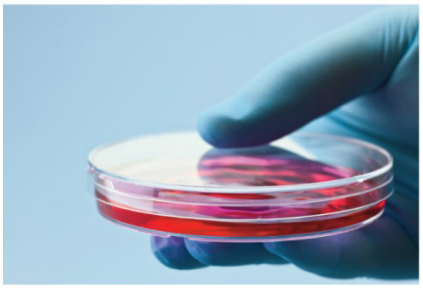
Canadian Food Inspection Agency
Agence canadienne d'inspection des aliments

# Microbiology Annual Report

## 2012/13

## National Microbiological Monitoring Program



## Foods of Plant and Animal Origin

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# Executive Summary

The Government of Canada verifies that food produced and/or sold in Canada meets federal food safety standards to ensure Canadians have confidence in what 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 verify that both domestically produced and imported products meet Canadian standards. It is 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 CFIA focuses its monitoring activities towards specific food-related hazards that may impair the health and safety of Canadians, it is important to note that most testing under the NMMP is done on commodities that are not further processed by the consumer as well as on raw foods that, if not properly cooked, can lead to illness. For food that is further processed, it is generally accepted that proper precautions taken in the home will destroy any bacteria that may be present.

During the 2012/13 fiscal year under the NMMP, 13237 tests were performed on 4980 domestic and imported products. Specifically, 8328 tests were performed on 3469 domestic products and 4909 tests were performed on 1511 imported products to verify they were compliant with Canadian standards. Results indicate that domestic products were 99.5% compliant whereas imported products were 99.0% compliant. Overall, a 99.4% compliance rate for combined domestic and imported products was observed.

In addition to testing food products, wash water samples and surface swabs taken within the food production environment are used to verify that food products are produced under sanitary conditions. This type of environmental sampling is performed in domestic establishments to verify the operator systems' ability to control the presence of pathogens within the processing environment. During 2012/13, there were 2563 tests performed on 1892 environmental samples which were assessed as 97.7% compliant.

The results of the 2012/13 NMMP sampling activities demonstrate that the majority of food products available in the Canadian marketplace were compliant with national standards.

# 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 and enforce 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 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 responsibility of the consumer to ensure that proper food safety practices are adhered to in the 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. Restaurants and catering services are also responsible for implementing these food safety measures. 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.

There are many Canadian standards pertaining to food safety. To ensure all food-related issues are addressed, these Canadian 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. 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.

The CFIA oversees the design, implementation and reporting of testing for allergen, chemical and microbial food safety hazards. These sampling and testing activities are an integral part of the tools used by the Agency to verify that food production practices are in compliance with applicable Acts, standards and guidelines. They demonstrate the quality of products available in the Canadian marketplace, assuring consumers that the government has systems in place to ensure that the food they consume is safe. In addition, sampling activities support international trade and demonstrate equivalency with trading partners.

This report summarizes the sampling and testing activities performed in the area of microbial hazards in food under the National Microbiological Monitoring Program (NMMP). During 2012/13, the Agency implemented 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.

The purpose of this report is to inform Canadians of the results obtained through the monitoring activities (which includes risk-based sampling) of the CFIA's NMMP. Analytical results from directed sampling activities are not included in this report.

Refer to Appendix A for a list of acronyms and abbreviations and Appendix B for a glossary of terms commonly used in this report.

# 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.

## 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.*

(2) The Agency is responsible for the enforcement of the *Consumer Packaging and Labelling Act* as it relates to food, as that term is defined in section 2 of the *Food and Drugs Act.*

(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.

(4) The Minister of Health is responsible for establishing policies and standards relating to the safety and nutritional quality of food sold in Canada and assessing the effectiveness of the Agency's activities related to food safety.

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.

## *Enforcement Actions*

CFIA compliance and enforcement actions occur all along the supply chain and involve numerous stakeholders and jurisdictions. However, it is the responsibility of the food producer or importer to comply with all relevant Acts and Regulations. When microbial contaminants are detected in food products, a food safety investigation may be performed to determine if a violation has occurred. 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). Where non-compliance is discovered there is a variety of measures that can be used to ensure a return to compliance and safety. As the degree of severity of the non-compliance increases, more stringent enforcement actions are used as determined on a case-by-case basis. 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 license, administrative monetary penalties and/or prosecution.

# 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. 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.

## 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 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 tolerated. 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 lots of food produced domestically or imported as this would be overwhelming. Therefore the CFIA implements a randomized approach 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.

## 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 common type of sampling implemented by the NMMP during 2012/13 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. Typically the sampled lots are not held, and distributed for sale before the analytical results are known.

Risk-based sampling was also used, but to a lesser extent. 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. As an example of risk-based sampling, the number of samples to be taken at each federally registered RTE meat establishment is calculated annually, based on individual establishment profiles and the level of risk to the consumer. These profiles may include parameters such as production volume, type of products produced and the use of antimicrobial agents or lethality treatments. Because they are identified as being high risk, the sampled lots are voluntarily held by the establishment until the analytical results are known.

There are a variety of other sampling activities that are implemented as appropriate by the Agency. Targeted surveys are information gathering studies used to determine the occurrence of contaminants in foods, but are usually limited in scope and duration. They may involve testing programs for microorganisms that are not included as part of the NMMP, such as certain parasites and viruses. In addition, targeted surveys may include pilot projects or baseline surveys, where an extensive amount of information is gathered to develop a large database that may contribute to future decisions, activities and policies. Furthermore, sampling and testing blitzes are used to obtain a snapshot concentrated in time to assess compliance with food safety requirements at selected locations. For example, the CFIA may coordinate border blitzes, and the scheduling of these blitzes is not announced.

When routine sampling and monitoring programs identify the presence of a risk, an effective control strategy is to use directed sampling and compliance activities to assess the extent and depth of the issue. When specific issues around food safety are identified, there are several sampling activities, also known as follow-up sampling that may be implemented.

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.

Legal sampling is performed under conditions where legal action is anticipated. Rigorously sound procedures are critical during the sampling and testing of these samples. For example, the establishment of a chain of custody for the sample is essential if legal proceedings are expected to ensue.

Data obtained as a result of any of these sampling activities may be used to support risk analysis 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.

# Food Safety Analyses

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 indicate 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.

## Pathogens

Amongst all microorganisms present in food, only a relatively small number are deemed pathogenic (i.e. illness-causing). 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 general 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**

This pathogen is commonly found in the intestinal tracts of cattle and other ruminants (e.g. sheep), but is rarely found in pigs and poultry. *Escherichia coli* O157:H7 may be introduced to the outer surface of the meat and the processing facility during slaughter. Contamination may also occur, although to a lesser extent, through contact with infected persons handling the food along the production line. Improperly cooked or raw ground beef is the most notable source of foodborne illness related to this organism. However, there are other sources of infection including other types of undercooked meat and

poultry, fermented meat products, non-pasteurized milk and fruit juices, non-chlorinated water and the surfaces of leafy greens (Health Canada, 2012). 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 *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, 2012). *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 and meningitis 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 (inflammation around the brain), septicaemia (blood poisoning) or death (Health Canada, 2010a).

***Salmonella* spp.**

There are more than 2500 serotypes of *Salmonella*, of which only a subset cause human illness. It is present throughout the environment and easily spread within a flock or herd.

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, 2012). 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. 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, 2012). 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***

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 of most concern to humans are resistant to freezing, commercial pasteurization and some sterilization processes (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, 2012). 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). 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.

***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, 2010b). 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).

## 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. Although there are various types of indicator organisms that can be used to determine quality, faecal coliforms and generic *E. coli* are the ones most commonly utilized as indicators of faecal contamination.

**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 only 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, 1999; 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). The amount of generic *E. coli* present can be used as a predictor of the possible presence of pathogens. Although *E. coli* is represented by many serotypes, the majority are not pathogenic. However, the use of indicator organisms should not negate the testing for pathogens, including *E. coli* O157:H7, due to their potential to induce serious illness.

## 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.

**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 is a measurement of acidity. 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.

## Non-Microbial Indicators

Not all methods are designed to determine the presence or absence of micro-organisms. 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, in some cases, the phosphatase test is not efficient (e.g. for soft cheeses produced by

fermentation like blue, Swiss, Camembert) because the phosphatase enzyme is produced by the microorganisms used during fermentation of the cheeses.

# 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. 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. Results from this testing enable the CFIA to make decisions concerning the acceptability of food based on its microbial quality. Based on these considerations and knowledgeable experts, the selection of specific foods and pathogens are prioritized on the basis of potential risk and likelihood of contamination. 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.

## Rationale

The primary purpose of the NMMP is to determine the level of compliance of the food industry with safety practices and standards. In addition, the NMMP contributes to:

1. The provision of data for the comparative risk associated with domestic and imported sources of foods, thus allowing an estimation of equivalency for trade purposes.

2. The provision of information on the effectiveness of control measures, as well as the effectiveness of program interventions with respect to improving food safety.

3. The independent confirmation of the degree of deviation from Good Manufacturing Practices, Good Hygienic Practices or Hazard Analysis Critical Control Point programs as demonstrated by industry testing. This is assessed from non-compliances found in the monitoring program. When rates of non-compliance exceed acceptable levels, further control activities may be triggered.

4. The assessment of the occurrence of adulterated food products containing pathogens. Domestic producers and importers in violation of Canadian standards are placed on enhanced inspection until there is appropriate compliance.

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.

## 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 sub-sample, and most commonly five sub-samples are taken for each sample. When sampling domestic commodities along the production line, sub-samples may be taken at different times during the production day but at the same point within the processing line.

The sub-samples are randomly selected and collected using sterile 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 sterile 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.

## 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 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 sterile 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.

## Methodology for 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, 2008). 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 sub-sample is taken and usually pooled for analysis as a single unit. When required, the sub-samples 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 Electrophoreses (PFGE) technology is one DNA-based subtyping tool utilized by the CFIA for the characterization of foodborne pathogens (sometimes referred to as "DNA fingerprinting"). This analysis is used to make epidemiological linkages between strains isolated from clinical cases with strains identified in a contaminated food source.

## 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.

There is zero tolerance for the presence of pathogens in food which may induce serious illness when a few of their 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. In such cases, the entire lot of food is considered unsatisfactory for human consumption and appropriate actions are immediately taken to mitigate the risk to consumers.

However, the presence of some pathogens at low levels in certain types of food is tolerated in the absence of risk to the consumer. Specifically, *L. monocytogenes* is permitted at low levels (<100 CFU/g) in some RTE foods. As such, RTE foods are classified into two categories based upon health risk. "Category 1" products are those which support the growth of *L. monocytogenes* and as a result, its presence is not tolerated. Conversely, the detection of *L. monocytogenes* at low levels is permitted in "Category 2" products, which are further sub-divided as follows: Category 2A contains RTE products which limit the growth of *L. monocytogenes* throughout the stated shelf-life (e.g. the "best before" date displayed on the package) while Category 2B contains RTE products in which the growth of *L. monocytogenes* cannot occur throughout the expected shelf-life of that food (Health Canada, 2011). Various factors are used to determine which Category RTE foods are classified as, such as processing (e.g. frozen foods, heat treatments), duration of the shelf-life, pH and water activity.

The CFIA also uses assessment criteria to determine the acceptable level of indicator organisms. Although indicator organisms, such as generic *E. coli*, do not pose a health

risk, their presence is used as a measure of sanitary quality. Very low levels of indicator organisms are considered acceptable as they are commonly present in the food source and environment. These levels are innate to the processing environment and pose no health risk, therefore no action is required. Slightly elevated levels of indicator organisms are also acceptable, however 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 investigative and appropriate follow-up activities are taken. This includes the identification and correction of the source of failure by the establishment in order to return to acceptable operational sanitation standards as quickly as possible. The presence of indicator organisms at high levels in certain food products (e.g. RTE food) is an indication of gross contamination or major non-compliance issues in the processing environment. When these levels are detected, the food and associated lot are typically deemed to be unsatisfactory and unfit for human consumption. Although it does not directly pose a health risk, the high levels are the result of system failures that could also lead to the presence of pathogens in the food. Appropriate follow-up actions are taken.

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, there is zero tolerance for the presence of CNS tissue in beef due to BSE requirements. In contrast, 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.

## Statistical Considerations

The NMMP is one of many tools utilized by the CFIA to verify that domestically produced and imported products comply with Canadian standards. Therefore it is not designed to provide statistical estimates of the compliance rate of food. For example, if no compliance issues are detected in 300 samples of a particular product, with 95% confidence one may infer that the non-compliance rate in the defined food is less than 1%. However, 300 samples for testing may not be available for all products, and the precision of such inferences decreases as the number of samples decreases. Nevertheless, smaller sample numbers can still be used to verify the effectiveness of industry practices.

This report is the second publication of the results of the NMMP's sampling and testing activities. As such its scope is limited to the assessment of compliance and non-compliance results identified through sampling and testing activities conducted over a 12 month period. Therefore, caution must be used when interpreting the results of this report. Over a longer period of time (e.g. five years), the information gathered during

these monitoring activities can be combined and used to perform more extensive analyses on the food supply, including trending and seasonal variation.

# Results of the 2012/13 National Microbiological Monitoring Program

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 process of harvesting these raw commodities, microbes from the 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 practice 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. Under the NMMP, random food and environmental samples are taken for laboratory analysis to verify compliance with food safety regulations and product standards.

The results of the 2012/13 NMMP are described below. 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 considered separately. The number of tests performed, the number of satisfactory, investigative (where appropriate) and unsatisfactory results as well as the overall compliance rate are listed for each commodity group. In addition, a breakdown of country of origin is provided for imported products.

## Red Meat and Poultry Products

Meat has historically been implicated in a significant proportion of human illnesses associated with foodborne diseases. During slaughter and processing, contamination can be spread by contaminated surfaces and equipment (CAC, 2005). Since it is expected that meat products, such as raw chicken, will be thoroughly cooked prior to consumption, the pathogens present in raw meat should be destroyed by the cooking process. If certain cuts of meat are consumed raw or undercooked, the internal temperature of the meat may not be sufficiently high to kill all pathogens. For this reason, the CFIA focuses its testing activities on RTE meat products as well as those that could be consumed in a partially cooked state, such as beef.

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 preserved instead using curing. They are required to be free of pathogens, such as *E. coli* O157:H7, though low levels of *S. aureus* are acceptable.

Every establishment processing or packaging meat products that is federally registered is monitored by CFIA inspectors. Random samples are taken for laboratory analysis to verify compliance with applicable food safety regulations and product standards, including the *Meat Inspection Act* and *Regulations*.

The CFIA is implementing a pilot project to determine the prevalence of *Salmonella* spp. and *Campylobacter* spp. in raw poultry at various points throughout the food chain. Upon completion of this survey, national microbiological monitoring activities will resume, taking into account the results of this study.

## Ready-To-Eat Meat Products

In Canada, all federally registered RTE meat establishments are inspected by the CFIA, and both product and environmental samples are tested on a regular basis. RTE meat products include all species of meat and are defined as food items subjected to an adequate heat treatment or other kill step, thus decreasing the number of bacteria and minimizing the chance of pathogenic strains surviving. They require no further cooking by the consumer prior to consumption. This includes 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 2012/13, 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 are summarized in Table 1. There were 1556 tests performed on 1062 domestic products determined to be 99.8% compliant. The 0.2% non-compliance was due to two Category 1 samples with unacceptable levels of *L. monocytogenes*. Although not deemed to be non-compliant, five Category 2 type samples were assessed as investigative due to the detection of low levels of *L. monocytogenes*. In addition, 355 tests were performed on 174 imported RTE meat products. These imported products were 98.9% compliant with two samples testing positive for *L. monocytogenes*. The majority of Canada's imported RTE meat products came from the United States (>58%) and Italy (>26%; Table 2).

Combining these results, at total of 1911 analytical tests were performed on 1236 RTE meat products with a compliance rate of 99.7%. Overall, *L. monocytogenes* was detected in five samples. Neither *Salmonella* spp. nor *E. coli* O157:H7 were detected in any of the samples analyzed.

**Table 1:** Compliance Rates of Domestic and Imported Ready-To-Eat Meat Products

| Source | # Tests | # Samples | # Satisfactory | # Investigative | # Unsatisfactory | % Compliance |
|---|---|---|---|---|---|---|
| Domestic | 1556 | 1062 | 1055 | 5 | 2 | 99.8 |
| Imported | 355 | 174 | 172 | 0 | 2 | 98.9 |
| **Total** | **1911** | **1236** | **1227** | **5** | **4** | **99.7** |

**Table 2:** Imported Ready-To-Eat Meat Products Analyzed by Country of Origin

| Country of Origin | # Samples | # Satisfactory | # Unsatisfactory |
|---|---|---|---|
| FRANCE | 18 | 18 | 0 |
| ISRAEL | 3 | 3 | 0 |
| ITALY | 46 | 45 | 1 |
| SPAIN | 1 | 1 | 0 |
| THAILAND | 3 | 3 | 0 |
| UNITED STATES | 101 | 100 | 1 |
| URUGUAY | 1 | 1 | 0 |
| Unknown | 1 | 1 | 0 |
| **Total** | **174** | **172** | **2** |

## Raw Ground Beef/Veal and Trims

Trimmings from cuts (e.g. pieces of meat remaining after steaks, roasts are removed) and boneless chucks are used as ingredients for raw ground meat products. In Canada, all federally registered meat establishments producing trims intended for grinding and all establishments producing raw ground beef or veal are sampled. The intent of this monitoring is to ensure the trims are not contaminated, thus avoiding the risk of spreading microbial hazards during the grinding process. 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. The production of ground meat products involves the pooling of meat from multiple animals. During the grinding process bacteria present on the surface of the intact cuts and trims can be distributed throughout the meat. The grinding process minces and mixes the meat increasing the surface area available for microorganisms to attach. For ground meat products this is the most likely point in production for cross contamination to occur.

Trim 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 indicator of sanitary control in the plant. In 2012/13, a total of 1770 analytical tests were performed on 243 domestic trim and 628 domestic ground beef/veal samples (Table 3). Of the domestic samples, one trim and two ground meat samples were assessed as unsatisfactory due to

the presence of *E. coli* O157:H7. Another eight samples of trim and 27 samples of ground product were assessed as investigative (discussed in greater detail below). In total, the domestic trim and ground products displayed compliance rates of 99.6% and 99.7%, respectively. Seven samples of ground meat (from the United States) and 16 samples of trims (from the United States, Australia and New Zealand) were analyzed (Table 4). No *E. coli* O157:H7 was detected in any of the imported products. Overall, 1816 tests were performed on 894 trim and raw ground beef/veal products, with 99.7% determined to be compliant.

**Table 3:** Compliance Rates of Domestic and Imported Trim and Raw Ground Beef/Veal

| **Product Type** | **# Tests** | **# Samples** | **# Satisfactory** | **# Investigative** | **# Unsatisfactory** | **% Compliance** |
|---|---|---|---|---|---|---|
| Domestic Trims | 495 | 243 | 234 | 8 | 1 | 99.6 |
| Domestic Ground Meat | 1275 | 628 | 599 | 27 | 2 | 99.7 |
| Imported Trims | 32 | 16 | 16 | 0 | 0 | 100.0 |
| Imported Ground Meat | 14 | 7 | 7 | 0 | 0 | 100.0 |
| **Total** | **1816** | **894** | **856** | **35** | **3** | **99.7** |

**Table 4:** Imported Raw Ground Beef/Veal Products and Trims Analyzed by Country of Origin

| **Product Type** | **Country of Origin** | **# Samples** | **# Satisfactory** | **# Unsatisfactory** | **% Compliance**[a] |
|---|---|---|---|---|---|
| Ground Meat | UNITED STATES | 7 | 7 | 0 | 100.0 |
| Trims | UNITED STATES | 4 | 4 | 0 | 100.0 |
| Trims | AUSTRALIA | 9 | 9 | 0 | 100.0 |
| Trims | NEW ZEALAND | 3 | 3 | 0 | 100.0 |

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

High levels of generic *E. coli* are used to indicate a breakdown in sanitation procedures within processing establishments. During 2012/13, no high levels of generic *E. coli* were detected in any of the imported samples (Table 4). However as previously mentioned, elevated levels were detected in eight domestic trim and 27 domestic ground beef/veal samples (Table 3). Since generic *E. coli* does not represent a health risk to consumers, these samples were deemed to be compliant but were assessed as investigative.

As depicted in Figure 1, 95.4% of the domestic and imported raw ground beef/veal products were assessed as satisfactory, 4.3% were assessed as investigative due to elevated levels of generic *E. coli* and 0.3% were assessed as unsatisfactory due to the presence of *E. coli* O157:H7. Conversely, 96.5% of domestic and imported trim products were assessed as satisfactory, 3.1% were assessed as investigative due to elevated levels

of generic *E. coli* and 0.4% were deemed unsatisfactory due to the presence of *E. coli* O157:H7.

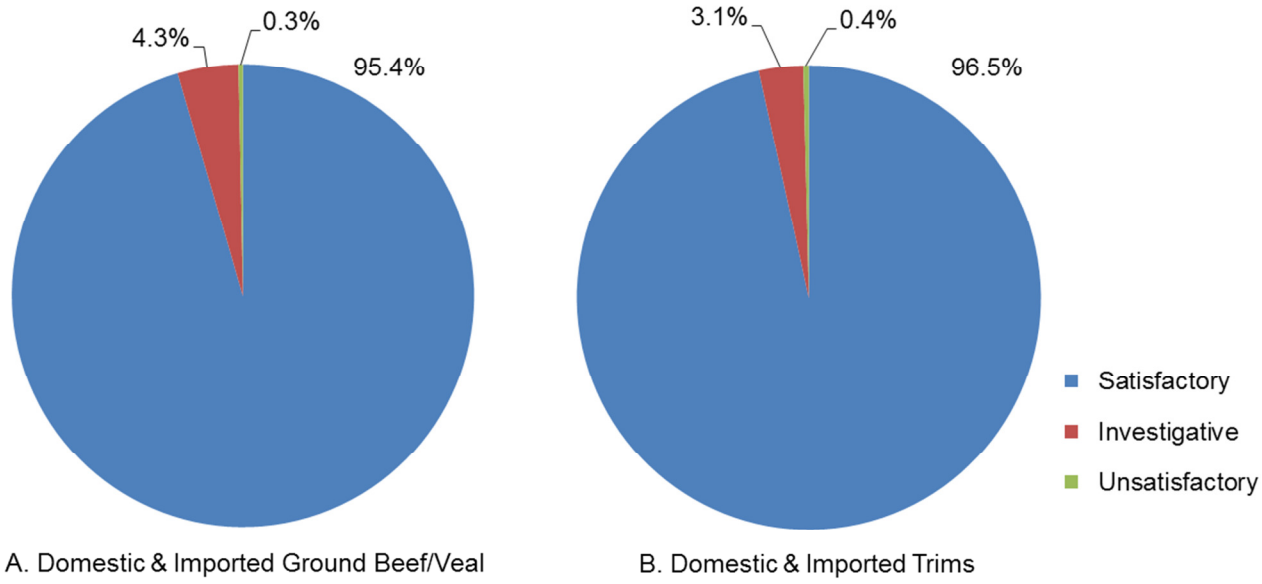


**Figure 1:** Microbial Assessment (%) of Domestic and Imported Raw (A) Ground Beef/Veal and (B) Trims

## Raw Mechanically Separated and Finely Textured Beef

In Canada, there are three producers of mechanically separated beef and finely textured beef. During 2012/13, 40 samples were tested, of which one was considered to be adulterated due to the presence of CNS tissue.

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.

## 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. Meat processing operators are responsible for implementing and maintaining records of all parameters required for process control. 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 2012/13, 338 samples representing over 31,000 animals (market hogs, breeder hogs and wild boars) were tested. *T. spiralis* was not detected in any of the samples analyzed.

## Species Verification

From a food safety perspective, species verification 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. Samples of these types of products are taken under directed sampling activities for investigative purposes only.

In 2012/13, a total of 78 species verification tests were performed on 20 imported meat products, of which 100% were compliant. Samples analyzed came predominantly from the United States (Table 5).

**Table 5:** Imported Single Species Meat Products Sampled by Country of Origin

| Country of Origin | # Samples | # Satisfactory | # Unsatisfactory | % Compliance |
|---|---|---|---|---|
| AUSTRALIA | 1 | 1 | 0 | 100 |
| BRAZIL | 1 | 1 | 0 | 100 |
| FRANCE | 1 | 1 | 0 | 100 |
| ITALY | 1 | 1 | 0 | 100 |
| UNITED STATES | 16 | 16 | 0 | 100 |
| **Total** | **20** | **20** | **0** | **100** |

## Environmental Testing

In addition to product sampling, 1004 environmental samples from 229 domestic federally registered establishments producing RTE meat products were analyzed for *Listeria* spp. Environmental sampling at the establishment is another tool for monitoring sanitation practices and the potential for environmental contamination of the products. The presence of *L. monocytogenes* is not tolerated in the production environment and its detection results in an unsatisfactory assessment. In some cases, environmental samples do not test positive for *L. monocytogenes* but may be positive for other *Listeria* spp. Since these species do not induce illness in humans but indicate a lack of sanitary control, the presence of other *Listeria* spp. in the environment results in an investigative assessment. Regardless, 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*. Of the 1004 environmental samples analyzed (Figure 2), nine (0.9%) were assessed as unsatisfactory due to the detection of *L. monocytogenes* and 35 (3.5%) as investigative due to the presence of other *Listeria* spp. Overall, 95.6% of the environmental samples were satisfactory.

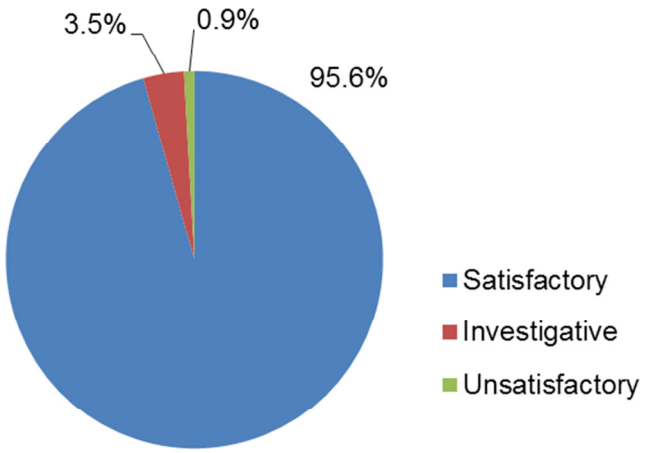


**Figure 2:** Environmental Analysis (%) of Domestic Federally Registered Meat Establishments Producing Ready-To-Eat Meat Products

## Shell Eggs and Egg Products

Under the NMMP, imported shell eggs are tested for *Salmonella* spp. while domestic and imported processed egg products are tested for ACC, coliforms, *L. monocytogenes* and *Salmonella* spp. In Canada, eggs are graded, sized and packed at egg grading stations registered by the CFIA. Within domestic shell egg grading stations, environmental sampling and testing is performed on wash water for ACC while surface swabs from areas before and after grading are tested for *Salmonella* spp. Environmental sampling in domestic egg processing establishments includes the random selection of food-contact surfaces or non-food contact surfaces from either the pre-operational stage or production stage for each sampling activity. The samples taken prior to production (pre-operational stage) are tested for *Salmonella* spp. while samples taken during production are tested for *Salmonella* spp. and *L. monocytogenes*.

## Shell Eggs

The United States is the sole exporter of shell eggs to Canada. A total of 284 imported samples were subjected to 284 tests for *Salmonella* spp. No *Salmonella* spp. was detected. In domestic egg grading establishments, the CFIA implements environmental testing to verify the adequacy of sanitary practices. Results from this environmental testing are discussed below in section 6.2.3.

## Egg Products

Domestic and imported egg products were tested for ACC, coliforms, *L. monocytogenes* and *Salmonella* spp. A total of 1066 tests were performed on 289 domestic egg products, of which 100% were deemed compliant (Table 6). As is the case with imported shell eggs, the United States is Canada's only source of imported egg products. During 2012/13, a total of 29 egg products from the United States were subjected to 116 tests, all of which were 100% compliant. Overall, 1182 tests were performed on 318 domestic and imported egg products with a 100% compliance rate.

**Table 6:** Compliance Rates of Domestic and Imported Egg Products

| Source | # Tests | # Samples | # Satisfactory | # Unsatisfactory | % Compliance |
|---|---|---|---|---|---|
| Domestic | 1066 | 289 | 289 | 0 | 100.0 |
| Imported | 116 | 29 | 29 | 0 | 100.0 |
| **Total** | **1182** | **318** | **318** | **0** | **100.0** |

## Environmental Testing

A total of 1197 tests were performed on 758 environmental samples, including wash water and surface swabs (Table 7). The overall compliance rate was 95.5% with 34 samples deemed unsatisfactory.

There are four critical points in the production environment which are sampled in order to verify sanitary controls: water used to wash the eggs, water used to wash the baskets containing the eggs, surfaces in areas containing ungraded eggs and surfaces in areas containing graded eggs. In total, 322 wash water samples were subjected to 322 tests for ACC (Table 7). Of these, 25 contained high levels of ACC indicating inadequate sanitary practices, while the remaining 92.2% were compliant. In shell egg grading establishments, each environmental sample consisted of swabbing five surfaces in the ungraded egg areas and five surfaces in the graded egg areas. At the laboratory, these swabs were pooled into two sub-samples (one for the ungraded area swabs and one for the graded area swabs) and tested for *Salmonella* spp. Thus, for each environmental sample, there were two tests for *Salmonella* spp. In total, 762 tests for *Salmonella* spp. were performed on 381 environmental samples representing 3810 surfaces within shell

egg grading establishments. Of these, 97.9% were compliant, with the detection of *Salmonella* spp. in eight samples.

In domestic egg product processing establishments, sampling was performed either during the pre-operational stage or during production. The sampling consisted of swabbing either food contact surfaces or non-food contact surfaces. Samples taken prior to production (pre-operational stage) were tested for *Salmonella* spp. while samples taken during production were tested for *Salmonella* spp. and *L. monocytogenes*. A total of 113 tests were performed on 55 samples (Table 7), representing 550 surfaces within the processing plants. Of these, one sample tested positive for *Salmonella* spp. for an overall compliance rate of 98.2%.

**Table 7:** Compliance Rates of Environmental Samples from Domestic Shell Egg Grading Stations and Egg Product Processing Establishments

| Product Type | # Tests | # Samples | # Satisfactory | # Unsatisfactory | % Compliance |
|---|---|---|---|---|---|
| Shell Egg Wash Water | 322 | 322 | 297 | 25 | 92.2 |
| Shell Egg Environmental Swabs | 762 | 381 | 373 | 8 | 97.9 |
| Egg Product Environmental Swabs | 113 | 55 | 54 | 1 | 98.2 |
| **Total** | **1197** | **758** | **724** | **34** | **95.5** |

## Dairy Products

Dairy samples are analyzed for coliforms, generic *E. coli*, *Salmonella* spp., *L. monocytogenes*, and *S. aureus.* Phosphatase testing is only performed when claims of pasteurization need to be confirmed. Domestic establishments producing products such as canned milk, frozen dairy products, milk based powders, fermented dairy products, and butter are subject to visual inspections by CFIA inspectors. Samples of these types of products are taken under directed sampling activities for investigative purposes only.

### Fluid Milk Products

During 2012/13, a total of 89 fluid milk products were sampled at domestic dairy producers and analyzed for generic *E. coli* and *L. monocytogenes*. This included all grades of milk, chocolate milk, coffee creams and specialty products (Table 8). A total of 178 analytical tests were performed and the samples were deemed to be 100% compliant. No *L. monocytogenes* was detected in any of the samples and all levels of generic *E. coli* were within compliance limits. Due to the extensive volume of milk production within Canada, these types of products are typically not imported, as such all samples collected were domestically produced.

**Table 8:** Compliance Rates of Domestic Fluid Milk Products

| Product Type | # Tests | # Samples | # Satisfactory | # Unsatisfactory | % Compliance |
|---|---|---|---|---|---|
| Skim Milk | 16 | 8 | 8 | 0 | 100 |
| 1% Milk | 18 | 9 | 9 | 0 | 100 |
| 2% Milk | 62 | 31 | 31 | 0 | 100 |
| Homogenized (3.25%) Milk | 20 | 10 | 10 | 0 | 100 |
| Chocolate Milk | 32 | 16 | 16 | 0 | 100 |
| Cream[a] | 12 | 6 | 6 | 0 | 100 |
| Specialty Milk[b] | 18 | 9 | 9 | 0 | 100 |
| **Total** | **178** | **89** | **89** | **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.

## Cheese Products

The other most commonly consumed dairy product is cheese. Cheese is a manufactured product for which the probability of microbial contamination is incurred due to handling and fermentation practices. As such, domestic and imported cheeses were sampled and analyzed for generic *E. coli*, *E. coli* O157:H7 (for cheeses made from raw milk only), *Salmonella* spp., *L. monocytogenes, S. aureus* and its enterotoxins. Phosphatase testing was performed when deemed appropriate.

Domestic samples consisted primarily of traditional cheeses, such as cottage cheese, cheddar, mozzarella, brie and cheese slices. However, some producers use "non-traditional" methods that do not use bacteria to coagulate the cheese. These types of cheeses, including paneer and channa, were also selected for analysis. In total, 378 domestic cheeses and seven domestic non-traditional cheese products were subjected to 1778 tests (Table 9). The traditional cheeses were 98.7% compliant with five samples assessed as unsatisfactory. Two samples were deemed to have high levels of generic *E. coli*, one sample was positive for *L. monocytogenes*, one sample had high levels of *S. aureus* and one sample was positive for *Staphylococcal* enterotoxins. The seven domestic non-traditional cheese products were assessed as 100% compliant.

A variety of cheeses imported from 20 countries were also tested. In total, 285 imported cheese samples were subjected to 1363 tests and 97.5% of these products were deemed to be compliant (Table 9). The seven samples assessed as unsatisfactory were imported from three countries (Table 10). Two samples from Italy and one sample from France contained high levels of generic *E. coli*. One sample from Bulgaria and one sample from

France were unsatisfactory due to the presence of *L. monocytogenes*. Lastly, two samples from France were unsatisfactory due to high levels of *S. aureus*.

**Table 9:** Compliance Rates of Domestic Traditional and Non-Traditional Cheeses and Imported Traditional Cheeses

| Product Type | # Tests | # Samples | # Satisfactory | # Unsatisfactory | % Compliance |
|---|---|---|---|---|---|
| Domestic Traditional Cheese | 1749 | 378 | 373 | 5 | 98.7 |
| Domestic Non-Traditional Cheese | 29 | 7 | 7 | 0 | 100 |
| Imported Cheese | 1363 | 285 | 278 | 7 | 97.5 |
| **Total** | **3141** | **670** | **658** | **12** | **98.2** |

**Table 10:** Number of Imported Cheese Samples Analyzed by Country of Origin

| Country of Origin | # Samples | # Satisfactory | # Unsatisfactory | % Compliance |
|---|---|---|---|---|
| BELGIUM | 1 | 1 | 0 | 100.0 |
| BULGARIA | 4 | 3 | 1 | 75.0 |
| DENMARK | 10 | 10 | 0 | 100.0 |
| FINLAND | 1 | 1 | 0 | 100.0 |
| FRANCE | 137 | 133 | 4 | 97.1 |
| GERMANY | 4 | 4 | 0 | 100.0 |
| GREECE | 11 | 11 | 0 | 100.0 |
| IRELAND | 1 | 1 | 0 | 100.0 |
| ISRAEL | 5 | 5 | 0 | 100.0 |
| ITALY | 38 | 36 | 2 | 94.7 |
| NETHERLANDS | 11 | 11 | 0 | 100.0 |
| NICARAGUA | 1 | 1 | 0 | 100.0 |
| NORWAY | 2 | 2 | 0 | 100.0 |
| POLAND | 3 | 3 | 0 | 100.0 |
| PORTUGAL | 3 | 3 | 0 | 100.0 |
| SPAIN | 2 | 2 | 0 | 100.0 |
| SWEDEN | 1 | 1 | 0 | 100.0 |
| SWITZERLAND | 14 | 14 | 0 | 100.0 |
| UNITED KINGDOM | 12 | 12 | 0 | 100.0 |
| UNITED STATES | 24 | 24 | 0 | 100.0 |
| **Total** | **285** | **278** | **7** | **97.5** |

## Environmental Testing

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 2012/13, a total of 130 environmental samples were tested and deemed to be 99.2% compliant. One environmental sample was deemed unsatisfactory due to the presence of *L. monocytogenes*.

## Fresh Fruits and Vegetables

Under the NMMP, a wide variety of fresh fruits and vegetables grown under various conditions are tested, including those grown using organic and conventional farming methods, and those grown 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.

Products such as herbs, sprouts and fresh-cut produce are tested for generic *E. coli*, *E. coli* O157:H7, *Salmonella* spp. and *Shigella* spp. Additional produce-specific testing include faecal coliforms (sprouts), *L. monocytogenes* (RTE fresh-cut produce) and VTEC (leafy vegetables, sprouts, herbs, green onions). Sampling includes whole fruits and vegetables that may be consumed raw and RTE fresh-cut produce such as coleslaws, salads, carrots, mushrooms and melons. RTE fresh-cut produce 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.

### Fresh Vegetables and Ready-To-Eat Fresh-Cut Vegetables

The sampling of domestic and imported vegetables was primarily composed of herbs, onions, peppers, sprouts and tomatoes. In addition to produce intended for local markets, (i.e. for sale to the general public), institutional sized bags of vegetables (e.g. shredded lettuce and spinach) destined for restaurants, hospitals or institutions were also sampled. Similar types and numbers of domestic and imported vegetables were tested (Figure 3).

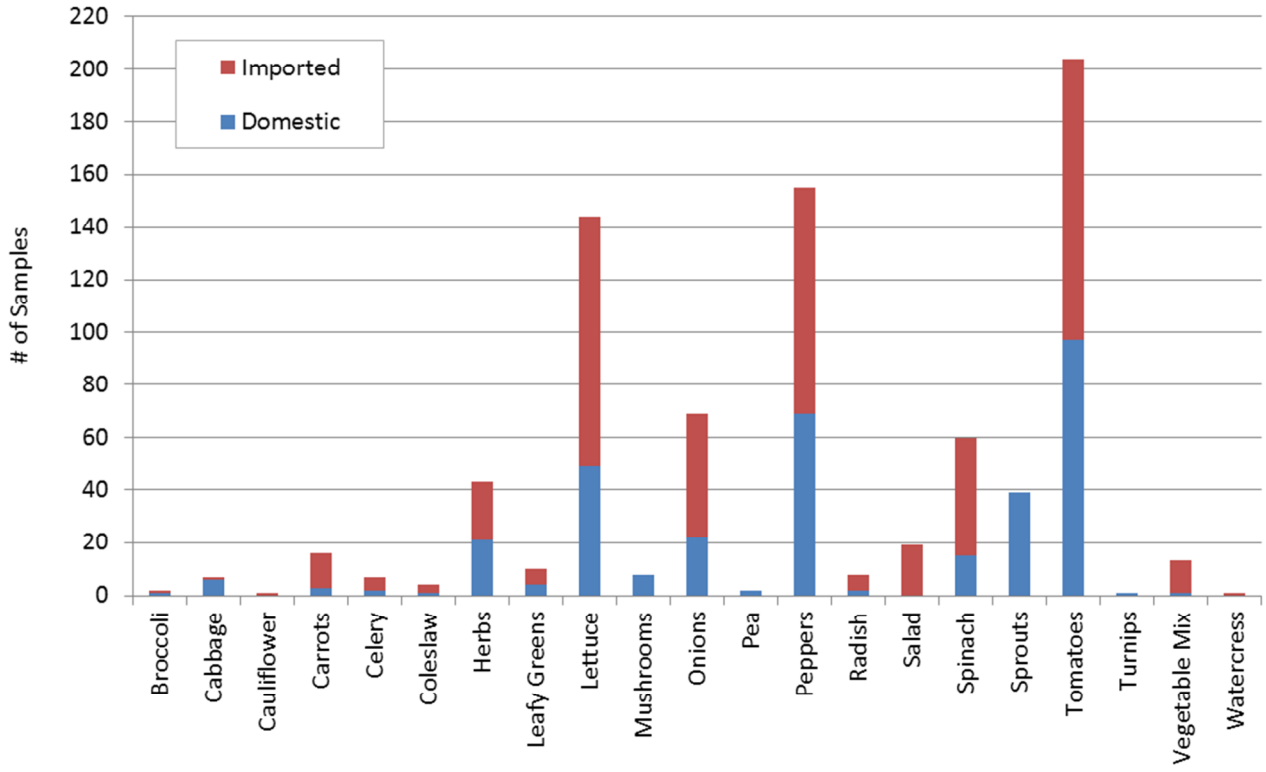


**Figure 3:** Number and Types of Domestic and Imported Vegetables (Fresh and Ready-To-Eat Fresh-Cut) Sampled for Testing

In total, 710 fresh vegetables and 90 RTE fresh-cut vegetables were subjected to 3172 tests (Table 11). Amongst the 307 domestic fresh vegetables, five samples of sprouts and were assessed as unsatisfactory due to high levels of faecal coliforms, for an overall compliance rate of 98.4%. Domestic RTE fresh-cut vegetables were assessed as 95.5% compliant, with the detection of *L. monocytogenes* in one sample of sliced mushrooms.

Samples of imported vegetables were analyzed from 14 different countries (Figure 4). Of the 403 samples of imported fresh vegetables, one herb sample from Vietnam and one lettuce sample from the United States were determined to be unsatisfactory due to high levels of generic *E. coli* and the presence of *E. coli* O157:H7, respectively. Compliance was determined to be 99.5%. All 72 samples of imported RTE fresh-cut vegetables were assessed as satisfactory for a compliance rate of 100%.

**Table 11:** Compliance Rates of Domestic and Imported Fresh Vegetables and Ready-To-Eat (RTE) Fresh-Cut Vegetables

| Product Type | # Tests | # Samples | # Satisfactory | # Unsatisfactory | % Compliance |
|---|---|---|---|---|---|
| Domestic Fresh Vegetables | 1281 | 307 | 302 | 5 | 98.4 |
| Domestic RTE Fresh-Cut Vegetables | 107 | 22 | 21 | 1 | 95.5 |
| Imported Fresh Vegetables | 1453 | 403 | 401 | 2 | 99.5 |
| Imported RTE Fresh-Cut Vegetables | 331 | 68 | 68 | 0 | 100.0 |
| **Total** | **3172** | **800** | **792** | **8** | **99.0** |

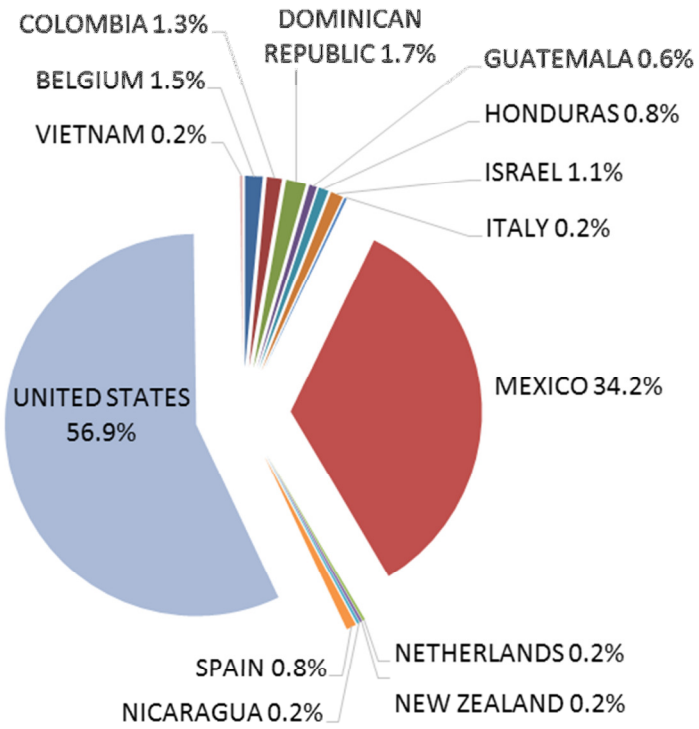


**Figure 4:** Countries of Origin of Imported Vegetables (Fresh and Ready-To-Eat Fresh-Cut) Sampled for Testing

## Fresh Fruits and Ready-To-Eat Fresh-Cut Fruits

A total of 195 fresh and RTE fresh-cut fruits were subjected to a total of 738 analytical tests (Table 12). Based on consultation and prioritization of food-hazard combinations deemed to pose the greatest potential health risk during the design of these plans, melons and berries were predominantly represented (Figure 5). Overall, 100% of the fresh fruits sampled were assessed as satisfactory. The imported fruits were sampled from 10 different countries (Figure 6), with products from the United States and Mexico accounting for 75% of the samples tested.

**Table 12:** Compliance Rates of Domestic and Imported Fresh Fruits and Ready-To-Eat Fresh-Cut Fruits

| Source/Product | # Tests | # Samples | # Satisfactory | # Unsatisfactory | % Compliance |
|---|---|---|---|---|---|
| Domestic Fresh Fruit | 126 | 34 | 34 | 0 | 100.0 |
| Domestic RTE Fresh-Cut Fruit | 45 | 9 | 9 | 0 | 100.0 |
| Imported Fresh Fruit | 552 | 149 | 149 | 0 | 100.0 |
| Imported RTE Fresh-Cut Fruit | 15 | 3 | 3 | 0 | 100.0 |
| **Total** | **738** | **195** | **195** | **0** | **100.0** |

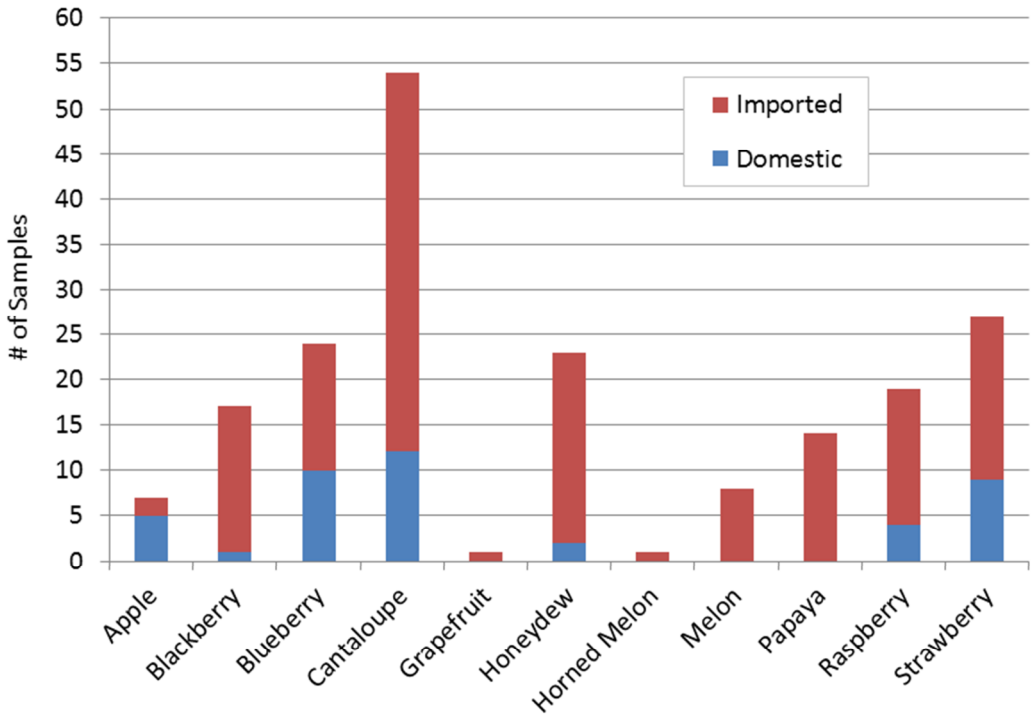


**Figure 5:** Number and Types of Domestic and Imported Fresh Fruits and Ready-To-Eat Fresh-Cut Fruits

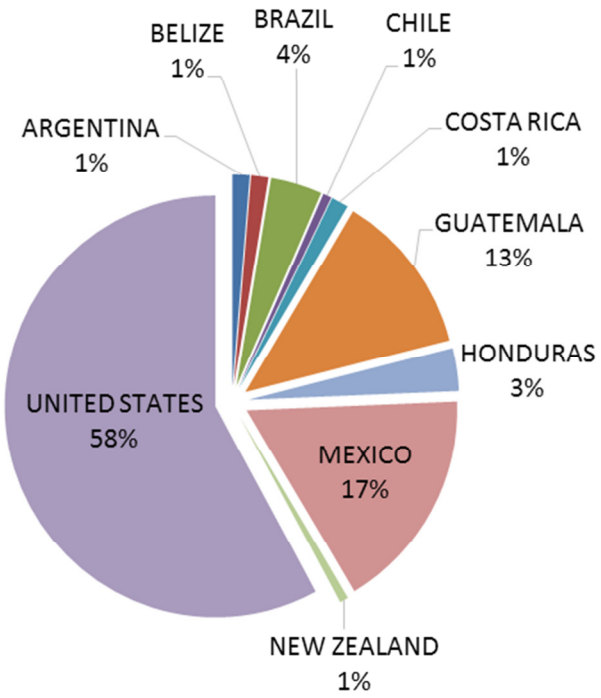


**Figure 6:** Countries of Origin of Imported Fruits (Fresh and Ready-To-Eat Fresh-Cut) Sampled for Testing

## Processed Fruit and Vegetable Products

Under CFIA's monitoring activities, processed fruit and vegetable products are sampled and tested. Commodities selected include frozen fruits and vegetables as well as acidified low-acid foods (i.e. foods treated so all components have an equilibrium pH of 4.6 or less; e.g. green olives, pickles, olives, sauerkraut, pickled eggplant, pickled peppers, pickled artichoke hearts, pickled asparagus).

With the exception of frozen foods, all of these products were packaged in cans or glass jars. The packaging process includes heat treatment to ensure sterility of the environment within the container. These packaged products were tested for physio-chemical parameters (pH, water activity, salt content) to determine their quality and safety. Additionally, those labelled as requiring refrigeration were tested for *L. monocytogenes*. In the absence of heat treatment, frozen foods were subjected to microbial analysis including aerobic colony counts, generic *E. coli*, *L. monocytogenes* and *Salmonella* spp.

## Acidified Low-Acid and Pickled Products

Acidified low-acid products and pickled products including eggplant, sauerkraut, pickles, olives, red beets, etc. are sold in cans or jars. Pickled products require refrigeration in order to maintain their shelf-life, while the acidified low-acid products can be stored at room temperature. All of these products were tested for pH, water activity and salt content, and those requiring refrigeration were also tested for *L. monocytogenes*.

During 2012/13, a total of 207 tests were performed on 21 samples (Table 13). No *L. monocytogenes* was detected. Two domestic and two imported pickled products were subjected to six analytical tests and deemed to be 100% compliant. Furthermore, 201 analytical tests were performed on 17 imported acidified low-acid shelf-stable products. All were assessed as satisfactory and therefore 100% compliant. The 19 imported products were from 10 different countries (Table 14).

**Table 13:** Compliance Rates of Domestic and Imported Acidified Low-Acid Products and Pickled Products

| **Product Type** | **# Tests** | **# Samples** | **# Satisfactory** | **# Unsatisfactory** | **% Compliance[a]** |
|---|---|---|---|---|---|
| Domestic Pickled | 3 | 2 | 2 | 0 | 100 |
| Imported Pickled | 3 | 2 | 2 | 0 | 100 |
| Imported Acidified Low- Acid | 201 | 17 | 17 | 0 | 100 |
| **Total** | **207** | **21** | **21** | **0** | **100** |

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

**Table 14:** Number of Imported Acidified Low-Acid Products and Pickled Products by Country of Origin

| Country of Origin | # Samples |
|---|---|
| INDIA | 3 |
| IRAN | 1 |
| ITALY | 2 |
| PERU | 1 |
| PHILIPPINES | 1 |
| POLAND | 1 |
| SOUTH AFRICA | 1 |
| TURKEY | 2 |
| UNITED STATES | 5[a] |
| VIETNAM | 2 |
| **Total** | **19** |

[a] Includes two refrigerated pickled products.

## Frozen Vegetables

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. Storage under these conditions typically does not support the growth of microorganisms, yet is not adequate to destroy all types of microbes. 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. These products 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 for *L. monocytogenes*.

In total, 19 domestic and 43 imported frozen vegetables were sampled, with an overall compliance rate of 93.5% (Table 15). Of the domestic frozen vegetables, 18 samples displayed cooking instructions and one sample did not. Together the samples were subjected to a total of 37 analyses and all were deemed to be satisfactory. With regards to imported frozen vegetables, 39 of the samples displayed cooking instructions while four samples did not. They were subjected to a total of 97 analyses. Four of the products with

cooking instructions were assessed as unsatisfactory due to the presence of high levels of ACC, leading to a compliance rate of 89.7%. The four samples without cooking instructions were all deemed satisfactory for a compliance rate of 100%. The 43 imported frozen products were from 11 different countries, with the majority of products coming from the United States (39.5%) and China (16.3%; Table 16).

**Table 15:** Microbial Testing and Compliance Rates of Domestic and Imported Frozen Vegetables

| **Product Type** | **# Tests** | **# Samples** | **# Satisfactory** | **# Unsatisfactory** | **% Compliance** |
|---|---|---|---|---|---|
| Domestic | 36 | 18 | 18 | 0 | 100 |
| Domestic - Without cooking instructions | 1 | 1 | 1 | 0 | 100 |
| Imported | 93 | 39 | 35 | 4 | 89.7 |
| Imported - Without cooking instructions | 4 | 4 | 4 | 0 | 100 |
| **Total** | **134** | **62** | **58** | **4** | **93.5** |

**Table 16:** Percentage, Number and Assessment of Imported Frozen Vegetables by Country of Origin

| **Country of Origin** | **% of Samples** | **# Samples** | **# Satisfactory** | **# Investigative** | **# Unsatisfactory** | **% Compliance** |
|---|---|---|---|---|---|---|
| BELGIUM | 7.0 | 3 | 3 | 0 | 0 | 100 |
| CHILE | 4.7 | 2 | 2 | 0 | 0 | 100 |
| CHINA | 16.3 | 7 | 7 | 0 | 0 | 100 |
| ECUADOR | 2.3 | 1 | 1 | 0 | 0 | 100 |
| HUNGARY | 2.3 | 1 | 1 | 0 | 0 | 100 |
| INDIA | 9.3 | 4 | 2 | 0 | 2 | 50 |
| MEXICO | 7.0 | 3 | 3 | 0 | 0 | 100 |
| PHILIPPINES | 4.7 | 2 | 2 | 0 | 0 | 100 |
| PORTUGAL | 2.3 | 1 | 0 | 0 | 1 | 0 |
| UNITED STATES | 39.5 | 17 | 17 | 0 | 0 | 100 |
| VIETNAM | 4.7 | 2 | 1 | 0 | 1 | 50 |
| **Total** | **100** | **43** | **39** | **0** | **4** | **90.7** |

## Frozen Fruits

Unlike most frozen vegetables, frozen fruits do not require heating or cooking prior to consumption. Since these products are not subjected to any treatments to kill potential pathogens, and do not display cooking instructions on their packages, they can pose a potential microbial health risk to consumers. A variety of frozen fruits, including cherry, mango, honeydew melon, pineapple and peach were tested for the presence of *L. monocytogenes*, while numerous types of frozen berries were tested for *L. monocytogenes* and *Salmonella* spp. Overall, 13 samples of domestic and imported frozen fruits were analyzed and determined to be 100% compliant (Table 17). The 11 imported samples originated from six countries (Table 18).

**Table 17:** Compliance Rates of Domestic and Imported Frozen Fruits

| **Source** | **# Tests** | **# Samples** | **# Satisfactory** | **# Unsatisfactory** | **% Compliance** |
|---|---|---|---|---|---|
| Domestic | 3 | 2 | 2 | 0 | 100 |
| Imported | 15 | 11 | 11 | 0 | 100 |
| **Total** | **18** | **13** | **13** | **0** | **100** |

**Table 18:** Number of Imported Frozen Fruits by Country of Origin

| **Country of Origin** | **# Samples** |
|---|---|
| CHILE | 1 |
| ECUADOR | 1 |
| GUATEMALA | 2 |
| MEXICO | 3 |
| SERBIA | 1 |
| UNITED STATES | 3 |
| **Total** | **11** |

# Summary

The NMMP is designed to sample and test a broad range of imported and domestic commodities for multiple hazards. 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. 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. The defined assessment criteria 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 2012/13 fiscal year under the NMMP, 4980 domestic and imported products were sampled and tested. A variety of testing was performed to verify the products were safe for consumption: 8328 tests were performed on 3469 domestic products and 4909 tests were performed on 1511 imported products. There were assessed as 99.5% and 99.0% compliant, respectively. Combined, 13237 tests were conducted on 4980 food products and deemed to be 99.4% compliant.

Environmental sampling was performed in various domestic establishments. It is an effective tool used to determine the efficacy of the operator's system to control the presence of pathogens within the processing environment. It is used to identify the presence of pathogens within the manufacturing environment and prevent downstream contamination of products. During the 2012/13 fiscal year, 2563 tests were performed on 1892 environmental samples from domestic establishments. Of these, 97.7% 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 periodical 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: Acronyms and Abbreviations

| | |
|---|---|
| ACC | Aerobic Colony Count |
| BSE | Bovine Spongiform Encephalopathy |
| CFIA | Canadian Food Inspection Agency |
| CFU | Colony Forming Unit |
| CNS | Central Nervous System |
| *E. coli* | *Escherichia coli* |
| FDA | Food and Drug Administration |
| ICMSF | International Commission on Microbiological Specifications for Foods |
| *L. monocytogenes* | *Listeria monocytogenes* |
| MPN | Most Probable Number |
| NMMP | National Microbiological Monitoring Program |
| RTE | Ready-To-Eat |
| *S. aureus* | *Staphylococcus aureus* |
| spp. | Species |
| *T. spiralis* | *Trichinella spiralis* |
| vCJD | Variant Creutzfeld-Jakob Disease |
| VTEC | Verotoxigenic *Escherichia coli* |

## Appendix B: 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** 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.