salmonella* spp., and *Shigella* spp. on Fresh Fruit Samples Analyzed Over a Seven-Year Time Period

Commodity/ Fiscal Year	Number of Samples Analyzed for Each Hazard			
	generic *E. coli*	*E. coli* O157:H7	*Salmonella* spp.	*Shigella* spp.
Fresh Fruit				
2007/2008	93	474	474	473
2008/2009	90	500	500	499
2009/2010	135	189	189	189
2010/2011	166	202	202	202
2011/2012	158	192	192	192
2012/2013	132	184	184	183
2013/2014	143	196	195	196
Total Number	**917**	**1937**	**1936**	**1934**
Number Positive	**1**	**0**	**1**	**1**
Estimated Prevalence	**0.11%**	**0%**	**0.05%**	**0.05%**
True Prevalence at 95% CI	**0.02-0.62%**	**0-0.20%**	**0.01-0.29%**	**0.01-0.29%**

Table 52: Estimated Prevalence and True Prevalence Range (at 95% Confidence Interval [CI]) of generic *E. coli*, *E. coli* O157:H7, *Salmonella* spp., *Shigella* spp., and *Listeria monocytogenes* on RTE Fresh-Cut Fruit Samples Analyzed Over a Seven-Year Time Period

Commodity/ Fiscal Year	Number of Samples Analyzed for Each Hazard				
	generic *E. coli*	*E. coli* O157:H7	*Salmonella* spp.	*Shigella* spp.	*Listeria monocytogenes*
RTE Fresh-Cut Fruit					
2007/2008	8	8	8	8	4
2008/2009	14	14	14	14	13
2009/2010	14	14	14	14	14
2010/2011	12	12	12	12	11
2011/2012	9	9	9	9	9
2012/2013	11	11	11	11	11
2013/2014	7	7	7	7	7
Total Number	**75**	**75**	**74**	**75**	**69**
Number Positive	**0**	**0**	**0**	**0**	**1**
Estimated Prevalence	**0%**	**0%**	**0%**	**0%**	**1.45%**
True Prevalence at 95% CI	**0-4.87%**	**0-4.87%**	**0-4.87%**	**0-4.87%**	**0.26-7.76%**

11. Processed Fruit and Vegetable Products

The Canadian Processed Products Regulations defines food products as "any article of food prepared wholly or in part from fruit or vegetable" and processed as "a food product, canned, cooked, frozen, concentrated, pickled or otherwise prepared to assure preservation of the food product in transport, distribution and storage, but does not include the final cooking or preparation of a food product for use as a meal or part of a meal…." (PPR, 2013). CFIA has classified these products into six categories: i) low acid foods in hermetically sealed containers (e.g. canned vegetables), ii) acidified low acid canned foods (e.g. horseradish, pickled products), iii) frozen fruits and vegetables, iv) acid foods (e.g. canned fruits, canned tomato products), v) low water activity foods (e.g. jams, jellies, pie filling), and vi) fruit and vegetable juices and nectars (CFIA, 2014b). Although many of these products are consumed as is or warmed but not cooked by the consumer (with the exception of most frozen vegetables), they are classified as processed and not as RTE based on the above definitions and to clearly distinguish them from raw fruits and vegetables.

Many of these products are packed in cans and subjected to a heat treatment to render the contents sterile. Due to their low risk to consumers in terms of foodborne illness, products subjected to this process are not sampled and tested under CFIA's monitoring activities. However, those which are not treated in this manner are selected for microbial analysis and include frozen fruits, frozen vegetables and pickled foods (i.e. olives, pickles, sauerkraut, pickled eggplant, pickled peppers, etc.). In terms of known food safety issues, these products are not considered to pose a high risk to consumers, and therefore, fewer samples are tested to verify compliance with food safety standards as compared to other food types.

Published data over the past three years shows varying results (Table 53). In 2011/12, 2012/13 and 2013/14, domestic and imported processed produce were deemed to be 88.6%, 95.8% and 96.8% compliant, respectively. The decrease in the number of samples analyzed after 2011/12 was as a result of multiple factors, including the discontinuation of some monitoring plans and a reduction in the number of samples collected based on a prioritization exercise of testing activities.

In 2011/12, the sampling and testing of domestic and imported canned tomato products for mould (n=26, 61.5% compliant), as well as imported produce in glass containers for the presence of glass particles (n=9, 88.9% compliant), were also performed, which contributed to a greater number of samples and a lower level of compliance (CFIA, 2014a). In 2012/13, these two monitoring sampling plans were discontinued but directed

sampling remains in order to develop an official Glass Policy, which is currently being addressed.

Table 53: Summary of NMMP Published Data for Domestic and Imported Processed Fruits and Vegetables

Fiscal Year	# Tests	# Samples	# Unsatisfactory	% Compliance [a]
2011/12	804	175	20	88.6
2012/13	359	96	4	95.8
2013/14	299	94	3	96.8
Overall Products	**1462**	**365**	**27**	**92.6**

[a] Due to small sample numbers, the significance of these results should be interpreted with caution.

The detection of mould filaments in canned products does not indicate a food safety issue but is indicative of substandard practices utilizing tomatoes that were harvested while lying on the ground, bruised or rotting. The probability of microbial contamination that could lead to illness in these products is minimal for several reasons. First of all, during the canning process these products are subjected to a heat process intended to render the product and its container sterile. Secondly, the pH of these products (tomato paste, puree, juice, canned) typically lies within the range 3.50-4.58 (USFDA, 2007) and most foodborne microorganisms cannot grow in an environment that has a pH less than 4.4.

11.1. *Refrigerated and Shelf-Stable Pickled Products*

Pickled products are also known as acidified low-acid foods which are defined as a low-acid foods to which acid(s) are added to decrease their pH making them more acidic; these foods include, but are not limited to, beans, cucumbers, cabbage, artichokes, cauliflower, and peppers (FDA, 2010). The final product has a water activity (a_w) greater than 0.85 and a pH of 4.6 or below, which decreases the chances of providing an environment which supports the survival of most pathogens. Although specific to each pathogen, in general, they require a minimum a_w of 0.92 or a pH of 4.4 or greater in order to survive and grow.

Pickled products can be manufactured in one of three ways. Some foods are pickled by fermentation using lactic acid bacteria. The fermentation process can take from one to three months, during which salts are used to selectively inhibit bacterial competition. When left unopened, these products have a shelf-life of 24 months. The second method involves preservation by acidification by packing the product in a vinegar or acidified brine solution. These products are also subjected to a heat treatment to assure preservation, and have an 18-month shelf-life. These two types of products are referred to

as being “shelf-stable” meaning that until the seal on the container is broken they may be stored at room temperature. The third method also includes packing the product in a vinegar or brine solution, the fermentation process takes place under refrigeration over a period of a few weeks but no heat treatment is received. These products must be refrigerated even prior to opening the container and are labeled with a “use by” date or “within one month of opening” notice on the jar.

The processes used in domestic establishments producing shelf-stable pickled products, are monitored by CFIA inspectors and therefore samples are not taken for monitoring purposes. However, imported shelf-stable pickled products are sampled and analyzed for pH, water activity and salt content to ensure conditions do not support the presence of microbial pathogens. These products included pickles, pickled garlic, pickled onions, pickled eggplant, pickled asparagus, pickled artichoke, stuffed olives, and bamboo shoots in water. During 2013/14, 158 tests were performed on 16 samples and deemed to be 100% compliant (Table 54). These products were imported from 10 different countries (Table 55).

Due to their pH and a_w levels and the fact that they do not receive heat treatment intended to destroy pathogens, refrigerated products are assessed as a Category 2B product in accordance with the HC Listeria Policy and therefore are tested for *L. monocytogenes* (CFIA, 2013). The refrigerated pickled products selected for analyses included sauerkraut and pickles. During 2013/14, three domestic and three imported samples (all from the United States) were tested for *L. monocytogenes* (Table 54). No *L. monocytogenes* was detected and the samples were deemed to be 100% compliant.

Table 54: Compliance Rates of Domestic and Imported Pickled Products

Product Type	# Tests	# Samples	# Satisfactory	# Unsatisfactory	% Compliance[a]
Imported Shelf-Stable Pickled Products	158	16	16	0	100
Domestic Refrigerated Pickled Products	3	3	3	0	100
Imported Refrigerated Pickled Products	3	3	3	0	100
Total	**164**	**22**	**22**	**0**	**100**

[a] Due to small sample numbers, the significance of these results should be interpreted with caution.

Table 55: **Number of Imported Shelf-Stable and Refrigerated Pickled Products Analyzed by Country of Origin**

Country of Origin	# Samples
CHINA	1
DENMARK	1
GERMANY	1
GREECE	1
INDIA	2
POLAND	1
SPAIN	5
THAILAND	1
UNITED STATES	5[a]
VIETNAM	1
Total	**19**

[a] Includes the three refrigerated pickled products.

Due to the extremely limited number of samples collected each year, no prevalence data has been calculated for pickled products.

11.2. *Frozen Fruits and Vegetables*

Generally frozen fruits are simply thawed or become an ingredient in a food product that will then be baked prior to consumption. Since these products are not subjected to any treatments to kill potential pathogens, they can pose a potential microbial risk to consumers. Due to limited volumes, few frozen fruits were sampled and submitted for analysis. Imported frozen fruits (avocado, banana, mango, and jack fruit) were tested for the presence of *L. monocytogenes*, while domestic and imported frozen berries (blueberries, cranberries, raspberries and strawberries) were tested for *L. monocytogenes* and *Salmonella* spp. Four domestic and nine imported frozen fruits were analyzed and determined to be 100% compliant (Table 56). No *Salmonella* spp. or *L. monocytogenes* were detected in any of the samples. The nine imported frozen fruits originated from six different countries (Table 57).

Table 56: Assessment of Domestic and Imported Frozen Fruit by Pathogen

Pathogen	# Tests	# Samples	# Satisfactory	# Unsatisfactory	% Compliance [a]
Domestic					
L. monocytogenes	4	4	4	0	100
Salmonella spp.	4	4	4	0	100
Overall [b]	**8**	**4**	**4**	**0**	**100**
Imported					
L. monocytogenes	9	9	9	0	100
Salmonella spp.	5	5	5	0	100
Overall [b]	**14**	**9**	**9**	**0**	**100**
Total Overall	**22**	**13**	**13**	**0**	**100**

[a] Due to small sample numbers, the significance of these results should be interpreted with caution.
[b] The overall number of tests is equal to the sum of tests for each pathogen. All other "overall" values may not equal the sum of the values due to the fact that individual samples may be subjected to multiple tests and may test positive for more than one pathogen.

Table 57: Number of Imported Frozen Fruits Analyzed by Country of Origin

Country of Origin	# Samples
CHILE	3
CHINA	1
COLOMBIA	1
INDIA	1
MEXICO	2
UNITED STATES	1
Total	**9**

While the majority of frozen vegetables are placed in boiling water by the consumer, some, such as frozen spinach, are only thawed. Frozen produce is not exposed to any processes effective enough to destroy all microorganisms of concern and may therefore pose a microbial health risk to the consumer. In addition, storage under these conditions prevents the growth of microorganisms, yet is not adequate to destroy all types of bacteria that may have been in the food before it was frozen. Therefore, when these products are thawed, there is the potential for microbial growth to occur.

Typically frozen vegetables require thorough heating or cooking prior to serving, and are clearly labelled with cooking instructions intended to kill any pathogens that may be present. Because it is expected that the product will be cooked prior to consumption, these foods are not tested for pathogens. Instead, they are tested for indicator organisms (ACC and generic *E. coli*) to verify the implementation of adequate sanitary procedures within the processing environment. However, there are some types of frozen vegetables

that are not clearly labelled with cooking instructions, for example frozen spinach. These types of products are not always subjected to cooking prior to consumption, and therefore are tested specifically for *L. monocytogenes*.

In total, 20 domestic and 34 imported frozen vegetables with cooking instructions on the package were sampled, including green beans, soybeans, lima beans, horseradish leaves, peas, carrots, corn, potatoes, asparagus, mushrooms, edamame, spinach, broccoli, squash, peppers, okra, and mixed vegetables. Of the domestic frozen vegetables, all 20 samples displayed cooking instructions. These samples were subjected to a total of 40 analyses and determined to be 100% compliant (Table 58). Neither ACC nor generic *E. coli* was detected in any of the domestic frozen vegetables. Amongst the imported frozen vegetables analyzed, 34 displayed cooking instructions while five samples did not. The frozen vegetable products that did not have cooking instructions were asparagus, black olives, corn, jute leaves and punjabi tinda. The 39 imported frozen products were from 13 different countries, with the majority of products coming from China (25.6%) and the United States (17.9%; Table 59 and Figure 10). The 34 samples with cooking instructions were subjected to 68 analyses, and three samples were assessed as unsatisfactory due to high levels of ACC. Generic *E. coli* was not detected in any of the samples. The compliance rate was 91.2%. The five samples without cooking instructions were all deemed satisfactory for a compliance rate of 100%. No *L. monocytogenes* was detected in any of the frozen vegetables without cooking instructions on the package.

Table 58: Assessment of Domestic and Imported Frozen Vegetables by Analysis

Product Type / Analysis	# Tests	# Samples	# Satisfactory	# Unsatisfactory	% Compliance [a]
Domestic Frozen Vegetables w/ cooking instructions					
ACC	20	20	20	0	100
generic *E. coli*	20	20	20	0	100
Overall [b]	**40**	**20**	**20**	**0**	**100**
Imported Frozen Vegetables w/ cooking instructions					
ACC	34	34	31	3	91.2
generic *E. coli*	34	34	34	0	100
Overall [b]	**68**	**34**	**31**	**3**	**91.2**
Domestic Frozen Vegetables w/out cooking instructions					
L. monocytogenes	0	0	0	0	n/a
Imported Frozen Vegetables w/out cooking instructions					
L. monocytogenes	5	5	5	0	100
Total Overall	**113**	**59**	**56**	**3**	**94.9**

[a] Due to small sample numbers, the significance of these results should be interpreted with caution.
[b] The overall number of tests is equal to the sum of tests for each pathogen. All other "overall" values may not equal the sum of the values due to the fact that individual samples may be subjected to multiple tests and may test positive for more than one pathogen.

Table 59: Number of Imported Frozen Vegetables Analyzed by Country of Origin

Country of Origin	# Samples	# Satisfactory	# Unsatisfactory	% Compliance[a]
BELGIUM	1	1	0	100
CHILE	3[b]	3	0	100
CHINA	10[b]	9	0	100
ECUADOR	1	1	0	100
FIJI	1	1	0	100
FRANCE	1	0	1	0[a]
GUATEMALA	1	1	0	100
INDIA	6[b]	5	1	83.3[a]
KOREA	1	0	1	0[a]
MEXICO	4	4	0	100
PHILIPPINES	1[b]	1	0	100
SPAIN	2[b]	2	0	100
UNITED STATES	7	7	0	100
Total	**39**	**35**	**3**	**92.3**

[a] Due to small sample numbers, the significance of these results should be interpreted with caution.
[b] Included frozen vegetables without cooking instructions on the package.

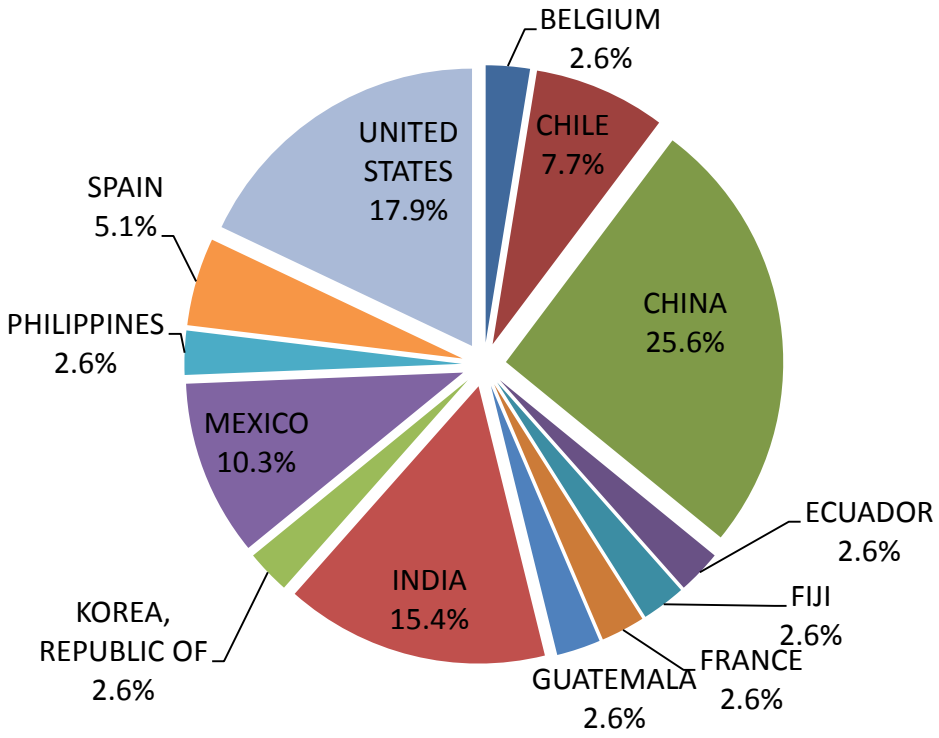

Figure 10: Percent Distribution of Imported Frozen Vegetables Analyzed by Country of Origin

Of the 59 domestic and imported frozen vegetable samples analyzed, three imported products with cooking instructions were assessed as unsatisfactory due to high levels of ACC (>250 000 CFU/g). These were cow peas from Fiji, enoki mushrooms from Korea and okra from India (Table 60). Although these levels of ACC do not pose a health risk to consumers, their levels are indicative of unsanitary practices in the manufacturing establishment which could lead to product contamination with pathogenic organisms if not corrected.

Table 60: Levels of Aerobic Colony Count (ACC) Detected in Imported Frozen Vegetables with Cooking Instructions on the Package

Product Type	Country of Origin	Date Sampled (y/m/d)	Level (CFU/g)
Enoki Mushrooms	Korea	2013-10-30	440,000
Frozen Cow Peas	Fiji	2013-05-30	830,000
Okra	India	2013-11-21	860,000

Due to the limited number of frozen fruit and frozen vegetables product samples collected each year, no prevalence data has been calculated.

12. Summary

The NMMP is designed to sample and test a broad range of imported and domestic commodities for multiple hazards. A comparison of the pathogens tested across the commodities is presented in Appendix B. With expert consultation, sampling plans are developed to test a variety of commodities including red meat and poultry products, shell eggs and egg products, dairy products, fresh fruits and vegetables and processed fruit and vegetable products. Food-hazard combinations deemed to pose the greatest potential health risks, recent outbreaks of foodborne illnesses, emerging food-hazard combinations and historical levels of compliance are taken into consideration during the annual designing of the NMMP. The defined assessment criteria (Appendix C) are based on Canadian and international standards, and are specific to the food and microbial organisms of concern.

Sampling activities are conducted for regulatory purposes and are used to verify that food production practices are in compliance with applicable Acts, standards and guidelines. They assure consumers that the government has systems in place to ensure that the food they consume is safe. During the 2013/14 fiscal year under the NMMP, 5510 domestic and imported products were sampled and tested. A variety of testing was performed to verify the products were safe for consumption: 8982 tests were performed on 3991 domestic products and 4819 tests were performed on 1519 imported products. These were assessed as 99.6% and 98.4% compliant, respectively. Combined, 13801 tests were conducted on 5510 food products and deemed to be 99.3% compliant. In addition, environmental sampling was performed in various domestic establishments, since it is an effective tool to determine the efficacy of the operator's system to control the presence of pathogens within the processing environment. During the 2013/14 fiscal year, 1986 tests were performed on 1895 environmental samples from domestic establishments. Of these, 97.6% were compliant.

Results indicate that the majority of food products tested were safely produced and maintained under sanitary conditions, and were therefore safe for consumption. While sporadic contamination did occur, all affected samples were subjected to food safety investigations and appropriate follow-up activities as conducted by the CFIA.

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For further information please visit:
CFIA's Consumer Center website at
http://www.inspection.gc.ca/food/consumer-centre/eng/1299093858143/1303766424564

Health Canada's Healthy Canadians website at:
http://www.healthycanadians.gc.ca/eating-nutrition/poisoning-intoxication/index-eng.php

Appendix A: Risk-based Sampling Performed Under the NMMP

Federally Registered Ready-to-Eat Meat Establishments

Currently risk-based sampling is used in the NMMP for the sampling and testing of various types of domestically produced meat products. Under these activities the number of samples taken at each federally registered establishment is calculated, based on individual establishment categories and the level of risk to the consumer. These categories are defined using parameters such as production volume, type of products produced and the use of antimicrobial agents or lethality treatments. Because the food products are identified as being high risk and have an extended shelf-life, the sampled lots are voluntarily held by the establishment until the analytical results are known.

Table A 1: Relative Risk Levels of Federally Registered RTE Meat Establishments

Category of RTE Product(s)	Antimicrobial Agent	Relative Risk Level	
		No Post-lethality Treatment	Post-lethality Treatment
Category 1	No	High	Medium High
Category 1	Yes	Medium High	Medium
Category 2A	No	Medium	Medium Low
Category 2A	Yes	Medium Low	Low
Category 2B	NA	Low	Very Low

Table A 2: Risk-Based Sampling Frequencies Based on Relative Risk Level

Relative Risk Level	CFIA Sampling Frequency
High	4 per year
Medium High	3 per year
Medium	2 per year
Medium Low	1 per year
Low	1 per year
Very Low	0 per year

Risk-based sampling involves determining the relative risk level (RRL) of each establishment using the Health Canada Listeria Policy (HC, 2011) to categorize the RTE products being produced and the use/absence of antimicrobial agents or lethality treatments during production (Table A 1). From this, a sampling frequency is assigned to

each establishment based on its calculated RRL (Table A 2). If the establishment produces more than one type of Category of product then the highest risk category is used. For example, if Category 1 and Category 2A products are produced within the same establishment, then Category 1 will be used to determine the RRL of that establishment.

Federally Registered Meat Establishments Producing Precursor Materials

In addition, all federally registered meat establishments producing precursor materials intended for grinding are subjected to risk-based sampling. The sampling frequency at each domestic establishment is determined using the following factors: production volume, compliance history and seasonality (Table A 3). The intent is to ensure the precursor materials are not contaminated, thus limiting the risk of spreading microbial hazards during the grinding process. Following the *E. coli* O157:H7 outbreak in 2012 (CFIA, 2012a) these sampling guidelines were re-designed to ensure the enhanced sampling of specific lots considered to pose a higher risk compared to those deemed to pose a lower risk, including enhanced sampling during periods of higher seasonal prevalence. Contamination of whole intact pieces of meat occurs on the outer surface of the meat during slaughter and is easily spread when further manipulation of the meat occurs.

Table A 3: Risk-based Sampling Frequency for Federally Registered Establishments Producing Precursor Material

Establishment Size (Production Volume per Year)	Normal Frequency [/1]			Enhanced Frequency	
	Sampling Frequency October to March	Sampling Frequency April to September [/2]	# Samples per Year per Establishment[/2]	Sampling Frequency October to March	Sampling Frequency April to September [/2]
Small (<25K kg)	1 per month (n=6)	1 per month (n=6)	12	2 per month	2 per month
Medium (25K to 400K kg)	1 per month (n=6)	3 per 2 months (n=9)	15	2 per month	3 per month
Large (400K to 40M kg)	3 per 2 months (n=9)	2 per month (n=12)	21	3 per month	4 per month
Extra Large (>40M kg)	2 per month (n=12)	4 per month (n=24)	36	4 per month	8 per month

[/1] Generally, all establishments will be sampled at a normal frequency. A compliance history including a positive *E. coli* O157 result from testing of precursor material or testing of the product downstream will be taken into account when placing an establishment on enhanced frequency of testing for the next 120 days.

[/2] Includes additional samples taken at each establishment during the *E. coli* O157:H7/NM high prevalence period of April to September.

Appendix B: Comparison of Pathogens Tested Across the Commodities (2013/14)

Number of Unsatisfactory Samples within Each Commodity Group in which Pathogens were Detected (grey cells indicate no testing was performed)

Commodity	# of Samples	*Listeria monocytogenes*	*Salmonella* spp.	*E. coli* O157:H7	VTEC	*Shigella* spp.	*Staphylococcus aureus*	*S. aureus* enterotoxins
Ready-To-Eat Meat	1185	3	0	0[f] (n=7)				
Ground Beef	676			0				
Meat Precursor Material	825			0				
Egg Products	329	1	0					
Shell Egg	291		0					
Pasteurized Milk Cheeses[a]	477	4	0				1	1
Raw Milk Cheeses	174	3	1	0[b]			4	1
Fluid Milk	78	0	0					
Fresh-Cut Fruit	7	1	0	0		0		
Fresh-Cut Vegetables	85	1	0	0		0		
Whole Fruit	198		0	0		0		
Whole Vegetables	692		1	0	0[c] (n=90)	0		
Frozen Fruit	13	0	0[d] (n=11)					
Frozen Vegetables	59	0[e] (n=5)						
Pickled Products	6	0						

[a] Includes traditional cheeses and non-traditional cheese-like products
[b] *E. coli* O157:H7 tested in cheese made from raw milk only
[c] Verotoxigenic *E. coli* tested in leafy vegetables, herbs, green onions and sprouts
[d] *Salmonella spp.* tested in frozen berries only
[e] *L. monocytogenes* tested in frozen vegetables without cooking instructions
[f] *E. coli* O157:H7 tested in fermented RTE products containing beef only

Appendix C: Assessment Criteria Used to Assess Monitoring and Risk-based Samples Taken Under the NMMP (2013/14)

This appendix is intended to capture the analytical assessment criteria currently recognized and utilized by the CFIA to assess the compliance of foods with respect to relevant food safety legislation and regulations, in support of Sections 4 and 7 of the *Food and Drugs Act*.

The following table identifies all food/hazard combinations that are tested under the NMMP sampling plans. The table is structured such that the criteria are grouped by commodity type, with the specific products and hazards tested under the NMMP identified within. In addition, the table identifies the assessment values (c, n, m and M; as defined in section 5.5 of this report) used to determine whether the analytical results of the sample and its associated lot, are to be assessed as Satisfactory, Investigative or Unsatisfactory. Note that two-class and three-class plans are utilized by the NMMP as deemed appropriate.

Since the CFIA is responsible for the implementation of regulations developed by Health Canada, assessment criteria are drawn from Health Canada's Interpretive Summary Policies (HC, 2008b) and Guidance Documents. In some cases there are other documents, such as the various Food Regulations posted by the Department of Justice, which also support these criteria.

In order to ensure the assessment criteria being used under the NMMP remain in line with internationally recognized standards, the criteria presented were cross checked with those published in the International Commission on Microbiological Specifications for Foods 8 (ICMSF, 2011). There are some criteria in this document that differ from what is in ICMSF 8. To address these discrepancies, CFIA is currently in discussions with Health Canada to determine if these ICMSF criteria should be adopted by Canada.

Commodity	Analysis	n	c	m	M	Satisfactory	Investigative	Unsatisfactory
Red Meat & Poultry Products and Environmental								
Category 1 RTE Meat Products	*Listeria monocytogenes*	5	0	0	-	Not Detected	n/a	Detected
Category 2 RTE Meat Products	*Listeria monocytogenes*	5	0	100	-	n/a	≤m/g in all sub sample units tested	>m/g in any sub sample unit tested
RTE Meat Products	*Salmonella* spp.	5	0	0	-	Not Detected	n/a	Detected
RTE Dry & Semi-dry Fermented Meat Products	*E. coli* O157:H7	5	0	0	-	Not Detected	n/a	Detected
Raw Ground Beef/Veal	generic *E. coli*	5	0	10^2	-	≤10^2/g	>10^2/g	n/a
Raw Ground Beef/Veal	*E. coli* O157:H7	5	0	0	-	Not Detected	n/a	Detected
Beef Trims	generic *E. coli*	60	0	10^2	-	≤10^2/g	>10^2/g	n/a
Beef Trims	*E. coli* O157:H7	60	0	0	-	Not Detected	n/a	Detected
Mechanically Separated & Finely Textured Beef	CNS	3	-	-	-	Not Detected	Detected	n/a
Pork Carcasses	*Trichinella spiralis*	100	-	-	-	Not Detected	n/a	Detected
Raw Meat & RTE Meat Products	Species Verification	-	-	-	-	Detected as declared or not detected and not declared	n/a	Not detected but declared or detected but not declared
Environmental - RTE Meat Establishments	*Listeria* spp.	10	0	-	-	Not Detected	*Listeria* spp. other than *L. mono*	*L. mono* detected

Commodity	Analysis	n	c	m	M	Satisfactory	Investigative	Unsatisfactory
Shell Egg & Processed Egg Products and Environmental								
Shell Eggs	*Salmonella* spp.	12	0	0	-	Not Detected	n/a	Detected
Processed Egg	ACC	5	0	$5x10^4$	-	≤m/g	n/a	>m/g in one or more sample units
Processed Egg	Coliforms	5	0	10	-	≤m/g	n/a	>m/g in one or more sample units
Processed & Cooked Egg Products	*Salmonella* spp.	10	0	0	-	Not Detected	n/a	Detected
Category 1 RTE Processed Egg Products	*Listeria monocytogenes*	5	0	0	-	Not Detected	n/a	Detected
Category 2 RTE Processed Egg Products	*Listeria monocytogenes*	5	0	100	-	n/a	≤m/g in all sub sample units tested	>m/g in any sub sample unit tested
Egg Wash Water - Basket Washer	ACC	1	n/d	n/d	10^5	≤M/mL	n/a	>M/mL
Egg Wash Water - Recirculating Washer	ACC	3	n/d	n/d	10^5	≤M/mL	n/a	>M/mL
Environmental - Shell Egg Grading Station (FCS, NFCS)	*Salmonella* spp.	10	0	0	-	Not Detected	n/a	Detected
Environmental - Processed Egg (FCS, NFCS)	*Listeria* spp.	5	0	0	-	Not Detected	*Listeria* spp. other than *L. mono*	*L. mono* detected
Environmental - Processed Egg (FCS, NFCS)	*Salmonella* spp.	10	0	0	-	Not Detected	n/a	Detected

Commodity	Analysis	n	c	m	M	Satisfactory	Investigative	Unsatisfactory
Dairy Products and Environmental								
Fluid Milk Products	generic *E. coli*	5	0	0	-	Not Detected	n/a	Detected
Category 1 RTE Fluid Milk Products	*Listeria monocytogenes*	5	0	0	-	Not Detected	n/a	Detected
Category 2 RTE Fluid Milk Products	*Listeria monocytogenes*	5	0	100	-	n/a	≤m/g in all sub sample units tested	>m/g in any sub sample unit tested
Cheese (pasteurized milk)	generic *E. coli*	5	2	10^2	$2x10^3$	≤m/g or if c is not exceeded	n/a	>M/g in one or more sample units or if c is exceeded
Cheese (raw milk)	generic *E. coli*	5	2	$5x10^2$	$2x10^3$	≤m/g or if c is not exceeded	n/a	>M/g in one or more sample units or if c is exceeded
Cheese (raw milk)	*E. coli* O157:H7	5	0	0	-	Not Detected	n/a	Detected
Cheese (pasteurized and raw milk)	*Salmonella* spp.	5	0	0	-	Not Detected	n/a	Detected
Category 1 RTE Cheese Products (pasteurized and raw milk)	*Listeria monocytogenes*	5	0	0	-	Not Detected	n/a	Detected
Category 2 RTE Cheese Products (pasteurized and raw milk)	*Listeria monocytogenes*	5	0	100	-	n/a	≤m/g in all sub sample units tested	>m/g in any sub sample unit tested
Cheese (pasteurized milk)	*S. aureus*	5	2	10^2	10^4	≤m/g or if c is not exceeded	n/a	>M/g in one or more sample units or if c is exceeded

Commodity	Analysis	n	c	m	M	Satisfactory	Investigative	Unsatisfactory
Cheese (raw milk)	*S. aureus*	5	2	10^3	10^4	≤m/g or if c is not exceeded	n/a	>M/g in one or more sample units or if c is exceeded
Cheese (pasteurized and raw milk)	*S. aureus* enterotoxins	5	0	0	-	Not Detected	n/a	Detected
Cheese (pasteurized milk)	Phosphatase	3	2	5ug	10ug	≤m/g or if c is not exceeded	n/a	>M/g in one or more sample units or if C is exceeded
Environmental - Cheese (FCS) & Dairy (FCS, NFCS) Processors	*Listeria* spp.	10	0	0	-	Not Detected	*Listeria* spp. other than *L. mono*	*L. mono* detected
Fresh Fruits & Vegetables and Environmental								
Fresh and RTE Fresh-Cut Fruits & Vegetables	generic *E. coli*	5	2	10^2	10^3	≤m/g or if c is not exceeded	n/a	>M/g in one or more sample units or if c is exceeded
Fresh and RTE Fresh-Cut Fruits & Vegetables	*E. coli* O157:H7	5	0	0	-	Not Detected	n/a	Detected
Leafy Vegetables, Herbs, Green Onions, Sprouted Seeds & Beans	VTEC	5	0	0	-	Not Detected	Detected	n/a
Fresh and RTE Fresh-Cut Fruits & Vegetables	*Salmonella* spp.	5	0	0	-	Not Detected	n/a	Detected
Fresh and RTE Fresh-Cut Fruits & Vegetables	*Shigella* spp.	5	0	0	-	Not Detected	n/a	Detected
Category 1 RTE Fresh-Cut Fruit & Vegetable Products	*Listeria monocytogenes*	5	0	0	-	Not Detected	n/a	Detected

Commodity	Analysis	n	c	m	M	Satisfactory	Investigative	Unsatisfactory
Category 2 RTE Fresh-Cut Fruit & Vegetable Products	*Listeria monocytogenes*	5	0	100	-	n/a	≤m/g in all sub sample units tested	>m/g in any sub sample unit tested
Sprouted Seeds & Beans	generic *E. coli*	5	2	10^2	10^3	≤m/g or if c is not exceeded	n/a	>M/g in any one unit or if c is exceeded
Blackberries	*Cyclospora*	5	0	0	-	Not Detected	n/a	Detected
Environmental - Fresh Produce Producers (FCS)	*Listeria* spp.	10	0	0	-	Not Detected	*Listeria* spp. other than *L. mono*	*L. mono* detected
Processed Products								
Shelf-Stable Pickled Products	a_w	5	1	0.85	0.87	≤m/g or if c is not exceeded	>0.85 but ≤0.87 in more than 1 unit when pH >4.8 in any unit	>0.87 in any unit when pH >4.8 in any unit
Shelf-Stable Pickled Products	pH	5	1	4.6	4.8	≤m/g or if c is not exceeded	>4.6 but ≤4.8 in more than 1 unit when a_w >0.87 in any unit	>4.8 in any unit when a_w >0.87 in any unit
Category 1 Refrigerated Pickled Products	*Listeria monocytogenes*	5	0	0	-	Not Detected	n/a	Detected
Category 2 Refrigerated Pickled Products	*Listeria monocytogenes*	5	0	100	-	n/a	≤m/g in all sub sample units tested	>m/g in any sub sample unit tested
Frozen Vegetables	ACC	5	0	$2.5x10^5$	-	≤m/g	n/a	>m/g
Frozen Vegetables	generic *E. coli*	5	2	10^2	10^3	≤m/g or if c is not exceeded	n/a	>M/g in one or more sample units or if c is exceeded

Commodity	Analysis	n	c	m	M	Satisfactory	Investigative	Unsatisfactory
Frozen Berries	*Salmonella* spp.	5	0	0	-	Not Detected	n/a	Detected
Frozen Fruit & Vegetable Products (Category 2)	*Listeria monocytogenes*	5	0	100	-	n/a	≤m/g in all sub sample units tested	>m/g in any sub sample unit tested