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Food Safety for First Nations People of Canada:

A Manual for Healthy Practices

Canada

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Cover photo: Delegates of the Assembly of First Nations' 2005 Annual General Assembly in Yellowknife enjoy a feast organized by the Host Committee

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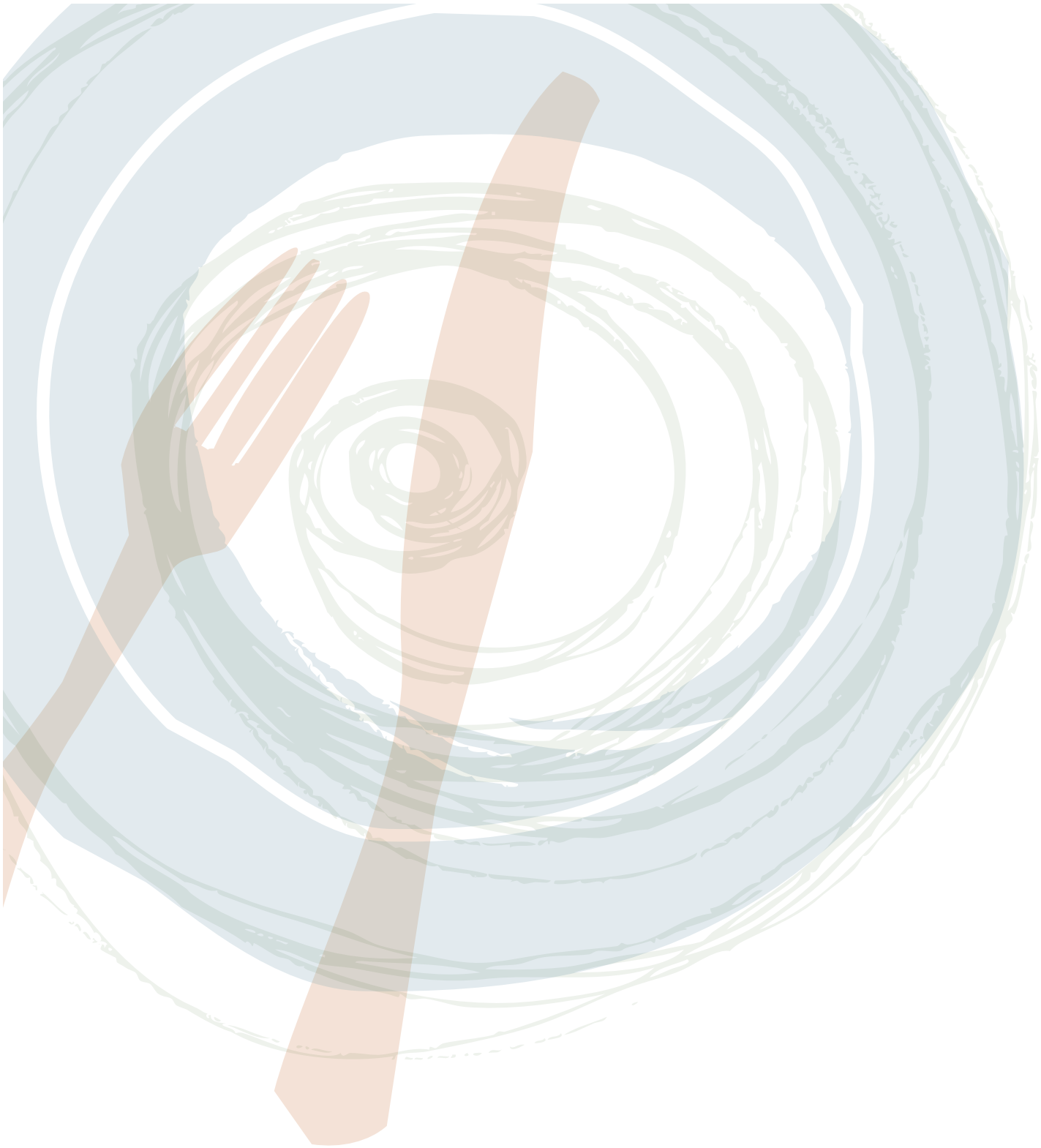


Foreword

As First Nations peoples we have a unique relationship with the land and the water. This inherent cultural relationship encompasses the four aspects of our being – physical, mental, emotional and spiritual. This relationship involves a unique diet that includes traditional foods that provide us with many essential nutrients, some of which are missing in market foods. Our peoples have thrived by living off traditional foods since time immemorial. It is only recently that market and convenience foods ("fast food") have begun to enter the First Nation diet – coincidently the same time that previously unknown diseases like diabetes and heart disease began to appear.

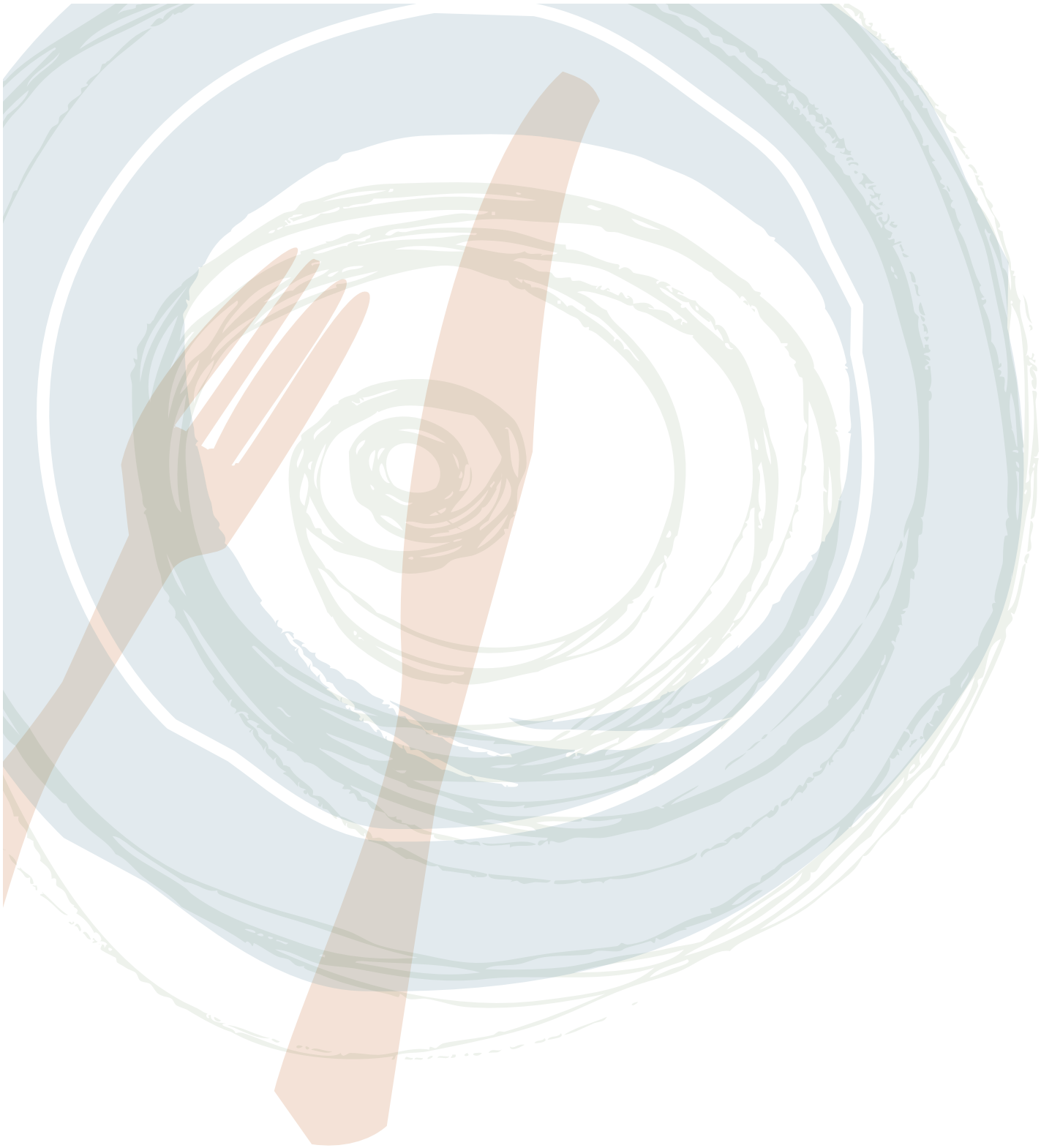
Traditional foods offer benefits far beyond basic dietary nutrition. The harvesting of traditional foods maintains our cultural and spiritual link to the land in a very real and tangible way. Many traditional foods are essential requirements in our ceremonies and some have important medicinal properties, and all carry cultural and spiritual meaning that are significant to First Nations peoples. Many of the stories that our elders share involve these foods, some of which are essential to our very identity as First Nations peoples.

Traditional knowledge is passed down to younger generations when we share our foods, hunt and gather and preserve and prepare what we have harvested. This is an important part of our cultural heritage and it must be maintained. It is important that we continue to harvest and enjoy our traditional foods but we must also be aware of any current or potential health risks that may be associated with them. Protecting the health of our peoples and the environment that these plants and animals depend upon will help ensure secure food systems and insure healthy diets well into the future.

We want to thank Health Canada for publishing this comprehensive manual on food safety with a First Nations focus. The practical guidance provided will ensure that traditional foods are harvested and prepared in a safe manner so that they may be enjoyed to their fullest.

Regional Chief Roger Augustine
Assembly of First Nations

Regional Chief Eric Morris
Assembly of First Nations



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Indian and Northern Affairs Canada (Northern Food Security)

Canadian Food Inspection Agency (Food Safety Division and Office of Food Safety and Recall)

Department of Fisheries and Oceans (Institute of Ocean Sciences)

Public Health Agency of Canada (Enteric Surveillance and Population Studies Division and Foodborne, Waterborne and Zoonotic Infections Division)

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Communicable Disease Control Division

Community Programs Directorate (Nutrition Unit)

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The Environmental Health Research Division and Environmental Public Health Division

First Nations and Inuit Health Branch

Primary Health Care and Public Health Directorate

Health Canada

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Acronyms

AFN: Assembly of First Nations

AHA: American Heart Association

APHA: American Public Health Association

ASP: Amnesic Shellfish Poisoning

ATSDR: Agency for Toxic Substances and Disease Registry

CACAR: Canadian Arctic Contaminants Assessment Report

CDC: Centers for Disease Control and Prevention

CEC: Commission for Environmental Cooperation

CFIA: Canadian Food Inspection Agency

CFISIG: Canadian Food Inspection System Implementation Group

CFP: Ciguatera Fish Poisoning

CFS: Centre for Food Safety

CWD: Chronic Wasting Disease

DDD: Dichloro-Diphenyl-Dichloroethane

DDE: Dichloro-Diphenyl-Dichloroethylene

DDT: Dichloro-Diphenyl-Trichloroethane

DFO: Department of Fisheries and Oceans

DNRE: Department of Natural Resources and Environment

DSP: Diarrheic Shellfish Poisoning

EC: Environment Canada

EHOs: Environmental Health Officers

FAO: Food and Agricultural Organisation

FOC: Fisheries and Oceans Canada

FPT: Federal/Provincial/Territorial

FSA: Food Standards Agency

GOS: Government of Saskatchewan

HABs: Harmful Algal Blooms

HC: Health Canada

HCB: Hexachlorobenzene

INAC: Indian and Northern Affairs Canada now known as Aboriginal Affairs and Northern Development Canada (AANDC)

IRR: Institute for Risk Research

MDH: Minnesota Department of Health

MNR: Ministry of Natural Resources

NSP: Neurotoxic Shellfish Poisoning

NZFSA: New Zealand Food Safety Authority

OCs: Organochlorines

OHEP: Ontario Hunter's Education Program

PAHs: Polycyclic aromatic hydrocarbons

PBDEs: Polybrominated diphenyl ethers

PBTs: Persistent, bioaccumulative, and toxic

PCBs: Polychlorinated biphenyls

PCDD: Polychlorinated dibenzo-p-dioxins

PCDF: Polychlorinated dibenzofurans

PFCs: Perflourinated chemicals

PFOA: Perfluorooctanic acid

PFOS: Perfluorooctane sulfonate or pefluorooctanyl sulfonate

PFSE: Partnership for Food Safety Education

PHAC: Public Health Agency of Canada

POPs: Persistent Organic Pollutants

PSP: Paralytic Shellfish Poisoning

SNSW: State of New South Wales

TCDD: Tetrachlorodibenzo-p-dioxin

UGA: University of Georgia

UNEP: United Nations Environment Programme

UNIDO: United Nations Industrial Development Organization

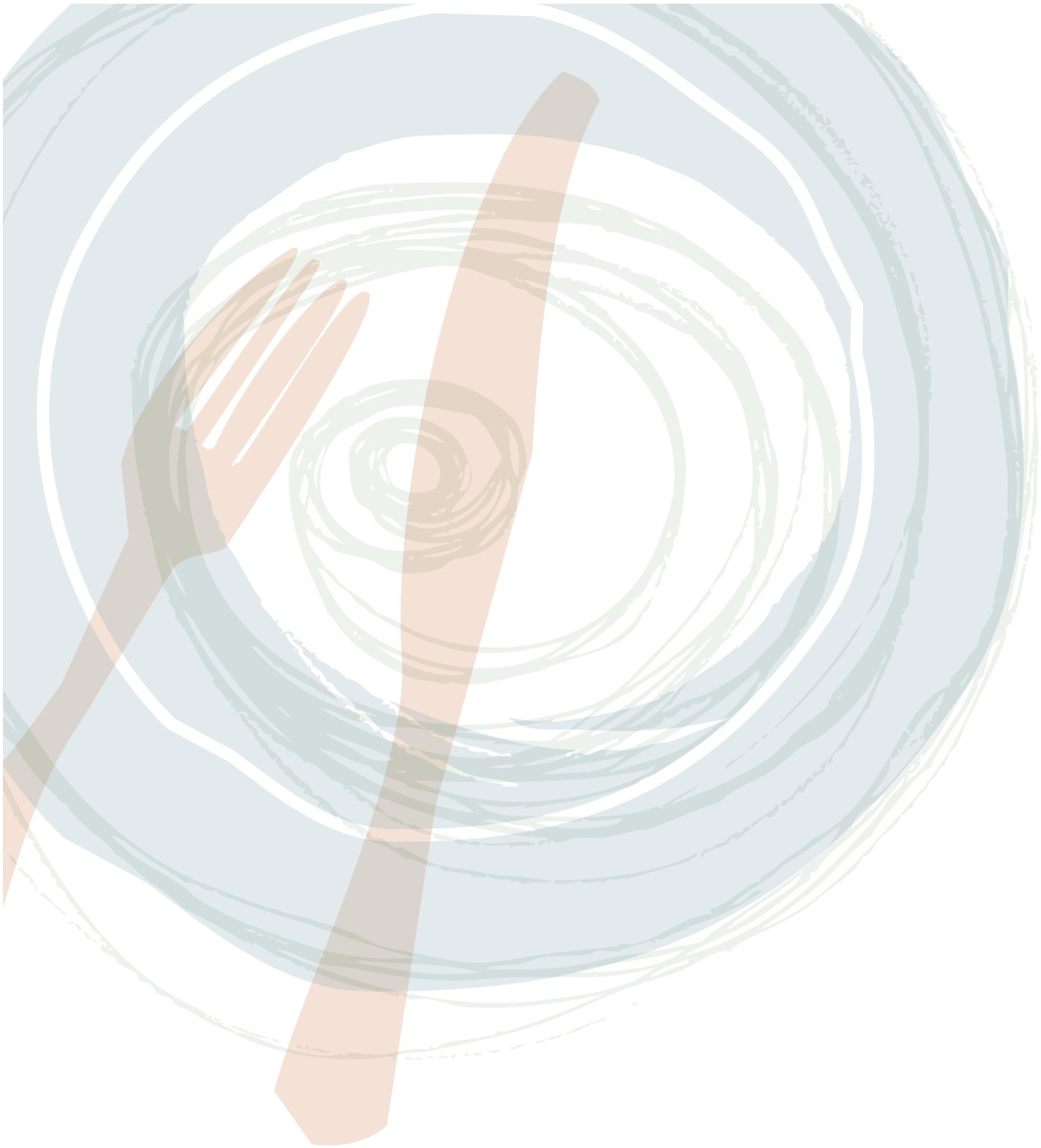
USDA: United States Department of Agriculture

USEPA: United States Environmental Protection Agency

USFDA: United States Food and Drug Administration

VHS: Viral hemorrhagic septicemia

WHO: World Health Organization



Introduction

Food safety

Food safety is a public health priority, necessary in preventing foodborne illnesses. Foodborne illness is a significant public health concern, affecting hundreds of millions of people around the world every year (WHO, 2009). In Canada alone, an estimated 11 million people suffer from foodborne illnesses each year (PHAC, 2008).

Foodborne illnesses are defined as "*diseases, […] either infectious or toxic in nature, caused by agents that enter the body through the ingestion of food*" (WHO, 2007). They can occur when a person consumes food contaminated with pathogenic bacteria, viruses, parasites or chemicals. Contamination may occur during the production, harvesting, processing, transportation, preparation, storage and serving of food (WHO, 2002) or from toxins which may occur naturally in plants, animals and fungi.

Circumstances that may contribute to the contamination of foods include:

- infection or contamination of some foods before or during harvest,
- improper preparation and storage of foods,
- unsanitary practices (such as inadequate personal hygiene and improper washing of dishes),
- use of contaminated water to prepare food, and
- chemical contaminants that enter foods through various pathways (including natural toxicants, environmental contaminants, and naturally occurring chemicals in plants).

The symptoms of most common foodborne illnesses include abdominal cramps, nausea, vomiting, diarrhea and/or fever. However, the effects of contaminated foods in humans vary and depend on many factors, such as the level of exposure, and the toxicity of the substance. Young children, pregnant women, the elderly, and those with a weakened immune system generally tend to be the most susceptible and more likely to have severe illness if they get sick. For any symptoms of suspected foodborne illness, consult your health care provider, or go to the nearest health care centre.

Preventing foodborne illness can be as simple as keeping routine practices, such as the proper handling, processing and storage of food and the shortening of time between food preparation and consumption.

This manual, *Food Safety for First Nations People of Canada: A Manual for Healthy Practices*, is intended to raise awareness in First Nations communities on the safe handling, preparation, and storage practices of traditional foods, in order to reduce the risk of foodborne illnesses. The Manual also includes market foods as they are increasingly becoming a part of First Nations diet. The Manual will be used primarily as a resource by Environmental Health Officers (EHOs), health care providers (e.g., health directors and nurses) and First Nations authorities and their delegates.

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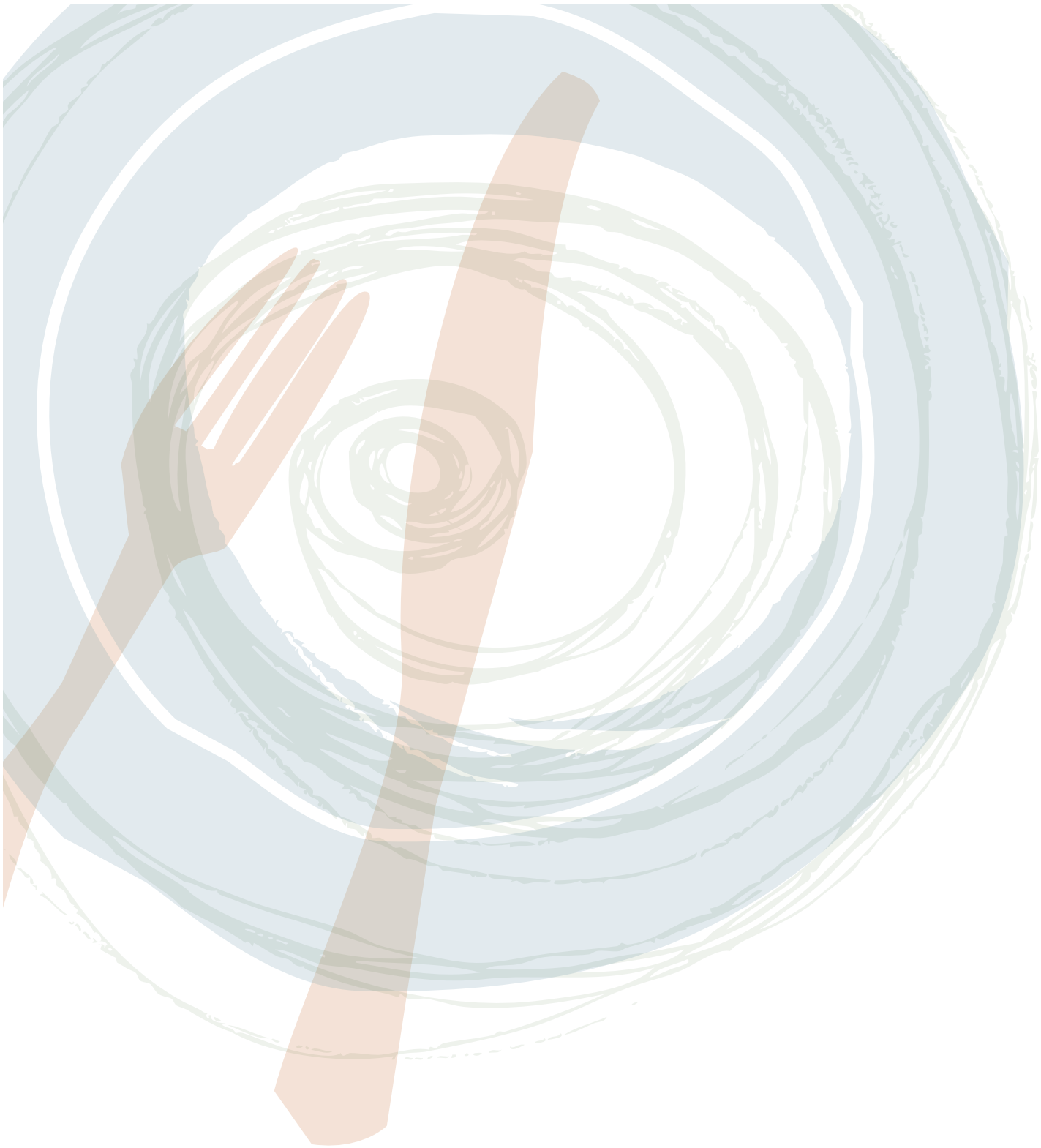

1. Microorganisms

1.1 What are microorganisms?

Microorganisms are microscopic forms of life, including bacteria, viruses, parasites and some fungi (see Table 1). While many microorganisms are harmless, and even beneficial to humans, a relatively small number can cause foodborne illnesses. These illnesses are of major concern in the field of food safety and can take the form of "*foodborne infection*" or "*foodborne intoxication*". *Foodborne infections*, such as Salmonellosis, can be caused by eating foods or beverages contaminated with harmful microorganisms which reproduce in the body (see Tables 2, 3 & 4). *Foodborne intoxications* can be caused by the consumption of foods contaminated with toxins produced by some types of bacteria or mould; eating food contaminated with other biological or chemical toxins (see Chapter 2 on bacterial toxins).

Table 1. Characteristics of microorganisms

MICROBIAL CONTAMINANT	Characteristics
Bacteria	• Carried by food, water, soil, insects, humans, or surfaces • Able to reproduce rapidly (under favourable conditions) • Some survive under freezing conditions • Some cause noticeable food spoilage • Some can multiply in fridge conditions (e.g., *Listeria*) • Some cause foodborne illness • Some produce toxins, which can cause foodborne intoxication
Viruses	• Rely on living cells to reproduce • Do not reproduce in food • Can contaminate food, water and food preparation surfaces • Use food as a vehicle and can be transmitted from person to person, person to food, or person to food preparation surfaces • May survive freezing and cooking
Parasites	• Do not reproduce in food • Need a host to survive • Exist in many animals, such as wild game, domestic and economic animals, fish and rodents • Can spread through food, water and food preparation surfaces
Fungi	• Cause food to spoil • Can contain toxins harmful to people (e.g., some mushroom types such as false morel, fly agaric, and panther cap) (see mushroom toxins section of chapter 2) Moulds • Cause food to spoil • Need air to grow • Grow at warm temperatures as well as at refrigerator temperatures or colder (USDA, 2010) • Can grow in salt and sugar • Grow well in acidic and moist conditions (WHO, 2009) • Freezing temperatures do not destroy moulds • Some moulds produce toxins such as aflatoxins that can cause illness Yeasts • Yeasts require sugar and moisture to survive • Grow well in acidic and moist conditions (WHO, 2009) • Cause food to spoil

1.2 Bacteria

Most foodborne illnesses are caused by bacteria. Bacteria vary in shape when observed under a microscope. Those found in food are usually rod-shaped (bacilli), spherical (cocci) or comma-shaped (vibrios).

Bacteria can grow on raw foods as a result of the improper handling and cleaning of storage and preparation areas, the use of unclean utensils, inadequate cooling/refrigeration/heating and leaving food at room temperature.

Keeping foods at temperatures below 4ºC/40ºF will slow the growth of bacteria but will not kill them.

Harmful bacteria, such as *Salmonella and Listeria*, can contaminate food at any point. They may already be on the foods when they are brought home, or can contaminate the food during its preparation, serving or even storage. If food is not handled properly during these stages, harmful bacteria can be transferred to food and cause foodborne illnesses. Bacteria use food as a nutrient and as a vehicle for transportation. Some foods, referred to as high-risk foods, that facilitate bacterial growth are:

- cooked meat, poultry and seafood,
- milk and dairy products,
- cream filled pastries,
- raw eggs (especially cracked eggs),
- cold cuts (e.g., ham, salami and bologna),
- shellfish,
- cooked rice, pasta and baked potatoes,
- cooked vegetables,
- raw fruits and vegetables, and
- prepared salads.

Precautions should be taken when handling these foods.

Conditions contributing to microbial growth

The following conditions contribute to microbial growth – in particular bacteria, though much is also applicable to yeasts and moulds.

Food

Bacteria need food to grow. They especially like moist, low acid, high-protein foods, such as meat, milk, eggs and fish. These types of food are the most likely to be associated with foodborne illness although contaminated fruits and vegetables can also carry pathogens.

Acidity

Acidity is measured on a pH scale ranging from 0 to 14.0. A substance with a pH of less than 7 is acidic, a pH greater than 7 is alkaline, and a pH of 7 is neutral. Bacteria grow best in neutral conditions. Some acidic foods, such as vinegar and citrus fruits, provide an unfavourable climate for harmful bacteria. Yeast and moulds are able to survive at a lower pH than most bacteria.

Keeping foods at temperatures below 4ºC/40ºF will slow the growth of bacteria but will not kill them.

Temperature

The ideal temperature range for the growth of bacteria is between 4ºC - 60ºC/40ºF -140ºF. This range is referred to as the ***danger zone***. Because bacteria multiply faster and some produce toxins in this range, raw and cooked foods should not be kept within this ***danger zone*** any longer than absolutely necessary. It is important to note that there are important exceptions including *Listeria* and *Yersinia* spp.

Time

The longer bacteria are allowed to sit in a warm, moist environment, the quicker they are likely to multiply. Under these conditions, some bacteria can double in numbers about every twenty minutes. A large percentage of foodborne infections are

caused by foods that have been allowed to remain at room temperature for a prolonged period of time.

Oxygen

Microorganisms differ in their need for oxygen. Those that need oxygen to grow are called aerobic. Those that do not need oxygen are called anaerobic. Facultative organisms can survive with or without oxygen, and microaerophilic organisms are able to grow in small quantities of oxygen.

Moisture

Bacteria need a moist environment to grow. Foods such as meat, fruits, vegetables and some cheeses have a high water content, which allows bacteria or moulds to multiply. Dry foods, such as crackers, are usually safe, as they provide little opportunity for microorganisms to reproduce. Foods preserved with a high concentration of salt or sugar are relatively safe, but once opened, they should be kept refrigerated and consumed within a month. Foods showing signs of spoilage (mould or yeast growth) should be discarded.

Preventing foodborne illness caused by bacteria

- Ensure good hygiene practices
  - avoid handling of food when ill, especially if suffering from diarrhea and/or vomiting,
  - wash hands frequently in warm soapy water while handling foods, especially after handling raw meat/game and seafood or after using the washroom
- Prevent cross-contamination
  - use clean utensils to prepare and serve food,
  - separate raw foods and ready-to-eat foods,
  - clean and sanitize surfaces used to prepare and serve food, and
  - store foods properly
- Purchase/obtain food from a reliable source
- Use clean water when preparing food, and
- Cook foods to proper internal temperatures.

It is important to keep cold foods at 4°C/40°F or lower, and hot foods at 60°C/140°F or higher.

Table 2. Bacterial foodborne illness identified in Canada

BACTERIA	Illness	Symptoms found in animals	Symptoms found in humans	Reaction time in humans	Associated foods/animals
Campylobacter jejuni	Campylo-bacteriosis	Can cause scarring (and diarrhea) in calves Adult cattle usually without symptoms	*May experience:* • Fever, headache and muscle pain, diarrhea, stomach pain, cramps, nausea, and vomiting. • Can cause septicemia in immunocompromised individuals	Usually within 2 to 5 days after eating contaminated foods	Raw or undercooked meat such as poultry, shellfish (e.g., clams), swine, rodents, wild birds, cattle, vegetables (e.g., mushroom, potato), and unpasterized milk
Preventive measures	• Purchase/obtain food from a reliable source • Ensure good hygiene practices: - avoid handling of food when ill, - wash hands frequently in warm soapy water while handling foods, - wash hands before and after handling food, changing diapers, using the washroom, and cleaning after pets	• Prevent cross-contamination - always use clean utensils to prepare and serve food, - clean and sanitize surfaces used to prepare and serve food, and - store foods properly • Use clean water when preparing food • Cook foods to proper internal temperatures	• Wash preparation areas and utensils before and after handling raw meat and poultry • Keep raw foods refrigerated immediately after purchase until ready to be cooked • Refrigerate or freeze raw poultry and meat • Prevent cross-contamination: separate raw meat and poultry from ready-to-eat foods • Do not drink unpasteurised milk	• Use a food thermometer to cook food to a safe internal temperature • Do not handle food if: - suffering from diarrhea or - caring for someone who is suffering from diarrhea	
Escherichia coli 0157:H7	E. coli infection	Can cause scarring (diarrhea) in young animals (e.g., calves)	*May experience:* • Diarrhea (sometimes bloody), and severe abdominal cramps • Some individuals can develop severe kidney problems including kidney failure Can develop into: • hemolytic uremic syndrome (haemolytic anaemia, acute renal failure and low platelet count, kidney failure, and blood disorder)	Usually within hours and up to 10 days after consuming contaminated foods or water.	Deer, cattle (e.g., undercooked beef, especially hamburger), chicken, raw fruits and vegetables (e.g., alfalfa sprouts, cabbage, celery, cress sprouts, lettuce, and melons), unpasteurised milk, and juice
Preventive measures	• Purchase/obtain food from a reliable source • Ensure good hygiene practices: - avoid handling of food when ill, - wash hands frequently in warm soapy water before and after handling food, changing diapers, using the washroom, and cleaning after pets	• Prevent cross-contamination - always use clean utensils to prepare and serve food, - clean and sanitize surfaces used to prepare and serve food, and - store foods properly • Use clean water to prepare food • Cook foods to proper internal temperatures	• Hamburger meat must reach an internal temperature of 71°C/160°F for at least 15 seconds • Use a food thermometer to measure the internal temperature of foods • Wash fruits and vegetables with clean water before eating them raw or cooking them	• Avoid cross-contamination of raw and cooked foods • Drink only pasteurised fruit juice • Infected food handlers should not handle food • Clean and sanitize preparation areas and utensils	

BACTERIA	Illness	Symptoms found in animals	Symptoms found in humans	Reaction time in humans	Associated foods/animals
Listeria monocytogenes	Listeriosis	Infected animals (e.g., cattle, sheep and goats) may trudge around in circles aimlessly and endlessly	*May experience:* • nausea, vomiting, cramps, diarrhea, severe headache, constipation, and persistent fever These symptoms may be followed by: • meningitis, encephalitis (brain infection or its surrounding tissues), and/or severe cases of septicaemia (blood poisoning) which can cause death • May cause death in unborn foetus (or abortion)	Symptoms usually occur within 2 days or as long as 70 days after eating contaminated foods (PHAC, 2008)	Domestic and wild mammals (especially raw and undercooked meat), fowl, soft cheeses (e.g., feta, brie, and camembert), unpasteurised milk, vegetables (e.g., bean sprouts, cabbage, cucumber, eggplants, lettuce, mushrooms, potatoes, and tomato), ready-to-eat meats (e.g., non-dried deli meats, deli cuts, hot dogs, luncheon meats, and cold cuts), fermented or dry sausage, poultry, and seafood
Preventive measures	• Purchase/obtain food from a reliable source • Ensure good hygiene practices: - avoid handling of food when ill, - wash hands frequently in warm soapy water while handling foods, - wash hands before and after handling food, changing diapers, using the washroom, and cleaning after pets • Prevent cross-contamination - always use clean utensils to prepare and serve food, - clean and sanitize surfaces used to prepare and serve food, and - store foods properly • Use clean water when preparing food • Cook foods to proper internal temperatures • Always wash vegetables and fruits before eating or adding them to other food • Keep food out of the temperature danger zone (between 4°C/40°F and 60°C/140°F) • Can grow at low temperatures (2°C to 4°C/36°F to 39°F) • Do not cross-contaminate raw and cooked foods		• Keep leftovers for a maximum of 4 days and heat them to an internal temperature of 74°C/165°F • Keep and serve leftovers at 60°C/140°F • Do not defrost foods at room temperature • Avoid keeping foods at room temperature for more than 2 hours (bacteria multiply and survive at low temperatures 3°C/37°F) • The bacterium is resistant to drying, freezing and high salt concentration, and can only be destroyed by heat		*Pregnant women, the elderly, people with weakened immune systems and young children should avoid:* • Ready-to-eat foods (non-dried deli meats such as cold cuts, hot dogs, and smoked salmon) • drinking unpasteurised milk or consuming food products made from it (e.g., cheese, semi-soft cheeses such as brie or camembert. Read label to ensure that it is not made with unpasteurised milk) and unpasteurised juices such as apple cider • eating raw sprouts (e.g., alfalfa sprouts) • eating raw fish or shellfish (oysters and clams)

Cont'd Table 2. Bacterial foodborne illness identified in Canada

BACTERIA	Illness	Symptoms found in animals	Symptoms found in humans	Reaction time in humans	Associated foods/ animals
Salmonella spp	Salmonellosis	*Mammals may experience:* • lesions, bloody and inflamed intestines, enlargement of the spleen and lymph nodes or fluid and blood in organs (e.g., lungs), and liver damage *Birds may experience:* • lesions, depression (may huddle together with ruffled feathers), unsteadiness, shivering, loss of appetite, increased or decreased thirst, rapid loss of weight, accelerated breathing, watery yellow, green or blood-tinged droppings, and closing of the eyes with swollen and pasted eyelids shortly before death. Feathers around the vent may become matted with faeces, enlarged liver and spleen, inflammation and haemorrhage of the intestinal tract, thickening of the inner surface of the crop into a yellow, cheese-like membrane. If the nervous system is affected, may experience: blindness, in-coordination, staggering, tremors, and convulsions	*May experience:* • diarrhea, abdominal pain, fever, headache, nausea, vomiting, dehydration, and anorexia • Severe cases can include blood infection, meningitis, and bone/ joint infections (especially in people with sickle cell disease)	Usually within 12 to 72 hours after eating contaminated foods	Wild and domestic mammals, birds (e.g., ducks, goose), reptiles, raw and undercooked meat and poultry, raw fruits (including their juices) and vegetables (e.g., alfalfa sprouts, celery, cantaloupe, green onions, parsley, salad greens, spinach, strawberries, and tomato), raw and undercooked eggs, unpasteurised milk and dairy products, fish and shrimp, peanut butter, and salad dressing
Preventive measures	• Purchase/obtain food from a reliable source • Ensure good hygiene practices: - avoid handling of food when ill, - wash hands frequently in warm soapy water while handling foods, - wash hands before and after handling food, changing diapers, using the washroom, and cleaning after pets • Prevent cross-contamination - always use clean utensils to prepare and serve food, - clean and sanitize surfaces used to prepare and serve food, and - store foods properly • Use clean water when preparing food • Cook foods to proper internal temperatures • Cook poultry parts to an internal temperature of 74°C/165°F and whole poultry to 82°C/180°F • Keep raw meat (especially poultry and seafood) away from other foods to avoid cross-contamination • Do not store fish eggs in plastic bags • Do not buy cracked eggs • Do not eat raw or cracked eggs • Keep eggs refrigerated near the back, the coldest section of the refrigerator • Do not eat raw or undercooked poultry • Do not drink unpasteurised milk or eat dairy products made from unpasteurised milk • Clean food utensils and equipment properly • Keep cold foods at proper temperature 4°C/40°F or below • Keep hot foods hot at 60°C/140°F or above • Wash all fruits and vegetables before consumption			
Shigella	Shigellosis		*In mild cases may experience:* • diarrhea and dysentery (inflammation of the large intestines with bloody stools (Omaye, 2004) *In severe cases may experience:* • bloody stools, dehydration, fever, chills, toxaemia (blood poisoning), and vomiting.	Usually within 12 to 50 hours (or 3 to 7 days) after eating contaminated foods.	Salads made from contaminated potato, chicken, tuna, shrimp, pasta/ macaroni, lettuce, raw oysters, water-melon, apple cider, cream puffs, hamburger, and fruits and vegetables (e.g., strawberries, spinach, cantaloupe, lettuce, parsley), deli meats, and unpasteurised milk
Preventive measures	• Purchase/obtain food from a reliable source • Ensure good hygiene practices: - avoid handling of food when ill, - wash hands frequently in warm soapy water while handling foods, - wash hands before and after handling food, changing diapers, using the washroom, and cleaning after pets • Prevent cross-contamination - always use clean utensils to prepare and serve food, - clean and sanitize surfaces used to prepare and serve food, and - store foods properly • Use clean water when preparing food • Cook foods to proper internal temperatures • Keep cold foods cold at 4°C/40°F or below • Keep hot foods hot at 60°C/140°F or above • Do not drink unpasteurised milk				

BACTERIA	Illness	Symptoms found in animals	Symptoms found in humans	Reaction time in humans	Associated foods/animals
Staphylococcus aureus	Staphylococcal		May experience: • Nausea, stomach cramps, diarrhea, and vomiting	Usually within 1 to 6 hours after ingestion	Salted meat, (e.g., smoked ham, sliced meat), dairy products (e.g., milk, cheese), puddings, some pastries, sandwiches, poultry, egg products, fish, cooked pasta, and fruits and vegetables (alfalfa sprouts, carrots, lettuce, parsley, scallions/green onions)
Preventive measures	• Do not keep cooked food at room temperature for longer than two hours • Do not cook too much food in advance	• Divide leftovers into smaller portions in shallow containers for faster cooling	• Freeze or discard leftovers after four days • Keep hot foods above 60°C/140°F until served		• Reheat leftovers to 74°C/165°F
Clostridium perfringens	Clostridium perfringens		May experience: • Nausea and abdominal cramps	Usually within 8 to 24 hours after ingestion	High protein, starchy foods (e.g., meat, poultry, sauces, and gravies) and other foods held at warm temperatures before serving, food left at room temperature or on steam tables for too long, meats, meat products, and gravy
Preventive measures	• Do not keep cooked food at room temperature for longer than two hours • Do not cook too much food in advance	• Divide leftovers into smaller portions in shallow containers for faster cooling	• Freeze or discard leftovers after four days • Keep hot foods above 60°C/140°F until served		• Reheat leftovers to 74°C/165°F
Bacillus cereus	*Bacillus cereus*		May experience: • severe nausea, vomiting, abdominal cramps, and diarrhea	Nausea and vomiting occur usually within 1-6 hours (average 4 hours) after ingestion Abdominal cramps and diarrhea occur usually within 6-24 hours (average 17 hours) after ingestion	Food left at room temperature, such as cooked vegetables (e.g., alfalfa sprouts, cress sprouts, and cucumbers), meat, boiled or fried rice, vanilla sauce, custards, soups, ice cream, herbs, spices, sandwiches, and cold cuts
Preventive measures	• Food handlers with lesions on hands should ensure that their hands are properly covered (wear gloves to avoid contamination of food)	• Keep cooked rice hot, above 60°C/140°F, until served • Cool rice quickly (in shallow pans) to a temperature below 4°C/40°F in less than 4 hours and reheat to a temperature of 74°C/165°F within 2 hours	• Cook and hold foods at recommended temperatures • Serve hot foods hot and cold foods cold		• Do not keep cooked food at room temperature for longer than 2 hours

Cont'd **Table 2. Bacterial foodborne illness identified in Canada**

BACTERIA	Illness	Symptoms found in animals	Symptoms found in humans	Reaction time in humans	Associated foods/animals
Clostridium botulinum	Botulism		May experience: • nausea, vomiting, fatigue, weakness, dizziness, headache, blurred vision, dry throat and nose, difficulty swallowing and speaking, diarrhea, constipation, and abdominal swelling. In severe cases, may experience: • respiratory failure, paralysis, and death	Usually within 12 to 36 hours after ingestion	Improperly home-prepared, preserved and canned game: fish, land and marine mammals (e.g., salmon, caribou, beaver, seal, whale, walrus meat), fermented beaver tail, seal flippers, fermented salmon roe and head, fermented sea mammal meat in oil (seal meat and walrus), dried seal meat, aged seal oil, improperly stored game, and improperly home-smoked salmon Improperly canned and stored foods (e.g., corn, green beans, baked potatoes, and honey)
Preventive measures	• Cook foods to recommended temperatures • Do not eat foods from damaged (dented, leaking or bulging) cans • Do not use or eat from cans that have an unpleasant odour when opened • Refrigerate all home-made foods that are preserved in oil, and use within ten days • Do not feed honey to children less than one year of age • Date and label all preserves and home-canned foods	• Do not store beluga, seal, narwhal or walrus at warm temperatures or in a container that does not allow proper air circulation • Age narwhal, seal, beluga and walrus in very cool places • Use safe methods to prepare traditional foods: - Follow traditional methods (e.g., grass-lined hole in the ground) or other methods that allow air to circulate to ferment foods - Ferment foods in a cool (below 3°C/37°F), shaded, shallow pit in the ground lined with wood, animal skins or leaves and covered with moss or leaves	- Do not use plastic or glass containers with tight fitting lids or buckets to ferment food (these containers do not allow air to circulate) - Do not ferment foods above ground or indoors on the counter at room temperature - Consider boiling fermented food for at least ten minutes to destroy the botulism toxin that may be present before you eat it	Canning • Use a pressure canner to can low acid foods at home • Preserve and can foods properly, following recommended procedures • Cook canned foods at 80°C/176°F for at least 10 minutes to destroy the toxins that may be present • Do not re-use the lids of home canned foods as they may not seal properly after being used previously When in doubt about the safety of a food, throw it out

1.3 Viruses

Viruses are the smallest microorganisms. Unlike bacteria, viruses cannot multiply in food. Viruses can be transferred from people into foods, and can spread by contact to surfaces used for food preparation which may cause viral foodborne infections. Viruses that are pathogenic to humans do not grow in food but they can be carried in food and when ingested can lead to infection. Sources of viral foodborne infections are water (including iced drinks), salads, shellfish, and other ready-to-eat foods. Norovirus and Hepatitis A (see Table 3) are common viruses carried by food.

Preventing foodborne illness caused by viruses

- Ensure good hygiene practices,
  - avoid handling food when ill (vomiting and diarrhea),
  - avoid handling food for at least 2 days after symptoms disappear,
  - wash hands frequently in warm soapy water while handling foods, and
  - wash hands in warm soapy water after using the washroom
- Prevent cross-contamination
  - use clean utensils to prepare and serve food,
  - clean and sanitize surfaces used to prepare and serve food, and

- store foods properly
- Purchase/obtain food from a reliable source,
- Use clean water when preparing food,
- Cook foods to proper internal temperatures, and
- Use only shellfish from a reliable source or from known clean water sources.

Table 3. Viral foodborne illness identified in Canada

VIRUSES	Illness	Symptoms in animal	Symptoms in humans	Appearance of symptoms in humans	Associated foods
Hepatitis A	Hepatitis		*May experience:* • Jaundice, fever, fatigue, loss of appetite, nausea, vomiting, abdominal pain, clay-coloured stool, and joint pain,	Usually within 15–50 days (average 28 days)	Ready-to-eat, raw and undercooked foods, shellfish, fresh produce, and fecally contaminated water (and ice)
Preventive measures	• Purchase/obtain shellfish from a reliable source • Ensure good hygiene practices: - avoid handling of food when ill, - wash hands frequently in warm soapy water while handling foods, - wash hands before and after handling food, changing diapers, using the washroom, and cleaning after pets • Prevent cross-contamination - always use clean utensils to prepare and serve food, - clean and sanitize surfaces used to prepare and serve food, and - store foods properly				• Use clean water when preparing food • Cook foods to proper internal temperatures • People diagnosed with Hepatitis A should not handle food
Norovirus (previously known as Norwalk virus)	Stomach flu		*May experience:* • nausea, vomiting, and/or diarrhea, abdominal cramps, headache, fever/chills, and muscle aches	24 to 48 hours (or as early as 12 hours) after eating contaminated food or drinking contaminated beverages (HC, 2010)	Shellfish harvested from contaminated waters (e.g., oysters and clams), salads and fruits (e.g., celery, melon), contaminated ice and water, or foods prepared on contaminated surfaces, food handlers who are ill with the norovirus/stomach flu
Preventive measures	• Purchase/obtain food from a reliable source • Ensure good hygiene practices: - avoid handling of food when ill, - wash hands frequently in warm soapy water while handling foods, - wash hands before and after handling food, changing diapers, using the washroom, and cleaning after pets • Prevent cross-contamination - always use clean utensils to prepare and serve food, - clean and sanitize surfaces used to prepare and serve food, and - store foods properly • Use clean water when preparing food • Cook foods to proper internal temperatures				• People infected with norovirus should not handle food • People recovering from a norovirus infection should not handle food for at least 2 or 3 days after recovery • Harvest shellfish only from open areas • Wash raw vegetables thoroughly

1.4 Prions

Prions are neither bacteria nor viruses but are transmissible agents made up of a kind of protein that can exist in more than one form. They are also known as transmissible spongiform encephalopathies (TSE) and are responsible for a number of diseases in humans and animals. Chronic wasting disease (CWD) is an animal prion disease which affects wild animals such as deer, moose and elk (see Diseases found in game section of chapter 5), although no human infections have been reported to date, unlike Bovine Spongiform Encephalopathy (BSE).

1.5 Parasites

Parasites are microorganisms that obtain their nourishment from other organisms, called hosts. They range in size from microscopic, single-celled organisms to larger, multicellular worms (helminths) that are visible to the naked eye. Parasites are present in many animals (e.g., fish), and are commonly transmitted to humans in the following ways: contaminated drinking water or food - during handling, and in vegetables and fruits grown in contaminated soils. If foods are not cooked to the proper internal temperatures, foodborne illness may occur. Some examples of common parasitic foodborne infections are Anisakiasis and Giardiasis (see Table 4). Parasites are now more frequently being identified as causes of foodborne illnesses.

Preventing foodborne illness caused by parasites

- Ensure good hygiene practices,
  - avoid handling food when ill, and
  - wash hands frequently in warm soapy water while handling foods
- Prevent cross-contamination
  - use clean utensils to prepare and serve food,
  - clean and sanitize surfaces used to prepare and serve food, and
  - store foods properly
- Purchase/obtain food from a reliable source,
- Use clean water when preparing food,
- Cook foods to proper internal temperatures, and
- Freeze foods properly – freezing kills some parasites in food (Agriculture and Agri-Food Canada, 2008) (see Chapter 8 for more information on food preparation and preservation).

Table 4. Parasitic foodborne illness identified in Canada

PARASITES	Illness	Symptoms in animal	Symptoms in humans	Incubation period	Associated foods/animals
Trichinella spp (roundworm)	Trichinellosis or Trichinosis	*Muscle infection:* muscle pain, oedema, fever, and cysts	*May experience:* Gastrointestinal illness that can lead to flu-like symptoms, oedema around the eyes (upper eyelids), muscle pain, fever, diarrhea, headache, itchiness, skin rash, and abnormal fear of light *In severe cases:* breathing difficulty (caused by infection of the diaphragm), inflammation of the brain, and heart failure	Usually within 5 – 15 days	Raw or undercooked meat (of walrus, seal, cougar and bear infected with the larvae of the trichinella worm species), rodents and mustelids (including otter, sea otter, ferrets, weasels, skunk, badger, mink, ferret, wolverine), polar fox, wolf, and lynx
Preventive measures	• Purchase/obtain food from a reliable source • Ensure good hygiene practices: - avoid handling of food when ill, - wash hands frequently in warm soapy water while handling foods,	- wash hands before and after handling food, changing diapers, using the washroom, and cleaning after pets • Prevent cross-contamination - always use clean utensils to prepare and serve food, - clean and sanitize surfaces used to prepare and serve food, and	- store foods properly • Use clean water when preparing food • Cook foods to proper internal temperatures • Freeze foods properly - freezing kills this parasite		• Do not eat raw or undercooked meat • Cook meat to an internal temperature of 77°C/170°F • Clean meat grinders thoroughly • Curing, drying, smoking, and microwaving do not destroy the parasite

PARASITES	Illness	Symptoms in animal	Symptoms in humans	Incubation period	Associated foods/animals
Anisikasis spp (nematode)	Anisakiasis		Symptoms of *anisakiasis* can mimic other gastrointestinal diseases, and can be misdiagnosed as appendicitis, stomach ulcers, acute abdomen (peritonitis) or stomach ulcers	Usually within a few hours and up to a few days after the ingestion of infected fish	Fish, polar and grizzly bear
Preventive measures	• Purchase/obtain food from a reliable source • Ensure good hygiene practices: - avoid handling of food when ill, - wash hands frequently in warm soapy water while handling foods, - wash hands before and after handling food, changing diapers, using the washroom and cleaning after pets • Prevent cross-contamination - always use clean utensils to prepare and serve food, - clean and sanitize surfaces used to prepare and serve food, and - store foods properly • Use clean water when preparing food • Cook foods to proper internal temperatures • Avoid eating raw fish • Freeze foods properly				• Cook fish for a minimum of five minutes at 60°C/140°F • If fish is to be eaten raw, it should be frozen at -35°C/-31°F for at least 15 hours or at least 7 days at -20°C/-4°F • Marinating, salt curing, and smoking fish will not necessarily kill *Anisikasis*
Ascaris spp (roundworm)	Ascariasis		*May experience:* • Weight gain, abdominal pain, and difficulty breathing (if worms migrate through the lungs). In severe cases, the intestines may be blocked	Usually within 4 – 8 weeks	Uncooked food (e.g., pork and fish), and food grown in contaminated soil
Preventive measures	• Purchase/obtain food from a reliable source • Ensure good hygiene practices: - avoid handling of food when ill, - wash hands frequently in warm soapy water while handling foods, - wash hands before and after handling food, changing diapers, using the washroom, and cleaning after pets • Prevent cross-contamination - always use clean utensils to prepare and serve food, - clean and sanitize surfaces used to prepare and serve food, and - store foods properly • Use clean water when preparing food • Cook foods to proper internal temperatures				• Freeze foods properly - freezing kills some parasites in food • Avoid contact with soil contaminated with human faeces • Dispose of diapers properly • Wash all raw vegetables and fruits
Cryptosporidium parvum (protozoal)	Cryptosporidiosis		*May experience:* diarrhea, cramping, abdominal pains, weight loss, anorexia, flatulence and malaise, nausea, vomiting, dehydration, fever, and muscle pain (myalgias)	Usually within 1-12 days (average 7 days) and may last for weeks	Domestic and wild mammals, and contaminated water
Preventive measures	• Purchase/obtain food from a reliable source • Ensure good hygiene practices: - avoid handling of food when ill, - wash hands frequently in warm soapy water while handling foods, - wash hands before and after handling food, changing diapers, using the washroom, and cleaning after pets • Prevent cross-contamination - always use clean utensils to prepare and serve food, - clean and sanitize surfaces used to prepare and serve food, and - store foods properly • Use clean water when preparing food • Cook foods to proper internal temperatures				

Cont'd Table 4. Parasitic foodborne illness identified in Canada

PARASITES	Illness	Symptoms in animal	Symptoms in humans	Incubation period	Associated foods/animals
Cyclospora cayetanensis (protozoal)	Cyclosporiasis		*May experience:* • watery and explosive diarrhea, loss of appetite, weight loss, stomach cramps, bloating, increased gas, nausea, fatigue, vomiting, body aches, fever, and headache	Usually within a week (some people may be asymptomatic)	Fresh fruits and produce – local and imported (e.g., raspberries, fresh basil), contaminated irrigation or tap water
Preventive measures	• Purchase/obtain food from a reliable source • Ensure good hygiene practices: - avoid handling of food when ill, - wash hands frequently in warm soapy water while handling foods, - wash hands before and after handling food, changing diapers, using the washroom and cleaning after pets • Prevent cross-contamination - always use clean utensils to prepare and serve food, - clean and sanitize surfaces used to prepare and serve food, and - store foods properly • Use clean water when preparing food • Cook foods to proper internal temperatures				• Wash fruits and vegetables before consumption • Cook and bake food thoroughly to eliminate the risk of infection
Giardia intestinalis (also known as Giardia lamblia or Giardia duodenalis) (protozoal)	Giardiasis (beaver fever)		*May experience:* • Chronic diarrhea, abdominal cramps and bloating, loose, pale, greasy stools that tend to float, fatigue, weight loss, and dehydration	Usually within 1-4 weeks (average of 7-10 days) (some infected persons may be asymptomatic), and may last weeks	Raw and uncooked food (e.g., from cattle, deer, bear, and beaver) contaminated with the faeces of infected human and/or animal (cats, dogs), and water and ice made with contaminated water sources (lakes, streams, or poorly maintained wells)
Preventive measures	• Purchase/obtain food from a reliable source • Ensure good hygiene practices: - avoid handling of food when ill, - wash hands frequently in warm soapy water while handling foods, - wash hands before and after handling food, changing diapers, using the washroom, and cleaning after pets • Prevent cross-contamination - always use clean utensils to prepare and serve food, - clean and sanitize surfaces used to prepare and serve food, and - store foods properly • Use clean water when preparing food • Cook foods to proper internal temperatures				• Wash all fruits and vegetables • Cook and bake food thoroughly to eliminate the risk of infection
Entamoeba histolytica (protozoal)	Amebiasis		*May experience:* • loose stools (can be bloody), stomach pain, and fever *Pregnant or immunocompromised individuals may experience:* • an abrupt onset of fever, severe abdominal cramps, profuse bloody diarrhea and tenesmus; complications include massive hemorrhage, peritonitis, amebomas, and liver abscesses	Usually within 2-4 weeks (or a few days to several months)	Contaminated food (e.g., raw vegetables)
Preventive measures	• Purchase/obtain food from a reliable source • Ensure good hygiene practices: - avoid handling of food when ill, - wash hands frequently in warm soapy water while handling foods, - wash hands before and after handling food, changing diapers, using the washroom, and cleaning after pets • Prevent cross-contamination - always use clean utensils to prepare and serve food, - clean and sanitize surfaces used to prepare and serve food, and - store foods properly • Use clean water when preparing food • Cook foods to proper internal temperatures				• Use clean water to wash fruits and vegetables

PARASITES	Illness	Symptoms in animal	Symptoms in humans	Incubation period	Associated foods/animals
Echinococcus granulosus (a tape worm)	Echinococcosis, (also known as Hydatid disease or hydatidosis)	Large fluid-filled cysts (the cysts are not infectious to people) in the lungs or liver of direct hosts: moose, caribou, voles, lemmings, shrews and mice	*If lungs are affected may experience:* • breathing difficulty *If abdomen is affected may experience:* • liver damage *If brain is affected:* • death may occur	Usually within 12 months to years	*Direct host:* • contaminated food, water, soil or direct contact with fox, coyote, wolf, and raccoon
Preventive measures	• Purchase/obtain food from a reliable source • Ensure good hygiene practices: - avoid handling of food when ill, - wash hands frequently in warm soapy water while handling foods,	- wash hands before and after handling food, changing diapers, using the washroom and cleaning after pets • Prevent cross-contamination - always use clean utensils to prepare and serve food, - clean and sanitize surfaces used to prepare and serve food, and	- store foods properly • Use clean water when preparing food • Cook foods to proper internal temperatures • Wear gloves to handle canines, their faeces, pelts or carcasses • Wash hands after handling canines, their faeces, pelts and or carcasses		• Hunters and trappers should use gloves when handling fox, coyote or other wild canines • Wash all fruits and vegetables thoroughly • Avoid eating organ meats with cysts

1.6 Fungi

Fungi are multi-celled or single-celled organisms lacking chlorophyll which feed on organic matter and are found in air, soil, plants, water and food. They include mushrooms, moulds and yeasts.

Moulds are organisms that grow from tiny spores that float around in the air. When some of these spores fall on moist food, they grow into mould. While some moulds are beneficial (those used to make certain (hard) cheeses such as roquefort, blue cheese, Gorgonzola and Stilton) and are safe to eat, other moulds may appear as fuzzy growths on food and may cause spoilage. Some moulds also produce mycotoxins that can cause illness and allergic reactions.

Moulds have branches and roots that are very thin and thread-like, making them difficult to see when they grow on food. They are able to survive in both sugar and salty conditions – in opened cans of jam, jelly, and on cured salty meats such as ham, bacon, salami, and bologna as well as on foods left uncovered for long periods. The removal of mould on food does not remove the toxin and food with mould growth should be discarded (USFSIS, 2010).

While some yeasts are used in food production (e.g., wine and bread), others are known for their ability to spoil food. Yeast may appear as a pink discoloration or slime and bubbles and, may have an alcoholic smell or taste. Yeast grows well in acidic foods with low water content, such as jellies, jams, syrup, honey and fruit juice. Food that has been spoiled by yeast should be discarded.

Summary

To ensure food safety, certain measures can be taken to limit the growth of microorganisms in food, such as proper handling, processing and storage.

The following safe handling practices are necessary to ensure that the chances of cross-contamination are greatly reduced:

- Wash hands with soap and water, or use hand-sanitizing solutions, before and after handling food,
- Keep food covered,
- Keep raw and cooked foods separate,
- Do not use the same equipment or surface to prepare raw and cooked foods,
- Ensure that there are no insects or other pests in areas where food is prepared, stored or served,

- Keep work surfaces and equipment clean by washing them (see Chapter 3), and
- Discard mouldy food.

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2. Naturally Occurring Toxins

Natural toxins are potentially harmful substances produced by animals, fish, plants, insects and microorganisms during normal growth. Natural toxins are not harmful to the organisms that produce them, but they may be harmful to humans or animals when consumed at low doses over a long period of time or at high doses over a short period of time. In general, the concentrations of natural toxins in foods are low and are not considered to pose health risks to consumers. Of most relevance to food safety are those toxins produced by a) microorganisms and b) plants. The ingestion of any food containing toxins that are released by microorganisms reproducing in the food or the ingestion of certain plants (or parts) that contain natural toxins can cause adverse health effects in humans.

2.1 Microbial toxins

Microbial toxins are chemical substances produced naturally by microorganism and are one of the primary concerns in the area of food safety (Reid & Harris, 1999). Microbial toxins are produced by algae, fungi and bacteria.

Algae

Algae can be unicellular (e.g., most phytoplanktons) or multicellular (e.g., seaweed) and are found in freshwater, marine and terrestrial habitats. Some algae, such as dinoflagellates, produce algal toxins (phycotoxins) that can be harmful to humans. Under certain conditions, the population of algae in an aquatic system can increase rapidly to become an algal bloom. Various species of algae are involved in algal blooms, and these species change over time, based on temperature, light, nutrients and other factors. Algal blooms are called Harmful Algal Blooms (HABs) when they pose environmental or health hazards. The blooms occur when water is contaminated by phosphates. During HABs, or as a consequence of bioaccumulation through the marine food chain, the toxins produced by algae may accumulate in a variety of marine organisms, such as the molluscs, crustaceans and finfish, as well as in freshwater fish and shellfish (Baker et al., 2005).

Algal toxins

Algal toxins are tasteless, odourless and heat-resistant. The most common algal toxins are saxitoxins, brevetoxins, dinophysistoxins, domoic acid and ciguatoxins. Shellfish and finfish contaminated with these toxins can be potentially harmful to human health, causing a variety of foodborne illnesses such as Paralytic Shellfish Poisoning (PSP), Neurotoxic Shellfish Poisoning (NSP), Diarrheic Shellfish Poisoning (DSP), Amnesic Shellfish Poisoning (ASP) and Ciguatera Fish Poisoning (CFP) (See table 5).

Saxitoxins

Saxitoxins are produced by microscopic marine algae found in coastal waters. Saxitoxins may accumulate in the neck (siphon) and the gills of butter clams (Kvitek & Beitler, 1991); in the roe or gonads of scallops, (FOC, 2008), and in the tomalley (also known as hepatopancreas – soft green substance inside the body cavity) of crabs and lobsters (CFIA, 2009b). It is recommended that people avoid eating these parts. The consumption of shellfish that contain high levels of saxitoxins can cause Paralytic Shellfish Poisoning in

Oysters: Photo by AFN

humans (See Table 5). Saxitoxins cannot be destroyed by cooking (Omaye, 2004).

Brevetoxins

Brevetoxins are released by *Karenia brevis*, a marine dinoflagellate formerly known as *Gymnodinium breve*, and *Ptychodiscus brevis* (Baker et al., 2005). These toxins, which are tasteless, odourless and resistant to heat and acid, are toxic to fish, marine mammals, birds and humans but not to shellfish such as oysters and mussels (FAO, 2004). The consumption of raw or under-cooked shellfish that have accumulated high levels of brevetoxins can cause Neurotoxic Shellfish Poisoning in humans (see Table 5).

Dinophysistoxins

Dinophysistoxins are produced by dinoflagellates belonging to the genus, *Dinophysis*, and the genus, *Prorocentrum*. In humans, they can cause Diarrhetic Shellfish Poisoning (see Table 5), a gastrointestinal illness associated with the ingestion of contaminated bivalves, such as mussels, scallops and oysters (Baker et al., 2005).

Domoic acid

Domoic acid is found in some marine algae of the genus *Pseudo-nitzschia*, particularly *Pseudo-nitzschia pungens*. Domoic acid is a neurotoxin that cannot be destroyed by cooking or freezing and that accumulates in filter-feeding, bivalve shellfish such as clams mussels, oysters and scallops. People may be at risk for Amnesic Shellfish Poisoning if they eat shellfish that contain high levels of domoic acid (Baker et al., 2005; Washington State Department of Health, 2010).

Table 5 lists the most common types of food poisoning caused by shellfish and fish contaminated with algal toxins, as well as the preventive measures that can be followed in order to prevent such food poisoning.

Preventing shellfish poisoning

- Do not harvest fish and shellfish from closed harvest areas,
- Purchase fish and shellfish only from a reliable supplier, and
- Keep fish and shellfish on ice in a cooler if it can't be refrigerated or cooked within 2 hours after catching/buying – within 1 hour, especially if in hot weather (see Chapter 6 on Harvesting Fish and Shellfish) (Fraser Health, 2009).

Fish or shellfish suspected to have been harvested in areas prone to harmful algal blooms should not be eaten. The local office of Fisheries and Oceans Canada and environmental health officers can provide information on areas closed to fishing (consult: www.dfo-mpo.gc.ca).

Table 5. Algal toxins in shellfish and finfish

Saxitoxin

ILLNESS	Symptoms in humans (individuals experiencing any of these symptoms should seek medical attention immediately)	Reaction time	Associated finfish and shellfish
Paralytic Shellfish Poisoning – PSP	In mild cases may experience: • tingling sensation or numbness around the lips (which slowly spreads to the face and neck), prickly sensation in the fingertips and toes, headache, and dizziness In severe cases may experience: • Incoherent speech, prickly sensations in the arms and legs, stiffness and uncoordinated movement, weakness, rapid pulse, difficulty breathing, salivation, temporary blindness, nausea, and vomiting. In extreme cases may experience: • paralysis of respiratory muscles, which may lead to respiratory arrest and death within 2 to 12 hours after eating contaminated shellfish	Usually within a few minutes (5 to 30) to 10 hours after ingestion	Oysters, scallops (e.g., pink, spiny, and purple hinge rock scallops), clams (e.g., butter clams, razor clams, and littleneck clams), mussels (e.g., blue mussels), cockles, whelks, and tomalley (hepatopancreas) of crustaceans such as crabs and lobsters
Preventive measures	• Do not harvest or eat shellfish from closed areas or areas prone to hazardous algal blooms • Obtain shellfish from a reliable supplier • Uncooked shellfish should be refrigerated or frozen until ready to be prepared • Do not eat shellfish such as clams and scallops that do not open during cooking • Because of the possibility of the accumulation of saxitoxin, Health Canada recommends that lobster tomalley (hepatopancreas) be eaten in small quantities: no more than the amount from one cooked lobster daily for adults and no consumption of lobster tomalley by children		

Brevetoxins

ILLNESS	Symptoms in humans (individuals experiencing any of these symptoms should seek medical attention immediately)	Reaction time	Associated finfish and shellfish
Neurotoxic Shellfish Poisoning – NSP	May experience: • gastrointestinal symptoms (diarrhea, nausea, vomiting) • respiratory symptoms (shortness of breath, reduction of respiratory rate) • cardiovascular symptoms (hyper/hypotension) • neurological symptoms (sensation of tingling, prickling, numbness of lips, tongue and throat, dizziness, and hot and cold sensations	Usually within 30 minutes to 24 hours after ingestion	Mussels, oysters scallops, and clams
Preventive measures	• Do not harvest or eat shellfish from closed areas or areas prone to *Kerenia brevis* blooms • Obtain shellfish from a reliable source		

Dinophysistoxins

ILLNESS	Symptoms in humans (individuals experiencing any of these symptoms should seek medical attention immediately)	Reaction time	Associated finfish and shellfish
Diarrheic Shellfish Poisoning – DSP	May experience: • diarrhea, nausea, vomiting, and abdominal pain, chills, headache, and fever	Usually within 30 minutes to a few hours (2-3) after ingestion	Mussels, scallops, oysters, and clams
Preventive measures	• Do not harvest or eat shellfish from closed areas • Obtain shellfish from a reliable supplier • Refrigerate and use shellfish within 2-3 days or freeze until they are ready to be eaten (see Table 25 for recommended refrigeration and freezing times)		

Domoic acid

ILLNESS	Symptoms in humans (individuals experiencing any of these symptoms should seek medical attention immediately)	Reaction time	Associated finfish and shellfish
Amnesic Shellfish Poisoning – ASP	May experience: • nausea, vomiting, diarrhea, muscle weakness, disorientation, and memory loss In severe cases (within 48 hours) may experience: • headache, dizziness, confusion, disorientation, short-term memory loss, muscle weakness, seizures, profuse respiratory secretion, cardiac arrhythmias (irregular heartbeat), coma, and possibly death	Usually within 30 minutes to 6 hours after ingestion	Clams (e.g., foot/siphon/mantle of razor clams), mussels, oysters, scallops, and crabs (e.g., viscera of dungeness crabs)
Preventive measures	• Do not harvest or eat shellfish from closed areas • Cooking does not destroy the toxin • Clean crabs thoroughly by removing all viscera		

Fungal Toxins

Some moulds and mushrooms have the ability to produce toxins, referred to as mycotoxins, which may cause illnesses (see Tables 6, 7, 8, 9, and 10).

Mycotoxins

Mycotoxins are toxic secondary metabolites produced by fungi found in food (e.g., grains, nut crops, celery, grape juice, and apple juice). The consumption of foods contaminated with mycotoxins can cause mycotoxin poisoning, referred to as *mycotoxicosis*.

Mycotoxins released by fungi make food unsafe to eat. The production of mycotoxins depends on temperature and moisture, and can occur before or after harvest and during storage, transportation and processing. Because mouldy foods may contain any of the mycotoxins identified in Table 6, they should not be eaten, but should be discarded and destroyed properly (FSA, n.d.).

It is important to note that in many cases, the identification of mycotoxins as the causative agents of disease in humans is difficult to determine. While acute effects, such as gastroenteritis, may be easily identified, chronic effects often result from the ingestion of low to moderate levels of mycotoxins and can be more difficult to recognize (Lindsay, 2005) and diagnose.

Some mycotoxins, such as the aflatoxins (named from the fungus, Aspergillus flavus), are carcinogenic, while others may be responsible for kidney and

liver damage (ochratoxin A), affect the reproductive function (zearalenone), and interfere with the body's immune system (trichothecenes) (O'Keefe, 2003).

The most common types of mycotoxins are aflatoxin, ochratoxin, trichothecenes, patulin, fumonisin, zearalenone and ergot alkaloids.

Aflatoxins

Aflatoxins are produced by three species of Aspergillus and are usually associated with grains or toxins in some mushrooms or toadstool species. They can also be found in milk and milk products from animals that have consumed plants, plant products or animal feed contaminated with the aflatoxin AFB1, which is transformed to AFM1, a less toxic metabolite (WHO, 2002). Long-term exposure to low levels of aflatoxin in the diet may pose certain health concerns for humans (see Table 6).

Ochratoxins

Ochratoxins are a group of toxic substances produced by the fungus, Penicillium verrucosum, and different species of *Aspergillus* (Bennett & Klich, 2003; WHO, 2002). Ochratoxin can be found in beer and wine (Reddy et al., 2010), some spices, and also in some foods such as cereals and fresh grapes. Ochratoxins are also produced in grains that have not been properly dried during processing, or have not been properly stored and hence can be found in animal products that have been fed contaminated grains.

Trichothecenes

Trichothecenes are a large group of structurally related mycotoxins, with over 80 identified. Only a few are detected in cereals and grains such as T2-toxin, deoxynivalenol, nivalenol, diacetoxyscirpenol and satratoxins. Acute toxicity varies considerably and T-2 toxin is more toxic than deoxynivalenol. Vomitoxin (deoxynivalenol) and HT-2 toxins, are non-volatile (do not evaporate at normal temperatures and pressures) and are heat-stable. In Canada and the United States, deoxynivalenol is the sole trichothecene present in corn, wheat, barley and other cereals.

Patulin

Patulin is a toxic secondary metabolite produced by some species of mould, such as *Penicillium* and *Aspergillus*. Apple juice made from bruised or damaged apple is the main source of patulin intake for humans. In Canada however, concentration of patulin levels in apple juice is not of concern for adults as it is below the recommended levels, though it may cause health issues in children as they are more likely to consume more apple juice. Patulin can be found mainly in mouldy fruits such as apple and apple products (CFIA, 2010). To reduce exposure to patulin, wash food thoroughly and remove damaged portions before consumption or adding to other foods.

Fumonisins

Fumonisins are produced by fungi such as *Fusarium proliferatun* and *Fusarium verticillioides*. *Fusarium moniliforme (Fusarium verticillioides)* is a common pathogen of corn and is found wherever corn is grown. Kernels that are intact may contain the fungus and the toxin but show no visual signs of the fungal contamination. Fumonisin is produced "only before harvest or during the early stage of drying" (Koenning et al., 1999; WHO, 2002).

Zearalenone

Zearalenone is a toxin excreted by fungi such as *Fusarium culmorum, and Fusarium equiseti*. It targets the reproductive organs of animals. Zearalenone needs high humidity and low temperatures to survive, and is found in mouldy cereal crops, such as corn, barley, oats, wheat, rice and sorghum (Park et al., 2001; Yazar & Omurtag, 2008).

Ergot alkaloids

Ergot is a plant disease caused by the fungus *Claviceps purpurea*, which produces alkaloids and infects the developing grains of cereals and grasses (GOS, 2011).

The ergot bodies (also called sclerotia) are formed from a hard mass of fungal mycelium, and are the over-wintering structures in the disease cycle. These have a black to dark purple hard protective rind on the outside, and a white to grey coloured interior. Ergot bodies are often elongated and protrude from the glumes of maturing heads, and may be up to 10 times larger than the seed it has replaced. Usually, ergot bodies fall to the soil before or during harvest, or may be harvested with the seed. Ergot bodies rarely survive

for more than one year in the soil and can easily be identified in unclean grain (GOS, 2011).

Crops (excluding broadleaf), such as rye and some grasses are more susceptible to ergot infection because they are open-pollinated, allowing easy access of the fungus into the flowering head. Grains such as wheat and barley are less likely to become infected because they are self-pollinated. Plants are less susceptible once the fertilization process has occurred (GOS, 2011).

Ergot bodies contain numerous alkaloids, or toxic chemicals which are toxic to humans and animals, that remain active even after the processing of food (e.g. flour) or feed. Ergotism develops in humans and animals after eating food (e.g., contaminated rye flour) or feed contaminated by ergot, but is however rare in humans because of the strict guidelines for allowable ergot bodies in grain, hence commercially produced flour and grain products are at very little risk of contamination (see Table 6 for symptoms). However, home-grown grain should not be used unless checked thoroughly to ensure it is free of ergot (GOS, 2011). Symptoms in animals (those fed contaminated grain at the farm level) may include lameness, loss of body parts from gangrene, abortions in pregnant animals, seizures, and eventually death. Animals will recover from these milder symptoms when contaminated feed is removed. Animals differ in their susceptibility to ergot poisoning. Young or pregnant animals are considered highly susceptible (GOS, 2011).

Table 6 lists the organisms responsible for the production of these mycotoxins, the foods in which these toxins can be found, and the symptoms of exposure in humans.

Table 6. Moulds and mycotoxins

MYCOTOXINS	Moulds	Related foods	Symptoms in humans
Aflatoxins	Aspergillus flavus, A. parasiticus, A. nomius	Ground nuts, and tree nuts, corn, wheat, bran, flour, peanuts, milk, and milk products	Chronic poisoning may cause: • liver cancer, impaired immune function Acute poisoning may cause: • diminished appetite, malaise, low fever, vomiting, abdominal pain, hepatitis, liver failure (may also affect kidney, spleen, and pancreas), and possibly death
Ochratoxins	Penicillium verrucosum, A. carbonarius (grows at high temp. and can withstand heat and ultraviolet light), A. alliaceus, A. auricomus, A. niger, A. ochraceus	Corn, oats, rye, wheat, coffee beans, spices, wine, grapes, fruits (including vine fruits and dried vine products), and pork	There is insufficient evidence of health effects in humans however, chronic exposure to Ochratoxin A from contaminated foods may cause: • kidney tumours
Trichothecenes	Fusarium sporotrichioides, F. poae, F. equiseti, F. acuminatum	Corn, wheat, millet, barley, cereals, oats, sorghum, and rye	May experience: • mouth and throat inflammation, inflammation of the mucous membrane of the stomach and intestines, vomiting, immunosuppression, skin hemorrhages and necrotic ulcers on the body, headaches, chills, severe nausea, vomiting, and visual disturbances
Patulin	Penicillium expansum, Byssochalamy spp, Aspergillus spp	Mouldy fruits (especially apples and apple products made with bruised apples or unfermented apple juice), and vegetables	May cause: • ulceration, congestion, and hemorrhagic lesions (especially in the gastrointestinal tract)
Fumonisins	Fusarium moniliforme, F. proliferatun, F. verticillioides	Corn, corn products (e.g., grits, germ, flour), wheat, and bran	May be linked to: • oesophageal and liver cancer
Zearalenone	F. graminearum, F. culmorum, F. equiseti, F. crookwellense	Mouldy grains, corn, oats, wheat, and barley	• There is inconclusive evidence of health effects in humans
Ergot Alkaloids	Claviceps purpurea fungus	Rye, wheat and barley (to a lesser extent)	*May cause:* • impaired blood circulation, causing alternating burning and freezing sensations, followed by gangrene of extremities (referred to as St. Anthony's fire) • Nervous convulsions may also occur leading to eventual death

Preventing mycotoxin contamination

Food safety can be improved by preventing mould growth and thereby preventing mycotoxin contamination. In Canada, mycotoxins occur mainly in cereal grains and corn, and occasionally in other crops such as alfalfa and oilseeds and other foods such as coffee, cocoa, rice, beer and wine (CFIA, 2009a).

Preventing mycotoxin contamination in grains

- Harvest grains as soon as possible,
- Dry grains properly to prevent mould growth and mycotoxin production post-harvest (e.g., *Fusarium* grows easily under damp conditions),
- Store dried grains properly; the minimum temperature for aflatoxin production is 12°C/54°F, the optimum is 27°C/81°F, and the maximum is 40°C-42°C (104°F-108°F), and
- Limit damage of grains by birds or insects, as moulds tend to invade damaged kernels more easily than intact ones (CFIA, 2009a; WHO, 1979).

Mushroom toxins

While there are many mushroom species that have been identified, some can cause poisoning in humans. Due to their similarities, non-edible (poisonous) mushrooms can easily be confused with edible ones; it is important to identify wild mushrooms accurately before picking and eating them. If their identity is uncertain, they should not be eaten as poisonous mushrooms can cause foodborne illness.

Mushroom poisonings are not only caused by natural toxins; the conditions under which mushrooms are handled, packaged, stored and transported can also facilitate bacterial growth. For example, unrefrigerated, air-tight, packaged mushrooms can cause botulism before any signs of spoilage can be seen (HC, 2009).

The toxins released by poisonous mushrooms are produced naturally and cannot be destroyed by cooking, canning or freezing. Mushroom poisoning can be caused by four types of toxins: protoplasmic toxins, neurotoxins, gastrointestinal irritants, and coprine or disulfiram-like toxins (USFDA, 2009).

Protoplasmic toxins

The consumption of mushrooms that contain protoplasmic toxins, such as amatoxin or orellanine, can cause protoplasmic poisoning. In humans, protoplasmic poisoning causes cell damage and organ failure (e.g., liver and kidney damage). Table 7 highlights the toxins responsible for protoplasmic poisoning, reaction times and associated symptoms (USFDA, 2009).

Amatoxins

Amatoxins are poisonous substances found in all parts of certain mushroom species, such as *Amanita, Galerina and Lepiota*. Cooking and drying (unless it is exposed to ultraviolet light or sunlight for several months) cannot destroy it (Faulstich, 2005; USFDA, 2009).

Hydrazines

Some mushroom species, such as *Gyromitra esculenta* (false morel) and *G. gigas* (snow morel), contain forms of hydrazine that can cause adverse human health effects. Hydrazine poisoning resembles Amanita poisoning, but is less severe. Hydrazine is also found in small amounts in edible mushrooms such as the shiitake mushroom (USFDA, 2009).

Orellanine

Orellanine is a poison produced by the mushroom genus, *Cortinarius* (Faulstich, 2005).

Omphalotus illudens (Jack O'Lantern)

Table 7. Mushrooms and protoplasmic toxins

TOXINS	Mushrooms	Reaction time	Symptoms in humans
Amatoxins	*Amanita phalloides, A. virosa, A. verna* (The green death cap, destroying angel, and fool's mushroom), *Galerina autumnales* (Autumn skullcap), *G. marginata, Lepiota helveola, L. brunneoincarnata, L. josserandii*	Usually between 8 (or as early as 6) to 12 hours after ingestion	*In mild cases may experience:* • Vomiting, diarrhea, abdominal pain, and nausea. *In severe cases may experience:* • Liver failure, coagulation disorders, brain damage, acute renal failure, and death
Hydrazines	*Gyromitra esculenta, G. gigas*	Usually within 6 to 10 hours after ingestion	*May experience:* • abdominal pain, severe headache, vomiting, diarrhea, liver damage, and damage to the central nervous system and blood cells
Orellanine	*Cortinarius speciocissimus, C. orellanus* (Sorrel webcap)	Usually within 3 to 14 days after ingestion	*May experience:* • burning thirst, excessive urination, nausea, headache, muscular pain, chills, spasms, and loss of consciousness *In severe cases may experience:* • kidney and liver damage, renal failure, and death

Neurotoxins

Some mushroom species contain neurotoxins (see Table 8), poisons that attack the nervous system and affect, damage or destroy nerve cells. The most common mushroom neurotoxins are muscarine, ibotenic acid/muscimol, and psilocybin. Table 8 lists the mushroom neurotoxins, reaction times and associated symptoms.

Muscarine

Muscarine is a poison found in the Fiber Head, Fragrant Funnel, Slim Anise and Blewit mushrooms. Muscarine is also found in other mushrooms, such as *Amanita, Boletus* and *Lactarius*. The ingestion of large amounts of muscarine can cause muscarine poisoning (Faulstich, 2005; USFDA, 2009).

Ibotenic acid and muscimol

Ibotenic acid and muscimol are poisons found mainly in two *Amanita* mushrooms. Muscimol is five times more potent than ibotenic acid. Ibotenic acid poisoning causes behaviour similar to alcohol intoxication (Faulstich, 2005; USFDA, 2009).

Psilocybin and psilocin

Psilocybin and psilocin are poisons found in some mushrooms such as Liberty Cap, Haymakers and Magic Blue Gym Cap. These mushrooms are sometimes "eaten for their psychotropic effects in religious ceremonies of certain native American tribes." Psilocybin and psilocin attack the central nervous system, and poisoning resembles alcohol intoxication accompanied by hallucinations (Faulstich, 2005; USFDA, 2009).

Gastrointestinal irritants

Some mushrooms (such as Jack O'Lantern and Naked Brimcap) contain toxins that can irritate the gastrointestinal tract (see Table 9).

Go immediately to a health care centre or your health care provider if you think you have mushroom poisoning (HC, 2009). If possible, take a sample of the mushroom with you to help identify the precise species and likely toxin.

Table 8. Mushrooms and neurotoxins

TOXINS	Mushrooms	Reaction time	Symptoms in humans
Muscarine	*Inocybe geophylla, I. patouillardi, I. fastigiata, I. geophylla, C. dealbata, A. muscaria, Boletus, Lactarius*	Usually within 15 to 30 minutes after ingestion	*In mild cases may experience:* • increased salivation, perspiration/sweating, and watery eyes/ tearing (lacrimation) *In severe cases may experience:* • abdominal pain, severe nausea, diarrhea, blurred vision, laboured breathing, and ingestion of large doses may cause cardiac/ respiratory failure
Ibotenic Acid and Muscimol	*A. muscaria* (Fly Agaric), *A. pantherina* (Panthercap), *A. gemmata*	Usually within 1 to 2 hours after ingestion	*May experience:* • nausea, vomiting, diarrhea, colour hallucinations, slow pulse, hypotension, irritability, lack of coordination, anxiety, hysteria, convulsions, fever and seizures (in children), abdominal discomfort, drowsiness, dizziness, hyperactivity, excitability, and coma
Psilocybin and Psilocin	P. *cubensis* (Golden tops), *P. mexicana, P. cyanescens, P. semilanceata* (Liberty cap), *C. cyanopus*	Usually within 20 minutes after ingestion	*May experience:* • anxiety, tension, visual effects (e.g., blurring), euphoria, increased colour perception (with eyes closed), headache, and fatigue

Table 9. Mushrooms and gastrointestinal irritants

TOXINS	Mushrooms	Symptoms in humans
Gastrointestinal Irritants	*Chlorophyllum molybditis* (Green Gill), *Entoloma lividum* (Gray Pinkgill), *Tricholoma pardinum* (Tigertop), *Omphalotus illudens* (Jack O'Lantern), *Paxillus involutus* (Naked Brimcap), *Russula emetica* (Sickener), *Verpa bohemica* (Early False Morel) *confused with Morchella esculenta* (True Morel), *Agaricus arvensis, A. xanthodermus* (Horse Mushroom), *and Boletus piperatus, B. calopus, B. santanas* (Pepper Bolete)	*May experience:* • nausea, vomiting, diarrhea, and abdominal pain

Coprine or disulfiram-like toxins

Coprine is an amino acid produced by some mushroom species such as *Coprine atramentarius* (Inky-cap mushroom) and *Clitocybe clavipes* (Fat-footed Clitocybe). Coprine is converted in the body to cyclopropanone hydrate, which interferes with the breakdown of alcohol during the consumption of alcoholic beverages. It is important to note that no illness (see Table 10) will occur if no alcohol is consumed within 72 hours of eating mushrooms that contain coprine or disulfiram-like toxins (USFDA, 2009).

Table 10. Mushrooms and coprine or disulfiram–like toxins

TOXINS	Mushrooms	Symptoms in humans
Coprine or Disulfiram-like Toxins	*Coprine atramentarius* (Inky-cap mushroom), *Clitocybe clavipes* (Fat-footed Clitocybe)	If alcohol is consumed within 72 hrs of ingesting the toxin, *may experience*: • headache, nausea, vomiting, flushing and cardiovascular disturbances, dilation of the pupils (mydriasis), abnormal skin sensations (paraesthesia), abnormal rapid heartbeat (tachycardia), sweating, and nausea

Ensuring safety when eating mushrooms

- Do not harvest or eat any type of wild mushroom unless it has been identified as being edible by someone with expertise in identifying wild mushrooms in your community or region,
- At the grocery store/market, select fresh mushrooms that are firm,
- At the grocery store/market, select only those cut mushrooms that show no signs of spoilage or bruising,
- Store cut mushrooms in a paper bag or their original packaging in the refrigerator at temperatures of 4ºC/40ºF or below for up to 5 days,
- Do not freeze fresh mushrooms; cook (steam/sauté) mushrooms before freezing them,
- Wash mushrooms under running water and pat dry with clean paper towel when ready to use, and
- Keep cooked frozen mushrooms for up to 8 to 12 months (HC, 2009).

Bacterial Toxins

There are two main types of bacterial toxins: endotoxins and exotoxins. Endotoxins are toxic substances bound within the cell walls of gram-negative bacteria, which are secreted when the cells rupture or die. Endotoxins are produced by different types of bacteria, such as *Salmonella, Listeria monocytogenes,* and *Shigella* (See Table 2 for more information on these bacteria). These toxins are heat-resistant; they are not destroyed by cooking (Todar, 2008). Exotoxins, or extracellular toxins, are toxic substances excreted by living gram-positive and gram-negative bacteria during their growth. Exotoxins are excreted by different types of bacteria, such as *Clostridium tetani, Corynebacterium diphtheriae, Clostridium botulinum*. Most exotoxins can be destroyed by heat (CFIA, 2006; Todar, 2008). Exotoxins are characterized by their mode of action on targeted tissues and organ systems.

Both types of bacterial toxins can cause a number of foodborne illnesses such as botulism and Staphylococcus-related illnesses, if ingested.

2.2 Plant toxins

Fruits, vegetables and other plant foods (including sprouts, leaves, seaweeds, roots, bulbs, tubers and inner bark tissues) are an important source of vitamins A and C, calcium, iron and fibre. Some food plants produce small amounts of toxins, referred to as phytotoxins (such as alkaloids and glycosides), in order to protect themselves against insects, diseases and plant-browsing animals.

Some plants are poisonous to humans at different stages of maturity. A plant is poisonous if it can make people ill after touching, tasting or swallowing its parts. For instance, fertile shoots of horsetail are edible (in small quantities), but the mature, green, vegetative shoots are not (Turner, 1997). In other cases, while some parts are edible at any stage, other parts have higher concentrations of natural toxins and are poisonous when consumed by humans. For example, although rhubarb stems are safe to eat, its leaves contain a high concentration of oxalid acid and should not be eaten.

Some of the most common phytotoxins found in plants are: cyanogenic glycosides, glycoalkaloids, lectins, oxalates and oxalic acid, and cucurbitacin (see Table 12).

Cyanogenic glycosides

Cyanogenic glycosides are naturally occurring toxins found in some wild plants, fruits and vegetables such as:

- bracken fiddleheads (with high concentration found in the rhizomes and fiddleheads),
- wild cherries such as choke, black, bitter and pin (found in the leaves, twigs, shoots, bark, and seed kernels,
- berries such as serviceberry, and Saskatoon berries (found in the leaves and twigs),
- elderberries (found in the roots, stems, bark and leaves including the flower and unripe fruit), and
- all parts of yew or ground hemlock (except the flesh around the seed).

These toxins can convert to hydrogen cyanide when ingested and are the primary causes of cyanide poisoning from food. The lethal dose of cyanide for all age groups of the population ranges from 0.5 to 3.0 mg per kilogram of body weight. Adequate boiling significantly reduces the amount of cyanide present in glycoside-containing plants. These plants should therefore never be eaten raw and they should always be well-cooked (CFIA, 2009c; CFS, 2007; Coulombe, 2001).

Glycoalkaloids

Glycoalkaloids are naturally occurring toxins, such as solanine, tomatine and charconine, found in some fruits and vegetables, such as eggplants, peppers, tomatoes and potatoes. Washing, soaking and cooking cannot destroy these particular toxins as they are heat resistant. The highest concentration of solanine and charconine in potatoes is found in the skin, eyes and sprouts of the tubers. Improper storage, light exposure, physical damage (e.g., cuts and bruises), and rotting (caused by bacteria or fungi) may facilitate the rapid production of these toxins. Sprouted, greened or damaged potatoes should not be consumed (CFIA 2009b; CFS, 2007; Turner & Szczawinski, 1992).

To reduce exposure to glycoalkaloids in potatoes:

- Store in a dark, cool and dry place – away from sun or artificial light,
- Cut away any parts that show damage (cuts and bruises), rotting and sprouting,
- Peel the skin to reduce the level of glycoalkaloids,
- Do not eat potato sprouts, flowers, and areas around the eyes, and
- Do not eat potatoes that taste bitter or cause a burning sensation in the mouth (HC, 2010a).

To reduce exposure to glycoalkaloid in tomatoes:

- Eat green tomatoes and its products in moderation (e.g., green tomato relish, fried green tomatoes), and
- Do not eat the green parts of tomato plants (HC, 2010a).

Lectin

Lectin is a naturally occurring toxin found in raw kidney beans (especially the red variety) and green beans. To destroy this toxin, soak kidney beans in water for at least 5 to 12 hours and then cook in fresh water at high temperatures (60°C/140°F) for at least 10 to 30 minutes evenly. Cooking these beans at a low temperature or with uneven heat transfer does not destroy the toxin and can cause the cooked beans to be more toxic than the raw ones (CFS, 2007; FSA, n.d.; NZFSA, n.d.)

Oxalates and oxalic acid

Oxalates are compounds ("salts") that form when oxalic acid is combined with metal ions such as calcium, magnesium, or potassium. Oxalic acid is a naturally produced metabolic by-product found in various plants in low concentrations. Foods that typically contain higher amounts of oxalates or oxalic acid are spinach, sorrel, beets chard, skunk cabbage, indian turnip and rhubarb (highest concentrations are found in the leaves) and cannot be destroyed by heat (Nova Scotia Museum, n.d.).

Cucurbitacin

Cucurbitacin is a poison released in small amounts by the Cucurbitacean family, including squash, pumpkins, zucchini, cucumbers, and melons, as a defence against insects. Cucurbitacin is commonly found in wild zucchinis. This toxin releases a strong and unpleasant smell and gives a bitter taste to food (NZFSA, n.d.; Washington State Department of Health, 2009).

Table 11. Plant toxins

TOXINS	Associated plants/fruits/vegetables/nuts	Symptoms in humans
Cyanogenic glycosides	Apple and pear seeds (in low levels), mangoes, bitter almonds, cassava roots (manioc), wild cherries, the inner kernel (pit) of apricots and peaches, lima beans, chickpeas, and cashew nuts	*May experience:* • rapid pulse and breathing, drop in blood pressure, dizziness, headache, stomach pains, vomiting, diarrhea, mental confusion, twitching, and convulsions
Glycoalkaloids	Roots, seeds, leaves, bark and stems, poppy, lupine, coffee, tea and cocoa, eggplant, tomatoes, and potatoes	*May experience:* • bitter or burning sensation in mouth, excess salivation, dilation or constriction of the pupils, vomiting, abdominal pain, diarrhea, lack of coordination, convulsions, and coma
Lectin	Kidney beans and green beans	*May experience:* • stomach ache, diarrhea, and vomiting
Oxalates and oxalic acid	Spinach, rhubarb, sorrel, and beets	*May experience:* • muscle twitching, cramps, decreased breathing, heart palpitations, vomiting, abdominal pain, headache, convulsions, and coma • an increase in the risk of kidney stone formation
Cucurbitacin	Squash, pumpkins, zucchini, cucumbers, and melons	*May experience:* • vomiting, stomach cramps, and diarrhea

Summary

To reduce the daily intake of natural toxins that can cause foodborne illnesses:

- Eat a wide variety of foods from the different food groups (see Eating Well with Canada's Food Guide, and Eating Well with Canada's Food Guide: First Nations, Inuit and Métis) (HC, 2010b),
- Store foods properly,
- Cook and prepare foods properly,
- Discard bruised, damaged or discoloured foods,
- Discard any foods that do not smell fresh, and
- Discard any food that has an unusual bitter taste, or causes a burning sensation in the mouth (FSA, n.d.).

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3. Preventing Foodborne Illnesses

Handling, preparing and storing food safely are key to preventing foodborne illnesses. These include *foodborne infections* (see Tables 2, 3 & 4) and *intoxications* (see Chapter 2). Although everyone is at risk of developing a foodborne illness, the elderly, children, pregnant women and people with weakened immune system are at greater risk (Lowry, n.d.).

3.1 Safe Food Handling Practices

To reduce the growth of harmful bacteria in foods, the following steps should be taken:

1. Clean,
2. Separate,
3. Cook, and
4. Chill (CFIA, 2010; Canadian Partnership for Consumer Food Safety Education, 2009).

Clean

It is important to use the following personal-hygiene practices to avoid contaminating foods and food-contact surfaces:

- Wash hands with soap and warm running water for at least 20 seconds:
  - before, during and after handling food (e.g., raw meat, poultry and seafood);
  - when switching from raw to ready-to-eat foods,
  - after using the washroom,
  - after changing diapers,
  - after coughing, sneezing or blowing the nose,
  - after handling garbage,
  - after touching hair and face,
  - after smoking,
  - after handling money, and
  - after handling pets (Canadian Restaurant and Foodservices Association, 2007; Clemson University, 2006).
- Wash all cooking equipment, utensils and dishes in warm soapy water and rinse properly
- Sanitize work surfaces (such as cutting boards, counter tops) before and after preparing foods, especially raw meat, poultry, eggs or seafood
  - To sanitize: use a mild bleach solution of 1 teaspoon (5 ml) of household bleach mixed with 3 cups (750 ml) of clean water; spray the bleach solution on the surface/utensil and let stand briefly; rinse with lots of clean water; and air dry or use clean towel (HC, 2009).
- Use paper towels or clean cloths to wipe and clean kitchen surfaces - sponges are harder to keep clean (Clemson University, 2006; CFIA, 2009; PFSE, 2006a).

Proper hand washing techniques

- Remove all hand and arm jewellery,
- Wet hands and exposed areas of the arms with warm running water,
- Apply a small amount of liquid* soap to the hands and exposed areas of the arms,
- Rub hands with the soap vigorously for at least 15 to 20 seconds,
- Use a brush to scrub under the finger nails,
- Rinse hands with clean warm water for at least 10 seconds, and
- Dry hands with clean paper towel (use paper towel to turn off the tap).

For more information on hand hygiene when running water is or is not available, consult: *http://www.phac-aspc.gc.ca/alert-alerte/h1n1/public/handhygiene-eng.php.*

*liquid soaps are more hygienic than bar soaps. If bar soap is used, ensure that it is stored on a rack, and does not sit in water.

Clean Water

If the drinking water supply is under a "Boil Water Advisory" or "Do Not Drink Advisory" the following precautions should be taken:

Boil Water Advisory – is issued when:

- unacceptable levels of disease-causing bacteria, viruses or parasites are in the water system - anywhere from the source to the tap,
- unacceptable levels in the cloudiness of the water - at its originating source, or
- there is concern that the water may be contaminated (for example, when emergency repairs are being done to the distribution system)

This type of water advisory is issued and lifted by the Chiefs and Councils. When this advisory is in effect, the water must be boiled before use.

To boil water

- Bring water to a rolling boil for at least one minute.

Once the boiled water has been cooled, it can be used to wash fruits and vegetables.

Do Not Drink Advisory – is issued when the water supply is unsafe. This advisory implies that the water should not be used in any way that it could be ingested (i.e., drinking, cooking, making/mixing drinks, ice cubes or soups), and boiling will not make it safe. This advisory is issued and lifted by the Chiefs and Councils. When this advisory is in effect, bottled water must be used (HC, 2007).

Separate (Do not cross-contaminate)

Cross-contamination is the transfer of harmful bacteria, parasites and viruses from raw food such as meat or vegetables, a person, object (such as cooking utensil), or food preparation area onto food. This transfer can occur during any stage of the preparation, storage and serving of food.

Cross-contamination can be direct or indirect. Direct cross-contamination occurs when there is direct contact between the source of contamination and food, such as when raw foods containing bacteria come into direct contact with cooked food. Indirect cross-contamination occurs when microorganisms are transmitted from the source of contamination to food by contaminated hands, equipment, or surfaces used for food preparation.

Using dirty utensils, equipment and surfaces, or touching food with hands that have not been properly washed, are examples of practices that put food at risk of indirect cross-contamination.

To avoid cross-contamination:

- Avoid touching ready-to-eat-food with bare hands,
  - use utensils (e.g., spatulas and tongs) and gloves during preparation and serving
- Use separate cutting boards for meats, fruits, vegetables, and ready-to-eat foods,
- Keep raw meat, poultry, seafood and their juices separated from other foods during shopping (e.g., in shopping cart and grocery bags), storage and preparation,
- Store raw meat, poultry and seafood on the bottom shelf of the refrigerator in sealed containers to prevent their juices from dripping on other food (see Table 25 and 26 for recommended storage time),
- Do not re-use marinades of raw meat, poultry or seafood on cooked foods, unless the marinades have been boiled,
- Wash hands in warm soapy water before and after handling raw meats, poultry and seafood, and
- Use a tasting spoon to taste food only once; wash it with warm soapy water before using it again (Canadian Partnership for Consumer Food Safety Education, 2009; Clemson University, 2006; PFSE, 2006b; USDA, 2008a,b).

Cook

Temperature control is essential for food safety; proper cooking temperatures will prevent or limit bacterial growth (see Chapter 9 for information on holding hot and cold foods).

Check internal temperatures

The best way to ensure that food, especially meat, is thoroughly cooked is by checking the internal temperature with a food thermometer (see Tables 12 and 13):

- Insert the thermometer in the thickest part of the food to ensure it is cooked to recommended temperatures

- Ensure that the thermometer does not touch the bone, fat or gristle (Canadian Partnership for Consumer Food Safety Education, 2009; Clemson University, 2006; HC, 2009).

Do not rely on the colour or the smell of food to determine whether or not it is thoroughly cooked, especially if preparing large quantities.

Table 12. Recommended minimum internal cooking temperatures for game

(Cutter, 2000; DNRE, n.d; University of Minnesota, 2003; USDA, 2006a,b; USDA, 2008c)

GAME	Recommended Temperatures
Ground meat and meat mixtures Ground venison, and sausage,	71°C (160°F) 74°C (165°F)
Chops, steaks, and roasts of fresh venison (e.g., deer, elk, moose, caribou/reindeer, antelope and pronghorn) - Medium rare - Medium - Well done	 63°C (145°F) 71°C (160°F) 77°C (170°F)
Bear, bison, musk-ox , and walrus	74°C (165°F)
Small game (e.g., rabbit)	71°C (160°F)
Game birds/waterfowl: - Game bird/waterfowl whole (e.g., wild turkey, duck and goose partridge, and pheasant,) - Breasts and roasts of all game birds and waterfowl - Thighs, wings - Stuffing (cooked alone or in bird)	 82°C (180°F) 77°C (170°F) 82°C (180°F) 74°C (165°F)
Fish	70°C (158°F)
Shrimp, lobster, and crab	70°C (158°F)
Scallops	70°C (158°F)
Clams, mussels, and oysters	70°C (158°F)

Table 13. Recommended minimum internal cooking temperatures for market foods

(CFIA, 2010; PFSE, 2006a,b; USDA, 2006a,b; USDA, 2008a,b)

MARKET FOODS	Recommended Temperatures
Ground meat and meat mixtures: - Beef, veal, lamb, and pork - Turkey and chicken	 71°C (160°F) 74°C (165°F)
Fresh beef, veal, lamb - Medium rare - Medium - Well done	 63°C (145°F) 71°C (160°F) 77°C (170°F)
Fresh pork - Medium - Well done	 71°C (160°F) 77°C (170°F)
Poultry - Whole chicken, turkey, duck, and goose - Pieces	 85°C (185°F) 74°C (165°F)
Stuffing - cooked alone or in birds	 74°C (165°F)
Ham - Raw ham - Cooked (to reheat)	 71°C (160°F) 60°C (140°F)
Seafood	63°C (145°F)
Fish	70°C (158°F)
Egg dishes	74°C (165°F)
Leftovers	74°C (165°F)

Adjust for altitude

Altitude affects stove-top cooking temperatures, but not oven cooking temperatures. At altitudes well above sea level, stove-top cooking times need to be adjusted. At sea level, the boiling point of water is 100°C/212°F. At higher altitudes, water and other liquids boil at lower temperatures, and as a result, cooking takes longer. To compensate for this, cooking times must be increased: cook the food longer, do not increase the heat.

Reheating foods safely

The risks of bacterial growth are increased if foods are improperly reheated. To reduce potentially harmful microorganisms, reheat cooked foods at a minimum internal temperature of 74°C/165°F.

When reheating foods in a microwave oven, stir the food, cover, and rotate the dish periodically to ensure even cooking of the food; this will prevent cold spots that may facilitate bacterial growth. Liquid foods, such as gravies, soups or sauces must reach the boiling point when reheated. Other leftover foods must reach a minimum internal temperature of 74°C /165°F (Canadian Partnership for Consumer Food Safety Education, 2009).

Chilling

It is important to chill fresh and cooked foods quickly and properly, as bacteria can grow rapidly in the danger zone of 4°C-60°C/40°F-140°F (CFIA, 2010). To reduce the growth of any harmful bacteria that may be present in foods (including any leftovers) refrigerate or freeze as soon as possible. For proper cooling, the freezer should be at -18°C/0°F or lower, and the refrigerator at 4°C/40°F or lower (Canadian Partnership for Consumer Food Safety Education, 2009; Clemson University, 2006).

To chill foods properly:

- Refrigerate hot foods in shallow pans or containers (not deeper than 7.5 cm (3 inches)) with moisture- and vapour-proof wraps to allow air to circulate around the food and speed up cooling (place on ice if refrigeration is not available at the time)
  - large amounts of food (such as rice) should be divided into smaller portions
  - large pieces of meat and poultry should be cut into smaller pieces before cooling
- Place containers of hot foods in the refrigerator with space between them to allow air to circulate
  - to prevent bacterial growth, the centres of hot foods need to reach a minimum temperature of 7°C/45°F within four hours
  - Do not overload the refrigerator; allow air to circulate freely
  - Freeze foods in air-tight durable containers, food-storage bags, freezer-grade foil or freezer paper (Canadian Partnership for Consumer Food Safety Education, 2009; CFISIG, 2004; Clemson University, 2006; HC, 2009).

Discard any perishable foods that have been left at room temperature for more than two hours.

Chill foods properly; refrigeration does not kill bacteria, it only slows their growth.

Thawing (de-frosting)

Properly handled foods stored at freezing temperatures are generally safe. However, once thawed, bacteria can become active and multiply rapidly to levels that can cause foodborne illnesses (Cutter, 2000).

When thawing frozen foods, use one of the following three methods:

- *In the refrigerator* – thaw frozen foods (especially game and raw poultry and seafood) on a plate or pan on the lowest shelves of the refrigerator (at 4°C/40°F) to avoid dripping and cross-contamination,
- *In cold water* – thaw frozen foods at a temperature of at least 21°C/70°F. The food must be submerged under the water in a sealed container/bag. Change the water every 30 minutes until the food is thawed, or

Do not thaw meat, poultry, seafood or game at room temperature or in hot water.

- *In the microwave* – thaw frozen foods in a microwave.

Food thawed in cold water or in the microwave should be cooked immediately (Canadian Partnership for Consumer Food Safety Education, 2009; HC, 2009).

Most raw and cooked foods, including game can be refrozen (except combination foods such as stews, soups, and casseroles) if ice crystals are still present and there is no odour being released. It is not recommended to refreeze foods thawed in cold water or the microwave unless it has been cooked (Clemson University, 1999; USDA, 2006a,b).

Safe food storage

Storing foods properly helps preserve the quality, nutrients, flavour and texture of the food and prevents the growth of harmful microorganisms (e.g., bacteria, mould). Foods can either be stored in a cupboard/storeroom, refrigerator or freezer (Kendall & Dimond, n.d.).

Cupboard/storeroom

Shelf stable foods, such as dry goods and canned items should be stored in a cool dry place such as a cupboard or storeroom at least 15 centimetres (6 inches) off the floor, and away from direct sources of sunlight and heat.

- Ensure that storage area is clean, dry and well ventilated.
- Store foods in the coolest parts (10°C-21°C/50°F-70°F) of the cupboard,
  - away from hot pipes, water heaters, dishwashers or ovens (for example, do not store potatoes and onions under the sink) (CFIA, 2002; Van Laanen, n.d.).

Refrigeration

Fresh meats or produce, and other perishable foods should be kept in a refrigerator. Ensure that the refrigerator is set at the recommended temperature of 4°C/40°F or lower. Use a fridge thermometer to ensure that the refrigerator is set at the appropriate temperature.

- Keep the refrigerator clean to avoid cross-contamination from spilled or spoiled foods,
- Store meat, poultry, fish, eggs and dairy products in the coldest sections of the refrigerator,
  - Do not store eggs in the door
- Ensure that foods are well covered,
  - Use food storage bags or leak proof containers
- Store raw meat, poultry and fish in the bottom shelf of the refrigerator so that their juices do not spill and drip on other shelves contaminating other foods,
- Do not store acidic food and beverages in containers made of tin, copper, zinc or lead-based glazes, antimony, and cadmium as they may dissolve and enter the food causing foodborne intoxication, and
- Do not refrigerate foods any longer than the recommended time (see Table 25 and 26 for recommended storage time) (CFIA, 2002 & 2009; CFISIG, 2004; Clemson University, 1999; HC, 2009; Van Laanen, n.d.).

Freezing

Ensure that the freezer is set at the recommended temperature of -18°C/0°F or lower.

- Freeze only fresh high quality foods,
- Store foods in leak proof containers or food storage bags,
- Label all foods with date and type of food, and
- Do not freeze foods any longer than the recommended times (see chapter 8 for recommended storage time) (CFIA, 2002; Van Laanen, n.d.).

Remember, good personal hygiene is an important practice for the prevention of food contamination.

Summary

Foodborne illnesses can be prevented by following these practices:

- Keep hands and all food-preparation equipment clean,
- Clean and sanitize all work areas,

Do not eat foods that look or smell bad; discard appropriately.

- Avoid cross-contamination of food,
- Cook foods to recommended temperatures,
- Chill foods properly,
- Use safe practices to thaw foods, and
- Store all foods for the recommended time.

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4. Naturally Occurring and Anthropogenic Chemical Contaminants

Synthetic and natural chemicals (e.g., metals) can be released as a result of industrial processes. When released in the environment, these contaminants may enter the food chain, where they pose potential health risks to living things.

4.1 Environmental contaminants

Environmental contaminants can be found naturally, or are released into the environment accidently or deliberately as a result of human activities. Some contaminants have been manufactured for industrial use and because they are very stable, they do not break down easily. Other environmental contaminants are naturally-occurring chemicals, but industrial activity may increase their mobility allowing them to enter the food chain at higher levels than would otherwise occur (HC, 2009a).

Environmental contaminants that are present in the air, water or soil may be taken up by plants, wildlife and fish, and a wide variety have been detected in foods. These contaminants range from metals and "ionic" species like perchlorate, to organic (e.g., carbon-based) substances, including "persistent organic pollutants" (POPs) – named for their ability to remain in the environment for prolonged periods without breaking down. Some POPs such as Polychlorinated biphenyls (PCBs) that have been banned for industrial or agricultural use in Canada for many years remain in the food chain. Other POPs, such as brominated flame retardants, have been more recently identified, and have been found in the environment and the food chain (HC, 2009a).

4.2 What makes chemicals harmful to humans?

The effect of the chemical on the body depends on the following factors:

1. Route of exposure (e.g., skin contact/dermal absorption, inhalation, or ingestion)
2. Amount entering the body
3. Characteristics of the chemical (e.g., toxicity, rate of removal from the body)
5. Biological variation of humans.

Routes of exposure

Contaminants may enter the aquatic food chain through waterbodies; plants, through contaminated soil; and deposition onto food plants through contaminants in the air.

Contaminants that are absorbed through ingestion enter the blood stream and are carried to different parts of the body. They are then stored either in the fat or bone, or metabolised by the liver and excreted through urine, lungs, sweat, semen, milk, saliva and bile. Infants can be exposed to contaminants in breast milk, though it is important to keep in mind that the benefits of breastfeeding outweigh the health risks posed by the low levels of contaminants that have been detected in breast milk.

Amount entering the body

The amount and frequency of any chemical entering the body is very important as it is the amount (or dose) that determines whether or not the chemical will pose a concern to the health of a person. Exposures can be either short-term or long-term:

- Short-term exposure to a contaminant is often associated with higher concentrations of contaminants.
- Long-term exposure to a contaminant is more often associated with lower concentrations of contaminants.

Type and toxicity

Toxicity is a measure of the poisoning strength of a contaminant. For contaminants that are not very

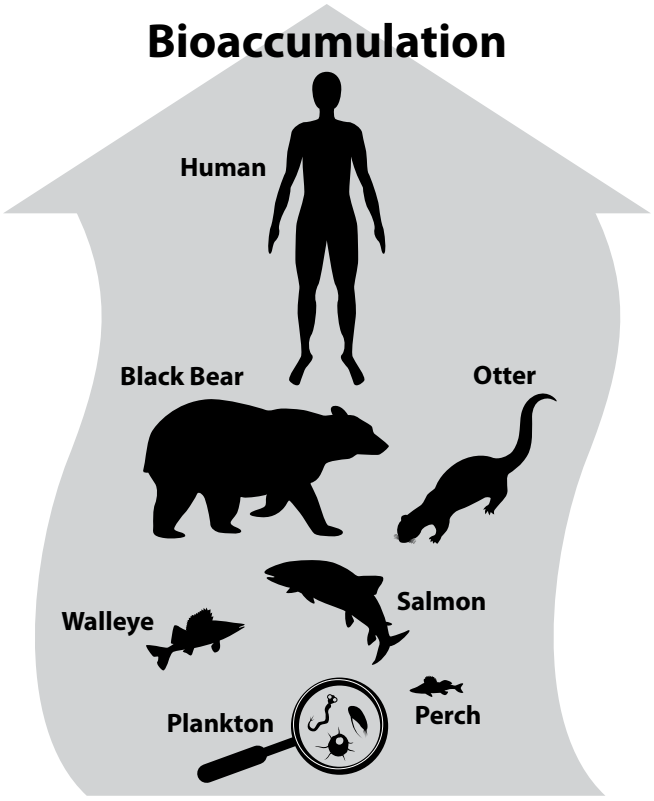
toxic, large amounts are needed to cause poisoning, and for those that are very toxic, only small amounts are needed to cause poisoning.

Rate of removal

Many chemicals entering the body may be excreted unchanged, while others are broken down by the human body. Eventually, most contaminants are removed from the body as waste in the faeces, urine, and sweat, or as exhaled breath. The health risks to people are reduced if the body is able to break down the contaminants into a less toxic product or rapidly remove them from the body.

Biological variation

Biological variation refers to the different characteristics (e.g., age and gender) of an individual that may make him/her more susceptible to poisoning from contaminants. Young children, the elderly, pregnant or lactating women, those with a weakened immune systems (Daugherty, 1998), and individuals with poor nutritional status may be more susceptible to the toxic effects of chemical contaminants.



Bioaccumulation is the concentration of a toxic chemical that gradually increases in the living tissues of plants, animals or people as they continue to drink contaminated water, or eat contaminated food (IRR, 1999).

Biomagnification is the result of the accumulation of a chemical in an organism at higher levels than are found in its food supply. It occurs when a chemical becomes more concentrated as it moves up through the food chain. For example, animals that eat other animals and plants consume all the contaminants that their food sources were exposed to. As a result, the animals at the very top of the food chain are exposed to the highest levels of contaminants (IRR, 1999). Plants, wildlife and humans absorb heavy metals from various food sources. In some wildlife (e.g., caribou, seal, fish), the levels of metals are often higher in the organs than in the muscle/ meat.

4.3 Common contaminants found in foods

The most common contaminants that can be found in foods are:

- **Heavy metals**
  - Cadmium (Cd), Lead (Pb), Mercury (Hg) and Arsenic (Ar)
- **Persistent Organic Pollutants (POPs)**
  - Pesticides: aldrin, dieldrin, endrin, heptachlor, hexachlorobenzene, mirex, Dichloro-Diphenyl-Trichloroethane (DDT), chlordane and toxaphene
  - Industrial chemicals: Polychlorinated biphenyls (PCBs),
  - By-products: polychlorinated dibenzo-p-dioxins (PCDD) (e.g., dioxins) and polychlorinated dibenzofurans (PCDF) ("furans")
- **Polybrominated diphenyl ethers (PBDEs)**
- **Perfluorinated chemicals**
  - Perfluorooctane sulfonic acid (PFOS)
  - Perfluorooctanoic acid (PFOA)
- **Polycyclic aromatic hydrocarbons (PAHs)**

- **Radionuclides**
  - Polonium, Radium, Cesium, Strontium, and Uranium

Heavy metals

Heavy metals (e.g., cadmium, lead, mercury and arsenic) are naturally occurring. They can also enter the environment as a result of anthropogenic activities. For example, naturally occurring chemicals can be the result of the weathering of rocks and soil which can release metals into rivers and lakes. Human activities such as mining, clear cutting, industrial processes, and burning of fossil fuels, garbage, and forests, also release heavy metals into the environment.

Heavy metals are a cause for concern because they do not break down over time and tend to bioaccumulate in the body. The rate at which a chemical is absorbed (bioavailability) is an important factor in toxicity. While some metals (at low levels) are considered essential nutrients for humans (e.g., iron and zinc), others such as cadmium, mercury and lead, are not needed by the body and can be harmful (see Table 15 for heavy metals and their effects).

Environmental contaminants are naturally-occurring or man-made chemicals found in the environment that accidentally or deliberately enter the environment, often, but not always, as a result of human activities. Contaminants present in the air, soil and water (e.g., pesticides, metals) can be taken up and stored by plants and animals that are a food source for humans).

Cadmium

Cadmium is a naturally occurring element found in the environment. It appears as a soft, silver-white, heavy metal and enters the soil, water, and air from mining, industry, and burning coal and household wastes. Cadmium has many uses, such as in batteries, pigments, metal coatings, and plastics (ATSDR, 2008).

Cadmium in humans

Human exposure to cadmium occurs through the consumption of contaminated foods e.g., milk, meat, fish, fruit, wheat, rice and potatoes (WHO, 2000). Elevated levels of cadmium are found in oysters and whole scallops harvested in British Columbia (CFIA, 2003). The organ meats of land animals are known to accumulate cadmium. Long term exposure is more problematic than short term exposure for wildlife; however, because land animals do not live long, the levels found are not of major concern for people who eat moderate amounts.

Cadmium levels in humans accumulate with age, with highest concentrations found in the kidney and liver. The placenta is an effective barrier to cadmium, making newborns partially safe from cadmium exposure as compared to adults (Coyer, 1991). In adults, the gastrointestinal absorption of cadmium amounts to about 5%, but may be increased by nutritional factors, such as the levels of iron, calcium and protein in the diet (WHO, 2000). Low dietary levels of iron, for example, are said to increase cadmium absorption (Piscato, 1985). Cigarette smoking represents an additional source of cadmium exposure which may equal or exceed that from contaminated food (WHO, 2000). Cadmium from smoking accounts for 10 to 20 percent of inhaled cadmium (HC, 1996). Most ingested cadmium is not absorbed and is eliminated in the stool, although long term exposure to elevated levels of cadmium may result in kidney damage.

Cadmium and wildlife

The highest cadmium levels (100-1000 µg/kg) are found in the internal organs (kidney and liver) of mammals and in certain species of molluscan shellfish such as mussels, scallops and oysters (WHO, 2000). Cadmium does not break down easily in animals and it tends to increase with age. Cadmium levels bioaccumulate in marine mammals, making marine mammals more adversely affected by cadmium exposure than birds and land mammals (HC, 2008c).

Lead

Lead is a persistent heavy metal that occurs naturally in the environment and is also released as a result of human activities. When released in the air, lead travels long distances in the environment. Though lead itself does not break down, its compounds such as lead acetate, lead chloride, and lead chromate, are altered by exposure to sunlight, air and water. Mobility and bioavailability of lead are influenced by pH, soil texture (clay content) and organic content (ATSDR, 2007a; USEPA, 2010a).

Lead in humans

Exposure to lead in humans is from the consumption of lead-contaminated wildlife (such as moose, deer, and waterfowl) that have been shot by lead shots/pellets (Verbrugge et al, 2008). The effects of lead in humans are the same, whether it enters the body through breathing or ingestion. Lead can affect almost every organ and system in the body (ATSDR, 2007a).

> If you are concerned about possible lead levels in drinking water, contact your Environmental Health Officer (EHO).

Because children are developing quickly, they have a higher metabolic rate and are more efficient at absorbing and retaining substances, such as lead. Unborn and young children are more vulnerable to the effects of lead. During pregnancy, the foetus may be exposed to lead through the mother (HC, 2008f).

Once lead is absorbed, it circulates in the bloodstream where it gradually accumulates in soft tissue such as the liver, kidneys, pancreas and lungs, with a high proportion transferred to the bone, where it accumulates over time and remains for long periods. The estimated time for the body to excrete half the accumulated lead is about 25 years (HC, 2008a).

Lead and wildlife

Lead poses a threat to wildlife, especially waterfowl and birds of prey. In wild mammals, lead poisoning is the result of the consumption of lead contaminated prey. Waterfowl and birds of prey are at greater risk of exposure to lead than mammals due to their feeding habits (see Table 14). The ingested lead bits (remnants from lead shots/pellets) enter the stomach of the waterfowl, which grinds and erodes the metallic lead and distributes it to other body tissues through the circulatory system. The lead is then absorbed in the body where it interferes with body functions that rely on the activity of calcium and haemoglobin. Some symptoms of lead poisoning in birds include neurological and gastrointestinal problems, emaciation, head tremors, green or bile-stained faeces, paralysis of lower legs, drooping wings and blindness (Miller et al, 2003).

Mercury

Mercury is a heavy metal that does not break down in the environment and hence, bioaccumulates. Mercury is released into the atmosphere as a result of human activities, such as combustion and industrial activities (HC, 2004b; HC, 2008e). Once in the atmosphere, it is widely dispersed and can circulate for many years. The long atmospheric lifetime of its gaseous form makes the emission, transport and deposition of mercury a global issue.

The concern over mercury in the environment arises from the toxic forms in which it can occur. Once released, mercury enters the air, water and soil and continues to move over long periods of time, depending on its chemical form.

Mercury exists in three forms:

1. Elemental (metallic) mercury is the pure form of mercury. It is a heavy, shiny, silver-white volatile liquid that releases a colourless and odourless toxic vapour at room temperature. It is the primary form of mercury released into the air by natural processes, such as volcanic activity.
2. Inorganic mercury enters the air, water, or soil from the weathering of rocks that contain mercury or from mining ore deposits, burning coal and waste, and from manufacturing plants. It is formed when

elemental mercury combines with other elements such as sulphur, chlorine or oxygen to create compounds known as mercury salts.

3. Organic mercury is formed when elemental mercury combines with carbon. Microorganisms in the environment can convert inorganic mercury to the organic form of mercury, also known as methylmercury. Methylmercury is a highly toxic organic compound of mercury, and is more toxic than elemental mercury.

Methylmercury is the most toxic form of mercury likely to cause adverse health effects in humans; the developing brain is the most sensitive for methylmercury toxicity. The mercury found in fish and seafood products is in the form of methylmercury; other food sources may also contain mercury but in the inorganic form.

Exposure to methylmercury is particularly dangerous to the developing embryo and young children who, because of their size, are more sensitive than adults. In pregnant women, it can cross the placenta into the foetus, building up in the brain and other tissues. Low levels of methylmercury can also be passed to infants through breast milk (HC, 2009c), though the benefits associated with breast milk consumption by infants are considered to outweigh the risks associated with low-level exposure to mercury.

Mercury in humans

In humans, the main source of mercury exposure is from the consumption of fish – present in the form of methylmercury. A wide range of adverse health effects has been observed in humans following methylmercury exposure, and the severity depends on the magnitude of the dose and the duration of exposure. The central and peripheral nervous systems are generally considered to be the target organs of organic mercury-induced toxicity in humans (HC, 2008d).

Individuals who consume fish may be exposed to some level of mercury, though concentrations are generally low. The consumption of certain types of fish (e.g., predatory) that contain high levels of methylmercury may pose certain health risks (HC, 2002). In particular, the developing fetus and young children (whose mothers consumed large amounts of fish) are more susceptible to adverse health effects (see Table 14). Mercury is stored in the muscle, liver and kidneys.

Mercury and wildlife

Mercury levels in wildlife depend on the body of water, the species, age and size of the animal. Younger and smaller animals tend to have lower concentrations of mercury than older and larger ones within the same water body. For example, seals have higher mercury levels than cod and loche, while pike and lake trout have higher mercury levels than geese or ptarmigan.

The persistence of mercury allows it to bioaccumulate in living organisms. The amount of mercury increases as it passes from small plants and animals in the water to aquatic insects and fish, meaning that higher levels are found in animals further up the food chain. Large, long-lived, predatory fish are known to contain higher levels of mercury in their muscle tissues relative to other types of fish. This accumulation poses a threat to fish and wildlife due

> Fish is an excellent source of high-quality protein and omega-3 fatty acids and is low in saturated fat; the nutritional benefits of fish consumption outweigh the potential risks posed by contaminants at low levels. However, pregnant women, women of child-bearing age and young children should limit the consumption of certain fish with higher mercury concentrations such as shark, swordfish, tuna, and walleye (HC, 2008d,e; Kris-Etherton et al., 2002).

to the adverse health impacts. Mammals that accumulate toxic levels of mercury exhibit abnormal behaviour, eating disorders or a lack of coordination (HC, 2009a). High levels of mercury can affect the ability of the fish to survive and reproduce. Birds exposed to mercury lay fewer and smaller eggs and have trouble caring for their chicks (National Wildlife Federation, 2006).

Mercury is fat-soluble and primarily accumulates in the intestines and internal organs, and is also found throughout the muscle tissue. Aquatic plants and animals living in mercury-polluted waters are more likely to be smaller in length and weight, have physical deformities, reproduction disorders and a shorter life span.

Mercury concentrates in the muscle tissue of fish, and cooking does not eliminate it.

Arsenic

Arsenic is a naturally occurring element widely distributed in the earth's crust. Arsenic is classified as a metalloid; it exhibits properties of both a metal and a non-metal (ATSDR, 2010). Arsenic exists in different forms and can be classified into two groups: organic and inorganic. Inorganic arsenic is considered to be the most toxic to human health (HC, 2008b).

Arsenic can be found in both surface water and ground water sources; levels are generally higher in ground water. Most provinces and territories across Canada report some areas where arsenic can be detected in drinking water supplies (e.g., natural geological source or a site of contamination), though levels are generally well below the guidelines. In the past, arsenic was also used to some extent, as a pesticide, feed additive, and pharmaceutical, including veterinary drugs (HC, 2008b).

While many common arsenic compounds can dissolve in water, most of the arsenic in water will ultimately end up in soil or sediment (HC, 2008b).

Foods that have been found to contain very low levels of arsenic include meat and poultry, milk and dairy products, bakery goods and cereals, vegetables, and fruits and fruit juices. These trace levels of arsenic reflect normal accumulation found in the environment. While both organic and inorganic arsenic can be found in food, the levels of each depend on the type of food; inorganic arsenic is not usually found at high levels (HC, 2008b).

Arsenic in humans

Exposure to arsenic in humans is from the consumption of contaminated food (particularly meat, fish and shellfish) and drinking water (HC, 2008b).

Long-term exposure to high levels of inorganic arsenic may contribute to the risk of cancer and can affect the gastrointestinal tract, kidneys, liver, lungs, and skin. Skin, bone, and muscle represent the major storage organs. Short term exposure to high levels of inorganic arsenic can also cause various health effects including skin effects, nausea, diarrhea, vomiting and numbness in hands and feet (HC, 2008b).

Arsenic can also cross the placenta and has been found in foetal tissue, and in breast milk (ATSDR, 2010).

Arsenic and wildlife

Arsenic concentrations in plants and animals are usually low, but are elevated in marine biota; higher levels of organic arsenic are generally found in fish, shellfish and seaweed (HC, 2008b). The organic form of arsenic (arsenobetaine) poses little risk in fish and shellfish, and therefore a low risk to humans who consume them (USEPA, 2007). While arsenic is bioconcentrated by organisms, it does not biomagnified in the food chain (USEPA, 2007).

Table 14. Heavy metals and their effects

HEAVY METALS	Source	Sources of exposure in animals	Sources of exposure in humans	Effects in humans	Reducing Exposure *For more information on consumption, consult your EHO, or your local, provincial, territorial governments*
Cadmium	Burning of coal or oil, vehicle exhaust, cigarette smoke, metal processing industries, mining, waste hauling, waste disposal activities, soil, surface water (as dust), volcanoes, and weathering of rocks	Plants (e.g., lichens, willows) grown in contaminated soil or water	Foods grown in contaminated soils (e.g., mushrooms), organ meats from contaminated animals, (e.g., caribou, and moose), shellfish and plants from contaminated waters (e.g., mussels, oysters, and seaweed), and contaminated drinking water	*Acute exposure may cause:* • Irritation of the stomach, vomiting, and diarrhea Chronic exposure: • Maternal exposure to cadmium is associated with an increase in spontaneous abortions and low birth weight babies	Eat a balanced diet (this reduces the amount of cadmium absorbed by the body). Refer to Canada's Food Guide for First Nations, Inuit and Métis. *http://www.hc-sc.gc.ca/fn-an/pubs/fnim-pnim/index-eng.php* • Avoid meat or organs that may have been shot by lead • Follow consumption guidelines for oysters in your area to minimize the intake of cadmium • Do not harvest fish or shellfish from closed harvest areas
Lead	Burning of fossil fuels, mining, thermal power plants, vehicle exhaust, old paintwork, production of batteries, ammunition (e.g., lead shots used for hunting), fishing sinkers, tackle and other related fragments, solder and lead pipes, devices used to shield x-rays, some children's toys, crayons, chalk, air near emission sources, house dust, soil, and paint flakes in old houses	Gravel contaminated with lead pellets, wounded or dead prey containing lead shot, and lead bullets or fragments	Contaminated foods such as wild birds (e.g., duck, swan, and geese), wild game, and crops grown in contaminated soil Contaminated water and the use of lead-glazed ceramics to cook	*Acute exposure may cause:* • Convulsions and memory loss *Chronic exposure may cause:* • muscle weakness, loss of appetite, abdominal pain, constipation, sleeplessness, irritability, headache, impaired mental function, impaired visual and motor performance, brain and kidney damage, damage to the nervous and reproductive systems, and weakness in fingers, wrists, or ankles *In men, high exposure levels may:* • damage the organs responsible for sperm production. *In pregnant women may cause:* • miscarriages and stillbirth *In young children may cause:* • decreased IQ, developmental delays, hearing problems, and behavioural disturbances	• It is recommended to use steel bullets to hunt • Avoid the meat or organs that may have been shot by lead • Do not put food or beverages in any leaded crystal containers (particularly acidic foods such as fruit juice) • Avoid drinking from leaded crystal (HC, 2008a,f) • For more information on lead, consult: *http://www.hc-sc.gc.ca/ewh-semt/contaminants/lead-plomb/asked_questions-questions_posees-eng.php*

Cont'd Table 14. Heavy metals and their effects

HEAVY METALS	Source	Sources of exposure in animals	Sources of exposure in humans	Effects in humans	Reducing Exposure *For more information on consumption, consult your EHO, or your local, provincial, territorial governments*
Mercury – *Elemental (metallic)*	Industrial processes, various commercial products (e.g., batteries, lamps, thermometers), dentistry (e.g., amalgam fillings), the pharmaceutical industry, sphygmomanometers (devices used to test blood pressure), electrical switches, lakes, streams and oceans, gold mine sites, spills, incinerators, and fossil fuels		Amalgam fillings and inhalation of mercury vapour	*Acute exposure may cause:* respiratory problems (such as, cough, sore throat, and shortness of breath), gastrointestinal problems (e.g., metallic taste, nausea, vomiting, diarrhea, and abdominal pain) as well as headache, weakness, and visual disturbances	• Follow Health Canada's consumption advice that has been issued for certain types of commercially-available predatory fish (see: *http://www.hc-sc.gc.ca/fn-an/securit/chem-chim/environ/mercur/cons-adv-etud-eng.php*) • Follow Federal Provincial Territorial (F/P/T) advice on sport fish consumption • Eat a variety of fish and shellfish that contain low levels of mercury and high concentrations of omega-3 fatty acids (e.g., anchovy, capelin, char, hake, herring, Atlantic mackerel, mullet, pollock (Boston bluefish), salmon, smelt, rainbow trout, lake whitefish, blue crab, shrimp, clam, mussel and oyster, (refer to Chapter 6 on fish), limit consumption of predatory birds and fish • Eat smaller, younger, non-predatory fish • Avoid consumption of fish from water bodies identified as being contaminated • Young children and women of childbearing age should limit consumption of fish known to contain mercury
Mercury – *Inorganic*	Mining of ore, coal burning, and waste incineration		Breathing vapours from spills, incinerators, and mercury-containing fuels	*Chronic exposure may cause:* renal damage *Acute exposure may cause:* • neurological damage, damage to the mouth, respiratory tract and lungs, and respiratory failure which can cause death	
Mercury – *Organic (methyl-mercury)*	Contaminated freshwater and saltwater fish and marine mammals		• Predatory fish with higher levels of mercury: Shark, swordfish, fresh and frozen tuna, escolar, marlin and orange roughy, and freshwater fish (that feed on other fish) that may have elevated levels of mercury: Northern pike and walleye • Fish-eating birds with high levels of mercury: loons, merganser ducks, osprey, eagles, herons, and kingfisher • Predatory mammals (e.g., otters)	*Short to long-term exposures to very high levels of methylmercury, may cause:* paresthesia, malaise and blurred vision, concentric constriction of the visual field, deafness, dysarthria, and ataxia *High exposures, may lead to:* coma and death *In the developing foetus, exposure may affect:* the developing nervous system at substantially lower doses than in adults	
Arsenic	Used in the manufacture of a variety of products (e.g., transistors, lasers, and semi-conductors, and in the processing of glass, pigments, textiles, paper, metal adhesives, ceramics, wood preservatives, ammunition, and explosives), also used in the hide tanning process and, to some extent, as a pesticide, feed additive, and pharmaceuticals, including veterinary drugs May enter our environment directly from industrial effluents and indirectly from atmospheric deposition	Surface and ground water including foods grown in contaminated soil	• Meat, poultry, milk and dairy products, bakery goods and cereals, vegetables, fruits and fruit juices, fish, and shellfish	*Low levels may cause:* • nausea and vomiting, decreased production of red and white blood cells, abnormal heart rhythm, damage to blood vessels, and a sensation of "pins and needles" in the hands and feet, while very high levels of arsenic can result in death *Long term exposure through ingestion may cause:* • darkening of the skin and the appearance of small "corns" or "warts" on the palms, soles, and torso	Contact the local environmental health officer if you think the water is contaminated with arsenic

Persistent Organic Pollutants

Persistent Organic Pollutants (POPs) are released into the environment through a variety of human activities. Some POPS are manufactured for commercial use; these include industrial chemicals, such as PCBs which are used as coolants in electrical transformers, and pesticides such as Dichloro-Diphenyl-Trichloroethane (DDT) and toxaphene. Other POPs, such as dioxins and furans, are unintentional by-products of combustion processes. POPs are persistent chemicals that bioaccumulate in the food web and may be hazardous to the environment and to human health.

POPs are not soluble in water, but dissolve readily in fats and oils. Because of their affinity to fat and their degradation, POPs tend to accumulate in the fatty tissues of animals and become more concentrated as they move from one animal to another up the food chain. The levels of POPs in water or soil can increase the exposure level of predators that feed at the top of the food chain, such as dolphins, polar bears, herring gulls and humans (Kuhnlein, 2000).

POPs in humans

POPs tend to bioaccumulate in higher organisms and to biomagnify in the food chain as levels increase from sea plankton through fish, and up to humans. Humans are exposed to POPs through their diet. The health effects of certain POPs are seen mostly in populations that consume large amounts of fish. Recent studies have indicated that individuals with high levels of POPs in the body are more likely to have diabetes (Wang et al., 2008).

Pregnant and nursing mothers should avoid the consumption of large amounts of foods contaminated with POPs (e.g., fatty and predatory fish), particularly as there are concerns about the potential risks of POPs being passed on in breast milk (Watson, 1997).

POPs and wildlife

In contaminated animals, POPs are stored in the fat or organs, such as the liver and kidneys. As the animal continues to consume POP contaminated foods, the levels bioaccumulate. Younger animals have lower levels of POPs in their bodies as compared to older animals. For example, polar bears, whales and seals usually have higher levels of POPs, as they are part of longer food chains and have a lot of fat, which allows more contaminants to accumulate in their bodies.

Pesticides

Pesticides are used to control pests in order to increase the quantity and quality of a harvest. They may also be applied to harvested food during transportation and/or storage in order to minimize spoilage and losses (Lippmann, 2003).

Atmospheric deposition is an important source of pesticide contamination of the Great Lakes and in the North, and a cause for concern as pesticides tend to be absorbed by soils and remain there for several years, breaking down very slowly and biomagnifying as they move upward through the food chain (HC, 1998). Pesticides have the ability to leach from the soil to water sources.

> While low levels of some contaminants may be found in breast milk, the benefits associated with breastfeeding are considered to outweigh the risks associated with low-level exposure to the contaminants.

Some pesticides belong to an older class of pesticides called *organochlorines*. Organochlorines are identified by the presence of chlorine in their structure; organochlorine pesticides are examples of POPs. Organochlorines can enter the environment as a result of the application of pesticides, disposal of contaminated waste into landfills, as well as through the release of chemicals from manufacturing plants. They stick to soil or particles in the air and in aquatic systems. The sediments adsorb organochlorines which then bioaccumulate in fish and aquatic

mammals (CDC, 2010). Organochlorines accumulate in the fatty tissues of animals and animal-derived foods such as fish or dairy products. Examples of organochlorine pesticides are DDT, aldrin, dieldrin, heptachlor, mirex, chlordane, toxaphene, and endrin (CDC, 2010; The Sustainability Report, 2004).

Aldrin and dieldrin

Aldrin & dieldrin are both pesticides that were used in Canada until 1970 to control insects in crops and in domestic, forestry and industrial situations (HC, 1995). Aldrin is converted to dieldrin in the body, and in the environment by bacteria and sunlight, making deildrin concentrations in the environment higher than would be expected by dieldrin use alone. Dieldrin binds tightly to the soil where it is taken up by plants. Dieldrin breaks down slowly in soil and water (ATSDR, 2002b).

Aldrin and dieldrin in humans

Aldrin and dieldrin are absorbed by humans through the consumption of contaminated foods or drinking contaminated water (see Table 15). Aldrin and dieldrin accumulate in the fatty tissue of humans (HC, 1995). Examples of foods known to contain aldrin or dieldrin are shellfish from contaminated lakes, root crops, dairy products and meat. Both aldrin and dieldrin are persistent chemicals and are able to build up in the body causing certain health effects (see Table 15) (ATSDR, 2002b).

Aldrin and dieldrin and wildlife

Wildlife that eat contaminated plants, high amounts of aldrin or dieldrin affect the nervous system. Exposure to low amounts over a period of time affects the liver of animals and weakens their immune systems (ATSDR, 2002b).

Endrin

Endrin is a synthetic organochlorine pesticide that was used in Canada from the early 1950s to the early 1980s as a treatment for pests. The registration and use of endrin under the Pest Control Products Act were discontinued in early 1991 (CCME, 1999a). Endrin is found in small amounts in the air and in fields where it was applied for agricultural purposes. It is also found in low levels in ground water and surface water; it clings to the bottom sediments of rivers, lakes and other bodies of water. Endrin may be broken down at high temperatures (ATSDR, 1997a). Along with other countries, the use of endrin has been banned in Canada.

Endrin in humans

Humans are exposed to endrin through contaminated water, foods grown in contaminated soil, and from hazardous waste. Endrin has also been detected in human breast milk and may be a route of exposure for nursing infants. Although there are no studies available on the adverse health effects from intermediate duration exposure in humans by any route, short term human poisoning from endrin contaminated food may result in jerking of legs, tonic-clonic contractions, convulsions and sudden collapse, and death (UNIDO, n.d).

Endrin and wildlife

Endrin can build up in the tissues of organisms that live in water, and is highly toxic to fish. Because land animals are able to metabolise endrin, it does not accumulate in their fatty tissues.

Heptachlor

Heptachlor is a man-made insecticide and termiticide that was used to kill termites in homes, buildings, and other insects in seed grains and food crops (UNIDO, n.d). It is a white powder that smells like moth balls. Heptachlor epoxide binds to soil, where it stays for many years, evaporating slowly into the air (ATSDR, 2007b). In Canada, Heptachlor was used from the mid-1950s to the early 1980s as a treatment for a variety of insect pests. The registration and use of heptachlor under the Pest Control Products Act were discontinued in early 1991 (CCME, 1999b).

Heptachlor in humans

Humans are exposed to heptachlor through the consumption of contaminated foods such as fatty tissues from fish and animals, inhalation of vapors, contaminated soil and water, or direct contact with residual heptachlor from pesticide application (UNIDO, n.d.). In addition, people whose homes have

been treated with heptachlor may also be exposed. Since heptachlor can volatilize from soil, people may be exposed to it in the air. Breastfeeding infants can be exposed through breast milk. There is no data on the health risks associated with chronic exposure to heptachlor (ATSDR, 2007b).

Heptachlor and wildlife

Levels of heptachlor are found in the soil and water and are taken up by plants and build up in the tissues of animals and fish. Heptachlor has been implicated in the decline of several wild bird populations such as Canada geese (UNEP, 2007).

Hexachlorobenzene

Hexachlorobenzene (HCB) was used as a pesticide, from 1945 to 1965 to protect the seeds of onions, sorghum, wheat and other grains against fungus (Northern Perspectives, 2000), as well as to make fireworks, ammunition and synthetic rubber (ATSDR, 2002d).

HCB is a white crystalline solid and is non-soluble in water, which means exposure through drinking water is limited. It is formed as a by-product in the waste streams of chloralkali and wood-preserving plants and when burning municipal waste. HCB is among the most persistent environmental contaminants because of its chemical stability and resistance to degradation.

Exposure to HCB may occur near industrial sites where it is produced as an unintentional byproduct, as a minor part of another chemical product, near hazardous waste sites where it has been discarded. Past disposal methods for industrial wastes containing hexachlorobenzene included incineration, disposal in landfills, discharge to municipal sewage treatment plants, and emission to the atmosphere (UNIDO, n.d.). At these sites, HCB may be carried in the air on dust particles, although exposure may also occur through contact with contaminated soil.

Hexachlorobenzene in humans

Exposure in humans is through inhalation of contaminated air, and the consumption of animal-derived fatty foods such as milk, other dairy products, meat, poultry, and fish. Infants may be exposed through breast milk.

Hexachlorobenzene and wildlife

Effects in animals include damage of the liver, thyroid, kidneys, blood, bones, and the immune and endocrine systems (ATSDR, 2002d).

Mirex

Mirex is a man-made pesticide that was used mainly to fight ants (especially fire ants), and termites in crops and stored grain. It is also used as a fire retardant in plastic, rubber, paint, paper and electronics. Mirex was never registered for use as a pesticide in Canada but has been used worldwide. It has entered Canada through long range atmospheric transport and via water and sediments in the Niagara River and via loadings from the Oswego River (EC, 2010). When released in the environment, mirex breaks down slowly and may stay for many years, binding itself to soil and sediment particles. Mirex has been detected in the air, surface water, soil and sediment, and aquatic organisms (UNIDO, n.d.). Mirex does not dissolve in water (ATSDR, 1996a).

Mirex in humans

People who live in areas where mirex was used or made may have higher levels in their tissues. In addition, exposure may occur through the consumption of contaminated meat and game (Northern Perspectives, 2000), as well as fish from contaminated water bodies. Infants may also be exposed through breast milk. In general most people are exposed to very low levels of mirex (UNIDO, n.d). Health effects of mirex exposure in humans are not known, although at high levels it may cause damage to the skin, liver, and nervous and reproductive systems (ATSDR, 1996a).

Mirex and wildlife

Mirex builds up in fish and shellfish that live in contaminated water as well as in plants and wildlife (ATSDR, 1996a). Mirex is toxic to plants, fish and crustaceans (Northern Perspectives, 2000). The ingestion of high levels of mirex by wildlife may

damage the stomach, intestines, liver, kidneys, eyes, thyroid, nervous system and reproductive system.

Dichloro-Diphenyl-Trichloroethane

Dichloro-Diphenyl-Trichloroethane (DDT) is a man-made pesticide that was used in the past to control mosquitoes and vector borne diseases. DDT is a persistent organic pollutant. It can travel long distances by air and by water. It is absorbed by plants and animals. It adheres strongly to soil where it may stay for a long time, depending on the type of soil, temperature, and the soil moisture. DDT disappears faster when the soil is flooded or wet than when it is dry and is broken down slowly by microorganisms to Dichloro-Diphenyl-Ethylene (DDE) and Dichloro-Diphenyl-Dichloroethane (DDD) – byproducts of DDT (UNIDO, n.d.).

Although DDT was never manufactured in Canada, it was registered in 1946 and used to control pests in crops as well as in domestic and industrial applications (CEC, 1991). DDT use was restricted in Canada and the United States in the 1970s, and was banned by both countries in the 1980s (CEC, 2003).

DDT in humans

DDT exposure may occur through breathing contaminated air, drinking contaminated water (near waste sites and landfills) or the consumption of contaminated foods, such as roots and leafy vegetables, meat, fish, poultry and dairy products. Breast-fed infants may be exposed through breast milk if the mother was exposed to DDT (ATSDR, 2002c; UNIDO, n.d).

DDT is stored in the fatty tissue of humans and leaves the body very slowly, primarily through urine. There are no known health effects associated with exposure to low levels of DDT. High levels may affect the nervous system (ATSDR, 2002c).

While there are no maximum residue levels for DDT in Canada, action levels for residues of DDT and its metabolites in foods have been established based upon periodically revised monitoring information that is collected on domestic and imported foods. Action levels range from 0.5-1.0 ppm in eggs, fresh vegetables, dairy products, meat and meat byproducts to 5 ppm in fish (CEC, 1991).

DDT and wildlife

DDT builds up in plants and fatty tissues of fish, birds and other animals. In fish, DDT may cause disruption of normal hormone function, affecting reproduction and development; smaller fish are more susceptible than larger ones of the same species. An increase in temperature decreases the toxicity of DDT to fish (Viswanathanand and Murti, 1989). In addition DDT and its metabolites can lower the reproductive rate of birds by causing eggshell thinning in wild birds such as falcon, brown pelican and bald eagle (Ehrlich et al., 1988).

Chlordane

Chlordane is a persistent pesticide that was widely used on lawns, gardens, crops, forests, and to control termites in houses, and in wood and wood products. Chlordane enters the environment and is transported long distances through the atmosphere where it remains in the soil for a long time and builds up through the food chain. Chlordane leaves the soil by evaporation to the air, where it may be redistributed by air currents, contaminating areas far from its original application site (EC, 2005).

Although Chlordane was never manufactured in Canada, it was used as an insecticide from 1949 to 1995 to control pests in crops and forests, as well as for domestic and industrial applications. Most uses of chlordane were phased-out by the mid-1970s (EC, 2005).

Chlordane in humans

Exposure to chlordane is through the consumption of contaminated foods, such as meat (from birds, and mammals), root crops grown in contaminated soil, and fish and shellfish caught in contaminated water. Exposure may also occur as a result of chlordane use in the home or workplace for termite control.

The amount of chlordane that enters the body depends on the concentration in the air, food, or water, and the length of exposure. Most chlordane that enters the body leaves in a few days, mostly

through the faeces, and in much smaller amounts in urine (UNIDO, n.d.).

High levels of chlordane affect the nervous and digestive systems and the liver. Inhalation or accidental ingestion of small amounts of chlordane may also cause headaches, irritability, confusion, weakness, vision problems, vomiting, stomach cramps, diarrhea, and jaundice. Large amounts of chlordane taken by mouth can cause convulsions and death in people (ATSDR, 1995).

Chlordane and wildlife

Chlordane is highly toxic and bioaccumulates in the fat of fish, birds, and mammals. Long-term exposure of chlordane affects the liver of animals (ATSDR, 1995; EC, 2005).

Toxaphene

Toxaphene is a persistent pesticide that was widely used in the 1970s to control lice, ticks, mange, and scab mites. It is released into the environment mainly as a result of its use as an agricultural insecticide, and is transported long distances. Toxaphene is also found in soils, surface water, sediments, rainwater, aquatic organisms, and food products, such as root vegetables, meats, and grains (UNIDO, n.d). Toxaphene was banned in Canada in 1985 (EC, 2005).

Toxaphene in humans

Humans are exposed to toxaphene through the consumption of toxaphene contaminated foods, particularly in the fatty tissues of fish, shellfish and marine mammals from contaminated water bodies (ATSDR, 1996c; ATSDR, 1997b; Gagné, 2007). Infants can be exposed through breast milk.

Once it enters the body, toxaphene rapidly spreads to all organs, where it is quickly broken down in the body and excreted in urine and faeces. Approximately 90% of the toxaphene is eliminated from the body within 24 to 36 hours after entering the body (ATSDR, 1996c).

High levels of toxaphene in humans may cause damage to the lungs, nervous system, liver and kidneys. Reversible respiratory failure has also been reported from exposure due to inhalation of toxaphene (UNEP, 2001).

Toxaphene and wildlife

Toxaphene has been found in high concentrations in the fatty tissues of shellfish, fish, marine mammals, yearling oysters, snails, raccoons, and algae (ATSDR, 1997b; INAC, 2010a). Toxaphene has also been found in the blubber of beluga whales from the north coast of Alaska (UNEP, 2001).

The effects of toxaphene on animals may cause disruptive and toxic effects to the immunological and neurological systems, and immuno-suppressive and behavioural developmental abnormalities (UNEP, 2001). Fish are extremely sensitive and become hyperactive, suffering muscular spasms and losing their equilibrium (INAC, 2010a).

Industrial chemicals

Industrial chemicals are chemicals that are used for various purposes, for example in fuels, lubricants, flame retardants, or as a fumigant in agricultural products. An example of an industrial chemical is polychlorinated biphenyls (PCBs).

Polychlorinated biphenyls

PCBs are a group of 209 synthetic organic compounds that were banned in North America in 1977. In the past, many industrial materials, such as sealing and caulking compounds, cutting oils, inks and paint additives, contained PCBs. They were also used to make coolants and lubricants for certain kinds of electrical equipment, such as transformers and capacitors. Today, trace levels of PCBs are found in the environment (air, soil and water) as a result of improper disposal practices. Contamination by PCBs is due primarily to long-range transport and has been found in remote areas of Canada (HC, 2006b).

Once in the environment, PCBs are present as absorbed particles where they easily move (from soil to water, water to air, air to water, sediments to water). PCBs can be carried long distances from where they were released, and eventually return to the land and water, settling as dust or precipitation – rain and snow. Because PCBs do not readily break down, they may remain in the soil for months or years

and bioaccumulate in the environment, increasing in concentration up the food chain. This is of special concern in areas where fish are exposed to PCB contamination and may be consumed by humans (USEPA, 2000). PCBs are able to accumulate in the leaves and above-ground parts of plants, including food crops; lighter PCBs leave the soil through evaporation (USEPA, 2010b; UNIDO, n.d).

PCB exposure in humans

People are exposed to PCBs primarily from contaminated food such as meat, dairy products, and fish caught in contaminated lakes or rivers, drinking contaminated well water near hazardous waste sites and breathing contaminated air (UNIDO, n.d). PCBs tend to accumulate in the fatty tissues of animal-derived foods and people who eat large amounts of sport fish, wildlife or marine mammals may be exposed to higher dietary levels (HC, 2002; HC, 2006b).

Once in the body, some PCBs may be transformed into other related chemicals called metabolites which may be as harmful as some unchanged PCBs. Some of these metabolites may leave the body in the faeces within a few days, although others may remain in fatty tissues for months. PCBs may be stored for years mainly in the fat and liver, but smaller amounts can be found in other organs as well (ATSDR, 2001). Effects of PCBs in humans may include skin conditions, liver, neurologic and gastrointestinal effects (USEPA, 2010b).

PCB exposure and wildlife

Once in the environment, PCBs accumulate in the cells of animals with the highest concentrations found in those at the top of the food chain (HC, 2006b). PCBs tend to bioaccumulate in the fatty tissues of animals (older animals have higher concentrations). Animals that eat only plants, and are naturally lean, do not accumulate high levels of PCBs in their bodies (INAC, n.d.). Fish absorb PCBs from water, suspended sediments, and their food.

Animals with elevated levels of PCBs may suffer liver damage, while those with lower levels may develop anaemia, and stomach and thyroid problems (ATSDR, 2001).

By-products

Polychlorinated dibenzo-p-dioxins (PCDD) and polychlorinated dibenzofurans (PCDF) are toxic chemicals commonly known as dioxins and furans (HC, 2006a). Dioxins and furans are found in very small amounts in the environment, including air, water, and soil (HC, 2006a). There are over 200 different dioxins and furans, but only 17 are known to be toxic and to bioaccumulate in food. The most toxic chemical in the group is 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) and other dioxins are measured in relation to TCDD (ATSDR, 1999a).

Dioxins can also be produced from natural processes, such as forest fires and volcanic eruptions. The airborne chemical can attach to small particles that can travel long distances in the atmosphere. This means that Canadians may also be exposed to dioxins and furans created in other countries. Exposure to dioxins can occur through the consumption of food grown in contaminated soils. Levels of dioxins in soil are higher than levels in both air and water (UNIDO, n.d).

Dioxins in humans

Humans are exposed to dioxins through the consumption of contaminated foods, particularly dairy products, fish, and meat. Dioxins may also be present in fruits and vegetables, although at much lower levels. Low levels of dioxins have also been measured in breast milk, and in infant formula (HC, 2006a).

Furans in humans

People are exposed to very low levels of furans through inhalation, drinking water, and consumption of furan contaminated foods, such as meat and other meat products, fish and fish products, and milk and milk products. Because furans concentrate in fatty tissues, consuming large amounts of fatty fish from water contaminated by furans may increase one's exposure from food (UNIDO, n.d). Furans may also be present in breast milk at low levels; the benefits associated with breast milk consumption by infants

are considered to outweigh the risks associated with low-level exposure to furan.

Dioxins and furans and animals

Both dioxins and furans accumulate in the fatty portions of animals, hence, meat, milk products and fish have higher levels of dioxins and furans than fruit, vegetables and grains. Visible fat can be trimmed from foods such as meat and fish and should be prepared in ways that allow the fat to drain. Effects of dioxins on animals include decreased food consumption and slowed growth (ATSDR, 1999a).

Polybrominated diphenyl ethers

Polybrominated diphenyl ethers (PBDEs) are a group of chemical substances used as flame retardants and are persistent in the environment (HC, 2009b). PBDEs enter the environment during their manufacture, and have been measured in air, soil, sediment, and water often far from sources of release. They do not dissolve easily in water, but can stick to particles and settle

Table 15. Persistent Organic Pollutants (POPs) and their effects

PERSISTENT ORGANIC POLLUTANTS (POPS)	Source	Associated foods for animals	Associated foods for humans	Effects in humans	Reducing Exposure
Aldrin & Dieldrin	Areas where pesticides have been used	Plants, roots, and crops grown in contaminated soils	Shellfish and fish from contaminated lakes, dairy products, contaminated meat from wildlife, plants, roots or crops grown in areas where insecticide has been used	*May cause:* • headaches, dizziness, irritability, vomiting, and uncontrolled muscle movements	• Avoid consumption of fish and seafood from contaminated waterbodies • Avoid consumption of foods/crops grown in areas where pesticides were used • Visible fat should be removed from animals prior to cooking • Cook meat and fish using methods that allow the fat to drain (e.g., broil, bake, boil or grill the meat) • Any excess fat should be drained after cooking • Follow Federal Provincial Territorial (F/P/T) advice on consumption of wild game and fish
Endrin	Areas where insecticides have been used	Plants, roots, and crops grown in contaminated soils	Wildlife, fish, and plants, roots or crops grown in areas where insecticide has been used	*Acute exposure may cause:* • headaches, dizziness, nervousness, confusion, nausea, vomiting, convulsions, and death	• Avoid consumption of fish and seafood from contaminated waterbodies • Avoid consumption of foods /crops grown in areas where pesticides were used • Visible fat should be removed from animals prior to cooking • Cook meat and fish using methods that allow the fat to drain (e.g., broil, bake, boil or grill the meat) • Any excess fat should be drained after cooking • Follow Federal Provincial Territorial (F/P/T) advice on consumption of wild game and fish
Heptachlor	Areas where insecticides have been used	Plants, roots, and crops grown in contaminated soils	Fish, dairy products, and contaminated fatty meats, and plants, roots or crops grown in areas where insecticide has been used	None known	• Avoid consumption of fish and seafood from contaminated lakes • Avoid consumption of foods/crops grown in areas where pesticides were used • Visible fat should be removed from the animal prior to cooking • Cook meat and fish using methods that allow the fat to drain (e.g., broil, bake, boil or grill meat) • Any excess fat should be drained after cooking • Follow Federal Provincial Territorial (F/P/T) advice on consumption of wild game and fish

Cont'd Table 15. Persistent Organic Pollutants (POPs) and their effects

PERSISTENT ORGANIC POLLUTANTS (POPS)	Source	Associated foods for animals	Associated foods for humans	Effects in humans	Reducing Exposure
Hexachloro-benzene	Areas where pesticides have been used	Plants and fish	Fish, milk, dairy products, and plants, roots or crops grown in areas where insecticide has been used	*May cause:* • liver disease causing red-coloured urine, skin sores, change in skin colour, arthritis, and problems of the stomach and nervous system	• Avoid consumption of fish and seafood from contaminated lakes • Avoid consumption of foods /crops grown in areas where pesticides were used • Visible fat should be removed from the animal prior to cooking • Cook meat and fish using methods that allow the fat to drain (e.g., broil, bake, boil or grill the meat) • Any excess fat should be drained after cooking • Follow Federal Provincial Territorial (F/P/T) advice on consumption of wild game and fish
Mirex	Areas where insecticides have been used	Plants, fish, and crustaceans	Fish, game, and plants, roots or crops grown in areas where insecticide has been used	*High levels may cause damage:* • To the skin, liver, and nervous and reproductive systems	• Avoid consumption of fish and seafood from contaminated lakes • Avoid consumption of foods /crops grown in areas where pesticides were used • Visible fat should be removed from the animal prior to cooking • Cook meat and fish using methods that allow the fat to drain (e.g., broil, bake, boil or grill the meat) • Any excess fat should be drained after cooking • Follow Federal Provincial Territorial (F/P/T) advice on consumption of wild game and fish
DDT /DDE/DDD	Areas where pesticide have been used (e.g., homes treated for termites), food grown in contaminated soil, and waste sites or landfills		Root and leafy vegetables, fatty meat, fish, shellfish, birds, and crops grown in contaminated soil	*Acute exposure may cause:* excitability, tremors, and seizures *Chronic exposure may affect:* the nervous system *In women, DDE can cause:* reduction in lactation duration and increased risk for premature baby	• Avoid consumption of fish and seafood from contaminated lakes • Avoid consumption of foods/crops grown in areas where pesticides were used • Visible fat should be removed from the animal prior to cooking • Cook meat and fish using methods that allow the fat to drain (e.g., broil, bake, boil or grill the meat) • Any excess fat should be drained after cooking • Wash fruits and vegetables in clean water to remove most of the pesticide from the surface • Follow Federal Provincial Territorial (F/P/T) advice on consumption of wild game and fish
Chlordane	Pesticides used on crops	Contaminated plants	Food grown in contaminated soil (e.g., crops), fish and shellfish from contaminated water, birds, and mammals	*May cause:* • Headaches, nausea, vomiting, poor balance, tremors, and mental confusion	• Eat smaller and younger fish • Cook meat and fish using methods that allow the fat to drain (e.g., broil, bake, boil or grill the meat) • Any excess fat should be drained after cooking • Wash fruits and vegetables in clean water to remove most of the pesticide from the surface • Follow Federal Provincial Territorial (F/P/T) advice on consumption of wild game and fish

PERSISTENT ORGANIC POLLUTANTS (POPS)	Source	Associated foods for animals	Associated foods for humans	Effects in humans	Reducing Exposure
Toxaphene	Insecticide contaminated soil and air	Toxaphene contaminated food sources and water	Contaminated food products such as root vegetables, meat, grains, fish and shellfish from contaminated water bodies, and beluga whales	*Acute exposure may cause:* • damage to lungs, nervous system, and kidneys *In severe cases, may cause:* • death	• Eat smaller and younger fish • Cook meat and fish using methods that allow the fat to drain (e.g., broil, bake, boil or grill the meat) • Any excess fat should be drained after cooking • Wash fruits and vegetables in clean water to remove most of the pesticide from the surface • Follow Federal Provincial Territorial (F/P/T) advice on consumption of wild game and fish
Polychlorinated biphenyls (PCBs)	Capacitors, transformers, and hydraulic fluids.	Contaminated water and food crops grown in contaminated soil	Caribou, muskox, moose, beluga whale and seal (blubber), migrating birds, bald eagle eggs, fish (e.g., chinook salmon), and sea otters, meat, fish, dairy products, poultry, and eggs	*May cause:* • Skin conditions, liver, neurologic and gastrointestinal effects	• Visible fat should be removed from the animal prior to cooking • Cook meat and fish using methods that allow the fat to drain (e.g., broil, bake, boil or grill the meat) • Any excess fat should be drained after cooking • Follow Federal Provincial Territorial (F/P/T) advice on consumption of wild game and sport fish
Dioxins and Furans	Industrial processes (e.g., bleaching paper pulp, chemical and pesticide manufacture), combustion activities (e.g., forest fires and waste incineration), and treated wood (dioxins)		Herring, mackerel, salmon, sardines, trout, and tuna, meat, dairy products, poultry, and eggs	*May include:* • skin disorders (e.g., chloracne), liver problems, impaired immune and endocrine systems and reproductive functions, effects on the developing nervous system, and certain types of cancers	• Skin the fish prior to cooking. • Trim all visible fat from meat and fish • Cook meat and fish using methods that allow the fat to drain (e.g., broil, bake, boil or grill the meat) • Any excess fat should be drained after cooking • Follow Federal Provincial Territorial (F/P/T) advice on consumption of wild game and fish

to the bottom of rivers or lakes, where some can accumulate in fish.

PBDEs in humans

Primary sources of human exposure to PBDEs are through the consumption of contaminated foods such as the fatty tissues of meat and fish, dairy products, and food crops grown in contaminated soils. Low levels of PBDESs have also been found in breast milk (HC, 2004a). While there is limited information on the health effects of PBDEs in humans (ATSDR, 2002a), levels of PBDEs in foods consumed by Canadians are not considered to pose a risk to human health (HC, 2002; HC, 2004a).

PBDEs and wildlife

PBDEs accumulate in wildlife including birds (particularly marine species and in their eggs), marine mammals such as seals, dolphins, killer whales and seafood (FSA, 2006). In Canada, levels of PBDEs found in fish and seafood are low (HC, 2004a).

Perflourinated chemicals

Perfluorooctane sulfonic acid (PFOS) and perfluorooctanoic acid (PFOA) are both man-made chemicals that belong to a family of compounds known as perflourinated chemicals (PFCs). PFOS and PFOA are the most common PFCs, and are extremely persistent with bioaccumulating and biomagnifying properties (Stockholm Convention on POPs, 2008). PFCs are no longer used in Canada, but were used in the past:

- in water, stain, oil repellent for textiles, carpet, and food packaging,
- as a surfactant in the electroplating industry, and
- as an additive in fire-fighting foams.

PFCs can be found in the air, soil, and water after release from use and disposal of products that

contain these chemicals (ATSDR, 2009). PFCs do not break down in water or soil, and can be found and may be carried long distances by ocean currents, or through soil by ground water. Due to their persistence and widespread use, PFCs have been detected in low concentrations in the environment, in food and wildlife such as polar bears, and some bird species. The levels of PFCs present in some foods sold in Canada are said to be well below levels thought to cause adverse health effects (HC, 2008g).

PFOS/PFOA in humans

Exposure to PFOS/PFOA in humans may occur through the consumption of contaminated food or drinking water, or breathing contaminated air. PFOS/PFOA can stay in the body for many years (ATSDR, 2009). Exposure to certain PFCs, in particular PFOS and PFOA, has been associated with various adverse health effects in laboratory animals, including immune, liver and thyroid function. Research is ongoing to determine if the effects observed in laboratory animals are relevant to humans. Estimated dietary intakes of PFCs for Canadians estimated using data from Health Canada's Total Diet Study are less than doses associated with these adverse health effects in laboratory animals. Therefore, exposure to PFCs in food is not expected to pose a significant risk to human health (HC, 2009a).

Polycyclic aromatic hydrocarbons

Polycyclic aromatic hydrocarbons (PAHs) belong to a group of over 100 different chemicals that are released into the environment from different sources such as forest fires and the incomplete burning of coal, oil, gas, garbage and other organic substances such as tobacco. Anthropogenic PAHs are found in coal tar, crude oil, creosote and roofing tar, and a few are used in medicines, dyes, plastics, and pesticides (see Table 16) (ATSDR, 1996b).

When released into the environment, PAHs can readily break down over a period ranging from a few days to several weeks. Most PAHs do not dissolve in water and are found in the bottoms of rivers or lakes. Major sources of PAHs in aquatic and soil environments are creosote-treated products, spills of petroleum products and metallurgical and cooking plants.

PAHs in humans

Exposure in humans is through breathing contaminated air from cigarette smoke, wood smoke, vehicle exhaust, smoke from agricultural burns, water or soil near hazardous waste sites, and consumption of contaminated foods, such as meats and fish (from contaminated waters). PAHs can also be found in foods that have been grilled or charbroiled. The method of cooking, preservation, and storage of foods is a factor in PAH exposure. PAH exposure may cause lung cancer in humans (ATSDR, 1996b).

PAHs and wildlife

PAHs have been detected in wildlife and aquatic organisms. Most species of aquatic organisms accumulate PAHs in the fatty tissues; uptake is highly species specific, being higher in algae, molluscs, and other species which are incapable of metabolizing PAHs.

Radionuclides

Radionuclides are radioactive contaminants that occur naturally as trace elements in rocks and soils (such as polonium and uranium), or result from the deposition of airborne, man-made radionuclides (such as cesium and strontium) (ATSDR, 1999b). Radionuclides release energy in the form of radiation (INAC, 2010b). Examples of radionuclides include: cesium, polonium, strontium, and radium.

Cesium is a persistent man-made radionuclide that was released during nuclear weapons testing and by the Chernobyl nuclear accident. Levels of cesium in the environment have dropped since the 1960s, and are not considered a health risk to caribou or to the people who eat them.

Polonium is the most commonly found natural radionuclide and is known to build up in caribou when they eat lichen.

Uranium is also a natural radionuclide that can be found in increased levels as a result of uranium mining, and is found in both ground water and

surface water. Humans are exposed to uranium through ingestion of contaminated food or water.

Strontium is said to be the most important because of its long radiation half-life of 29 years. Strontium is found in the environment as a result of nuclear fallout during atmospheric weapons tests, and accumulates in bones and teeth.

Radium (includes Radium-226 and Radium-228) is found in small amounts in natural ground water.

Most radionuclides found in food sources are of natural origin. Factors that can lead to ingestion of radionuclides include:

- radioactively contaminated drinking water (e.g., polluted ground water)
- locally grown food plants that take up certain soil radioactivity
- use of radioactively contaminated water to irrigate crops
- local livestock operations, when radionuclides that accumulate in animal tissue are present
- consumption of fish with radioactivity from local bodies of water (USEPA, 2010a).

Plants and lichens absorb radionuclides through the soil and air. Plants that grow back every year (perennials) do not build up radionuclides. Lichens, however, live many years and therefore build up radionuclides over time (INAC, 2010b). Humans can be exposed to radionuclides through the consumption of contaminated foods, such as caribou, which feed on lichens (INAC, 2010b). Levels found in some species (e.g., fish, beluga whales and waterfowl) in the Northwest Territories are low. Exposure to radionuclides in traditional food is not considered to be a health concern (INAC, 2010b).

Table 16. Polycyclic aromatic hydrocarbons (PAHs), Polybrominated diphenyl ethers (PBDEs), Perflourinated chemicals (PFOS/PFOA), radionuclides and their effects

Contaminants	Source	Associated foods for humans	Effects in humans	Reducing Exposure
Polycyclic aromatic hydrocarbons (PAHs)	Forest fires, burning coal, coal tar, crude oil, spills from petroleum products, garbage, tobacco, creosote and creosote-treated products, roofing tar, medicines, dyes, plastics, pesticides, and charbroiled foods	Grilled or charred meat, milk, cereals, flour, bread, vegetables, fruits, and processed or pickled foods	*May cause:* lung cancer	• Reduce consumption of grilled or charred meats or fish and/or cut away any charred portions of food • Eat a variety of foods from different sources (*Refer to Canada's Food Guide or Eating Well with Canada's Food Guide - First Nations, Inuit and Métis*)
Polybrominated diphenyl ethers (PBDEs)	Flame retardants added to plastics and foam products	Meat, fish, dairy products, and food crops grown in contaminated soils	No information on health effects on people	• Eat a variety of foods from different sources. (Refer to *Canada's Food Guide or Eating Well with Canada's Food Guide - First Nations, Inuit and Métis)* • Trim fatty tissue from meat before cooking and employ cooking methods that allow the fat to drain
Perflourinated chemicals (PFOS/PFOA)	Disposal of products that contain perflourinated compounds	Polar bears, some bird species, and foods grown in contaminated soils	No significant risk to human health	• Eat a variety of foods from different sources (Refer to *Canada's Food Guide or Eating Well with Canada's Food Guide - First Nations, Inuit and Métis*)
Radionuclides	Naturally, through rocks or soils or man-made through testing of nuclear weapons, nuclear waste dumping, mining	Lichen, caribou, fish, beluga, and waterfowl	No effects at low levels	Eat a variety of foods from different sources

4.4 Contaminants in fish, wildlife and plants

Contaminants in the environment can bioaccumulate in certain animal species. Contaminants that are present in marine, freshwater, or terrestrial wildlife and plants vary depending on the characteristic of the contaminant and species. In some cases, contaminant levels are barely detectable, while in others, levels are higher, depending on the type of animal and its eating habits. Certain contaminants tend to be highest in animals that are at the top of the food chain, such as marine mammals. For example, the polar bear has contaminant levels that may be potentially harmful. Age, migration, feeding and reproduction characteristics also have an influence on contaminant levels (Sindermann, 1996).

Land mammals

The level of some metals found in land mammals vary from region to region and depend on the time of year and the age of the animal. Levels tend to be higher near local sources of contamination such as mining sites. The most common contaminant in land mammals is cadmium, which accumulates at relatively high concentrations in the liver and kidneys of older and larger animals. Organochlorines are also found in land mammals, but in lower amounts than in marine animals as land animals have less fat.

Marine wildlife

The levels of contaminants in marine mammals are usually higher than in land mammals, mainly because they are part of a longer and more complex food chain, have more fat, and in general, live longer than land mammals. In marine mammals, such as ringed seal, narwhal, walrus and beluga whales, mercury is found mostly in the organs, while POPs are found in the fatty tissues.

Fish accumulate contaminants mainly by eating foods that contain contaminants, and to a lesser extent, from contaminated water passing through their gills. For example, because of their feeding habits, predatory fish and freshwater fish have higher levels of organochlorines.

To avoid or reduce the intake of contaminants from food, it is better to:

- harvest younger animals and those that do not migrate or live near contaminated areas,
- trim visible fat from animals prior to cooking,
- prepare and cook foods such as meat and fish in ways that minimize exposure to fat, and
- cook meat and fish using methods that allow the fat to drain such as broiling, baking, boiling or grilling. Any excess fat should be drained after cooking (refer to Chapter 8 for more information on food preparation).

Plants

Generally, low levels of contaminants have been measured in plants, with the exception of those found in areas where pesticides have been sprayed. Most contaminants in plants are a result of contamination from the air, snow, rain, soil or dust. In addition, some contaminants have been measured in algae.

Summary

Fish, wildlife, and plants are a very good source of nutrients, but they can also be a source of contaminants for humans. Exposure varies among individuals, depending on the frequency and quantity of the food eaten as well as the concentration of contaminants in foods that are consumed.

Pregnant and nursing mothers, infants, and those with compromised immune systems are more susceptible to the adverse effects of contaminants.

Breast milk may also contain some levels of contaminants which can be transferred to the infant during breastfeeding. The benefits associated with the consumption of breast milk by infants outweigh the potential risks associated with low levels of exposure to some contaminants in breast milk. Breast milk is still the safest and most nutritious food for infants (PHAC, 2002).

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5. Hunting Game

Wild game provides a major source of nutrient intake such as vitamin A and C, calcium, iron, protein and fat. Wild game includes large game, small game, wild birds and waterfowl. The First Nations people greatly depend on the land for their food (e.g., such as caribou, moose, elk and deer, seal, duck, beaver and hare). Harvesting wild game begins with the preparation for the hunt, and ends with the transportation of the carcass to the campsite or home where it is cooked, preserved and stored.

While it accounts for an important part of the First Nations diet, wild game can be contaminated by bacteria, viruses, prions, parasites, (see Chapter 1), and some bacterial toxins (see Chapter 2) and contaminants (see Chapter 4). The proper handling of game meat, from the field to the table, is very important. Once the animal has been captured, there is an increased risk of contaminating the carcass, particularly the way it is handled, from the time it is caught to when it is processed/prepared.

5.1 Hunting large and small game

Appropriate tools are necessary to field dress animals quickly and safely. The types of tools needed for a hunt depend on the location, the distance between the hunting field and the home or campsite, and the type of animal that will be hunted. Some of the necessary items needed for a hunt are:

- gloves,
- sharp hunting knife,
- small hatchet or axe,
- whetstone (to sharpen the knife if necessary),
- bone saw, chainsaw (to cut wood),
- some rope or string (light or nylon) to hang the animal,
- plastic bags,
- clean cloths or paper towels,
- clean water,
- compass,
- cooler filled with ice,
- matches, and
- cheesecloth and ground pepper – to preserve the meat in warm weather (Clemson University, 2007a,b; Garden-Robinson & Marchello, 2003a ; New Hampshire Fish and Game Department, n.d.; Vermont Fish and Wildlife Department, 2009).

To minimize the risk of contaminating game in the field, the carcass needs to be handled properly during the following processes:

- Bleeding,
- Field dressing,
- Cooling, and
- Transportation.

Large Game

To kill game quickly, aim at the vital organs or neck area, ahead of the diaphragm which has the highest concentration of blood vessels, including the heart and lungs. Shooting behind the diaphragm to the liver and spleen will cause heavy bleeding but will not kill the animal immediately (Vermont Fish and Wildlife Department, 2009).

Caribou

Bleeding

- If the animal has been shot in the head, neck or spinal cord, bleed the animal (Garden-Robinson & Marchello, 2003b and Clemson University, 2007b),
- If the animal needs additional bleeding, field dress it first, and then cut the main artery next to the spine or sever the neck at its base (Clemson University, 2007b), and
- To drain the blood from the body cavity, hang the animal in the shade with its head or back legs up in a tree. If there are no trees in the area where the animal was killed, place logs or stones under the animal to keep it off the ground, thus avoiding contamination (Benson, 2003).

If the animal has been shot in the chest area or any major artery, it is not necessary to bleed it (Boren and Wright, 1998).

Field dressing

Field dressing is the process of removing the intestines and stomach of an animal as quickly as possible. To avoid spoilage, field dress the animal as soon as possible to reduce the chance of bacterial contamination. A carcass can be contaminated during field dressing with intestinal contents, hair (fur) in the meat, soil/dirt, and leaves (Vermont Fish and Wildlife Department, 2009). The meat and hide of animals, such as bear, with high fat content can spoil quickly at temperatures above freezing (Maryland Department of Natural Resources, 2010).

To avoid spoilage and contamination during field dressing, the animal should be taken to a shady area.

Process for field dressing

- Always wear gloves to handle the carcass,
- Always use a clean sharp knife,
- Place the animal on its back, its head slightly uphill, with its front legs elevated and back legs spread open,
- Keep the animal in position by placing rocks or sticks on both sides,
- Starting at the hind legs, cut down through the leg muscles to the skin over the pelvic bone,
- Avoid puncturing the intestines or other organs by pressing on the entrails with two fingers with one hand, and with the other hand, use a knife with the blade turned upwards to cut through the hide from the pelvis to the breastbone (the contents can contaminate the meat),
- Sever the windpipe and oesophagus as close to the head as possible,
- Tie the oesophagus with a string to protect the meat from contamination from the stomach's contents,
- Cut the skin and muscle around the anus (7-10 cm (3-4 inches) from anus) and tie it off with a string,
- Cut down to the pelvic bone between the back legs,
- Cut the diaphragm to separate the heart and lungs from the stomach and away from the ribs. Be careful not to puncture the stomach or intestines, as their contents may spill over and contaminate the meat,
- Pull the intestines and stomach (which may contain bacteria and parasites) out of the body cavity,
- Remove the remaining organs (lungs, heart and liver) and place them in a plastic bag on ice (Benson, 2003; Boren & Wright, 1998; Clemson University, 2007b; New Hampshire Fish and Game Department, n.d.; Reynolds & Hristian, n.d.; Vermont Fish and Wildlife Department, 2009), and
- Trim any shot damaged tissue.

After the animal has been field dressed, it is recommended that all remaining blood be drained. Keep the carcass clean by using the following methods:

- Remove all foreign particles (e.g., dirt and leaves), blood and loose hair on the carcass,
- Use clean paper towels or cloth and clean water to wipe out excess blood in the gutted cavity and dry the carcass. Do not use grass or snow to wipe out the carcass as they may cause contamination. Use as little water as possible to wipe out blood so as not to dampen the meat and spoil it, and

- Hang the carcass in the shade and allow air to circulate around the body by propping the chest open with some sticks (Clemson University, 2007b; Garden-Robinson & Marchello, 2003a; New Hampshire Fish and Game Department, n.d.).

Cooling the Carcass

Once the field dressing has been completed, the carcass should be cooled and kept cool.

Cooling is the process of bringing the animal's body heat down. Cooling a carcass is important to prevent bacterial growth. Cooling starts from the time the animal is bled and continues throughout the time required to transport the carcass home.

To accelerate the cooling process:

- Prop the chest open to allow air to circulate
- Fill up the body cavity with bags of ice, or hang the carcass in the shade to allow fresh air to circulate around it,
- Cut the carcass into halves, quarters, or smaller pieces,
- Store pieces of the carcass in clean cloth bags (avoid putting too many pieces into one bag),
- Refrigerate the meat within 3 to 4 hours if the hunt is carried out in warm temperatures (10°C/50°F or warmer), and
- Wrap the whole carcass or quarters in a sheet (e.g., cheesecloth or light cotton bags) if the hunt is carried out in cool weather (-2°C to 2°C/28°F to 35°F), and hang to chill in a ventilated area to keep flies and other egg-laying insects away (Boren & Wright, 1998; Clemson University, 2007b; Garden-Robinson & Marchello 2003a).

In warm weather, the animal can be cooled off faster by skinning the carcass. To skin the carcass hang it first by its hind legs (by making an opening between the tendon and hock) or head. Cut the skin around the neck below the head and around each leg above the hoof, then up the inside of each leg to the middle near the pelvic bone. Separate the hide from the carcass working from top to bottom. While the fur can protect the carcass, it may also prevent the animal from cooling properly especially during warm temperatures. Skin the animal only if the appropriate tools are available. Keep dressed game cool (below 4°C/40°F) until the carcass is ready to be cooked or frozen.

Preparing the carcass for transportation

It is difficult to transport a whole carcass from the hunting site to the camp or home. To facilitate transportation, the carcass can be cut into quarters, halves or smaller pieces.

To cut a carcass:

- Hang it by its hocks or hock tendons,
- Cut lengthwise along the backbone from the tail to the neck, or chop with a cleaver or axe,
- Keep halves well spread to allow air to circulate,
- Cut between the last two ribs and through the backbone to divide halves into quarters,
- Remove the loins, located at the back between the upright vertebra and down-turned ribs,
- Trim fat and inedible parts from the carcass,
- Trim loose tissue and cut the long sausage-shaped piece into small pieces,
- Remove all flesh from bones by following the natural layer of muscles (if necessary), and
- Place pieces of meat in a clean cloth bag (Clemson University, 2007a,b).

Transporting the carcass

- During transportation, the carcass has to be kept cool until it reaches its final destination,
- If the game is to be dragged from the hunting site, leave the hide on,
- If the game has been skinned, cover the carcass to prevent contamination,
- Place the carcass in the back of a pickup truck or tie it to the roof of a car where there will be adequate air circulation,
- Do not place the carcass on the hood (where it would be heated by the engine) or in the trunk of a vehicle (does not provide good air circulation), and

- Use cheesecloth or pillowcases, which allow better air circulation and protect the carcass from dirt and moisture. Plastic tarps or canvas bags retain heat and moisture, which can spoil the meat (Clemson University, 2007b; Garden-Robinson & Marchello, 2003a,b; New Hampshire Fish and Game Department, n.d.; OHEP, 2010; Vermont Fish and Wildlife Department, 2009).

Small Game

Dress and cool small game (e.g., rabbits, beavers, hares, squirrels, muskrats) immediately after it has been killed.

To field dress the carcass:

- Wear gloves when handling the carcass,
- Use a clean sharp knife,
- Cut from the breastbone to the belly,
- Separate the shoulders, keeping the muscle intact,
- Cut and remove the loin,
- Remove the back leg (at the hock joint), the tail and forelegs (at the knee joints),
- Skin the animal from the rear leg to the base of the tail and continue to cut the skin up to the rear of the suspended leg,
- Pull the edges of the hide away from the flesh and down over the carcass, and
- Wrap the carcass and place it on ice in a cooler for transportation (College of Agricultural Sciences Agricultural Research and Cooperative Extension, 2000).

Some small game, such as muskrat can carry the infectious disease Tularemia and transmit it to humans. While dressing these animals, it is recommended to wear gloves and clean the knife with soap and water between cuts. Ensure that the meat is cooked thoroughly to avoid foodborne infection in humans.

Wild Birds and waterfowl

Wear gloves to handle wild birds, especially waterfowl which can be carriers of influenza viruses - though not transmissible through the consumption of the meat (PHAC, 2006). To facilitate cooling and avoid spoilage, field dress birds as soon as possible by removing the crop and intestines. To avoid contamination of wild birds and waterfowl in the field, carcasses need to be handled safely by following proper field dressing, cooling and transportation.

Mallard ducks: Photo by AFN

Field dressing

The following procedures are necessary to field dress and cool the carcass safely:

- Pluck the birds in the field or at the campsite,
- Remove the crop and intestines, and other organs to avoid fermentation and contamination,
- Use a clean cloth or paper towel to wipe out the body cavity. Do not use grass or snow, as they can contaminate the carcass,
- Cool the carcass quickly in order to retain the flavour,
- Hang or lay the bird in a well-ventilated place to allow the air to circulate in the carcass (especially in hot weather), and
- During hot weather, put the carcass and organs in plastic bags and place on ice in a cooler that is kept out of direct sunlight (Clemson University, 2007a).

Transportation

It is important that the carcass stays cool during transportation by keeping it in a cooler filled with ice. If access to a cooler is not possible, put the carcass in a plastic bag and transport it in a well-ventilated vehicle. The carcass should not be placed in the trunk, as it does not allow good air circulation. To facilitate cooling and avoid spoilage, it is important not to pack carcasses together. Maintain a temperature of 4°C/40°F or less during transportation (Clemson University, 2007a; College of Agricultural Sciences Agricultural Research and Cooperative Extension, n.d.).

Once the meat is transported home, ensure that it is properly cooked, refrigerated or safely preserved for future consumption (if it is not all going to be consumed on the same day).

5.2 Diseases found in game

During hunting, it is important for the hunter to pay attention to the animal's appearance and behaviour in order to identify animals that may be infected by pathogens such as bacteria (see Table 18). Hunters should remember to wear gloves when handling wild animals that appear sick or act abnormally.

Diseases can be spread not only through the consumption of an infected animal, but also during the handling (skin contact) of infected carcasses (see Table 18).

There is also growing concern of a prion disease affecting some wild game (e.g., elk, deer and moose) called Chronic Wasting Disease (CWD). CWD is the only known form of animal Transmissible Spongiform Encephalopathies (TSE) that exists in the wild (WHO, 2010). CWD is a progressive, fatal disease of the nervous system. The prions (abnormal proteins) that are responsible for causing CWD in animals can accumulate only in the brain, eyes, spinal cord, lymph nodes, tonsils, pancreas, spleen, and muscle tissue (Angers et al, 2006).

During hunting, it is important that hunters identify animals displaying CWD symptoms, and take the necessary precautions when handling and transporting infected carcasses (see Table 17).

Table 17. Animal prion disease

DISEASE	Symptoms in animals	Symptoms in humans	Associated animals	Safe handling practices
Chronic Wasting Disease (CWD)	May include: Depression, difficulty, swallowing, excess salivation, increased thirst, lack of coordination, paralysis, pneumonia, separation from the other animals in the herd, unusual behaviour, excessive urination, and emaciation	No evidence of human infection to date	White-tailed deer, black-tailed deer, mule deer, moose, and elk	• Do not shoot, handle or consume any wild animal that appears sick, or acts abnormally • Wear gloves when field dressing and processing animals • Avoid handling brain or spinal tissues and fluids • Wash hands thoroughly after handling or dressing game • Use a 50/50 solution of household chlorine bleach and water to disinfect tools and work surfaces • Do not consume the meat from any animal that shows signs or tested positive for CWD

If you suspect that an animal is displaying some, or all of the physical signs of Chronic Wasting Disease, follow the suggested safe handling practices and report this information to the Ministry of Natural Resources or send the head of the carcass for analysis.

To date, there is no evidence that CWD infected animals can transmit this disease to humans, neither is there enough evidence that such transmissions could not occur (Garden-Robinson & Marchello, 2003a). For this reason, it is recommended that meat from animals known or suspected to be infected not be consumed.

Table 18. Diseases caused by improper handling of infected wild game

Bacterial infections

BACTERIA	Disease	Symptoms in animals	Symptoms in humans	Incubation period	Associated animals
Leptospira spp	Leptospirosis		*In the first phase may experience:* Fever, headache, muscle aches, stomach ache, vomiting, diarrhea, and red eyes *In the second phase may experience:* Rash, meningitis, yellow skin and eyes, bleeding, or kidney failure *If left untreated, may experience:* Kidney damage, meningitis, liver failure, and breathing problems. In rare cases, death can occur	Usually within 10 days after eating contaminated foods or drinking contaminated water	Deer and rodents such as beaver and raccoon, and other foods contaminated with the urine of infected rats
Preventive measures	• Purchase/obtain food from a reliable source • Ensure good hygiene practices: - avoid handling of food when ill, - wash hands frequently in warm soapy water while handling foods, - wash hands before and after handling food, changing diapers, using the washroom, and cleaning after pets • Prevent cross-contamination - always use clean utensils to prepare and serve food, - clean and sanitize surfaces used to prepare and serve food, and - store foods properly • Use clean water when preparing food • Cook foods to proper internal temperatures • Wear disposable gloves to handle rodents, raccoons, and beavers • Wash hands after handling infected animals Clean cuts or wounds with soap and water				
Francisella tularensis	Tularemia	*May cause:* • swelling or ulceration and enlarged lymph nodes, and tiny pale spots and thin white strands on the organs (e.g., liver, spleen or lung)	*May experience:* ulcers on the skin or mouth, swollen glands and painful lymph glands, fever, chills, fatigue, headache, nausea, diarrhea, vomiting, muscle aches, abdominal pain, dry cough, sore throat, progressive weakness, joint pain, swollen and painful eyes, and respiratory difficulties	Usually within 3 to 5 days (or up to 14 days) after eating contaminated foods	Muskrats, ground squirrels, beavers, hare, and cottontail rabbits
Preventive measures	• Purchase/obtain food from a reliable source • Ensure good hygiene practices: - avoid handling of food when ill, - wash hands frequently in warm soapy water while handling foods, - wash hands before and after handling food, changing diapers, using the washroom, and cleaning after pets • Prevent cross-contamination - always use clean utensils to prepare and serve food, - clean and sanitize surfaces used to prepare and serve food, and - store foods properly • Use clean water when preparing food • Cook foods to proper internal temperatures • Wear gloves when handling infected animals • Wash hands after handling wild animals • Do not eat animals with white spots on the liver, spleen or kidneys • Cook beaver, hare, rabbits, and rodents thoroughly • Cook bear meat to an internal temperature of 77°C/170°F				
Bacillus anthracis	Anthrax	Infected animals may appear distressed, weak, have difficulty breathing, stop eating and drinking, develop swelling under the jaw or lower abdomen, and have normal or elevated temperature The infected carcass may bloat and decompose quickly, may also leak bloody discharge from the mouth, nose, and anus	The disease can manifest itself in 3 forms: 1) Cutaneous: a small painless bump on the skin which becomes a blister and then an ulcer with a black centre 2) Gastrointestinal: fever, loss of appetite, vomiting, and diarrhea 3) Pulmonary: Resembles the flu and includes fever, sore throat and general feeling of unwellness, shortness of breath, chest pain, and difficulty breathing	Usually within 1 to 7 days after exposure/ ingestion	Wood bison, white-tailed deer, elk, caribou, moose, bobcat, cougar, raccoon, and mink
Preventive measures	• Do not eat infected animals • Do not handle carcasses of infected animals				

Viral Infection

VIRUSES	Disease	Symptoms in animals	Symptoms in humans	Incubation period	Associated animals
Parapox-virus	Orf infection	*May develop:* • single or multiple crusty lumps on their lips, and lesions on the face, inside the mouth, the udder and above the hooves of wild sheep and goats	*May experience:* • red skin, lesions on the hands, arms and face, swollen and painful lymph nodes, and mild fever		Direct contact with infected deer, sheep, goat and cattle
Preventive measures	• Purchase/obtain food from a reliable source • Ensure good hygiene practices: - avoid handling of food when ill, - wash hands frequently in warm soapy water while handling foods, - wash hands before and after handling food, changing diapers, using the washroom, and cleaning after pets • Prevent cross-contamination - always use clean utensils to prepare and serve food, - clean and sanitize surfaces used to prepare and serve food, and - store foods properly • Use clean water when preparing food • Cook foods to proper internal temperatures • Do not touch sick animals with bare hands • Wear disposable gloves to handle infected animals • Trim away affected tissue Avoid contact between affected tissues and the rest of the meat				

Parasitic Infection

PARASITE	Disease	Symptoms in animals	Symptoms in humans	Incubation period	Associated animals
Toxoplasma gondii (protozoal)	Toxoplasmosis	Cysts in the muscle and nervous tissues, lungs, liver, and kidneys	May experience: • light fever, enlarged lymph nodes, and other flu-like symptoms (tender lymph nodes, muscle aches) *People with weakened immune system may develop:* • encephalitis, pneumonia or other life-threatening conditions *Pregnant women may experience:* • miscarriage, stillborn child or a child born with signs of toxoplasmosis (e.g., abnormal enlargement or smallness of the head) *Infants born with congenital toxoplasmosis may develop:* • mental retardation, eye, liver or brain diseases, or potential vision loss, mental disability, and seizures	Usually within 5 to 18 days after exposure	Fruits and vegetables (usually contaminated with cat faeces), sheep, pigs and rabbits, bears (more common in black bears) deer (e.g., white-tailed deer), moose, bison, venison, cougar, pronghorn antelope, red fox, caribou, muskoxen, skunk, opossum, mink, and marine animals such as harbour seals, hooded seals, bearded seals, ringed seals, grey seals, Pacific walruses, and sea otters
Preventive measures	• Purchase/obtain food from a reliable source • Ensure good hygiene practices: - avoid handling of food when ill, - wash hands frequently in warm soapy water while handling foods, - wash hands before and after handling food, changing diapers, using the washroom, and cleaning after pets • Prevent cross-contamination - always use clean utensils to prepare and serve food, - clean and sanitize surfaces used to prepare and serve food, and - store foods properly • Use clean water when preparing food • Cook foods to proper internal temperatures • Do not eat or sample uncooked or undercooked meat • Freeze meat at proper temperatures -18°C/0°F • Wash hands before and after handling raw meat and poultry • Wash all fruits and vegetables thoroughly				

Typical signs of sickness

Signs to look for in a sick animal are:

- Poor physical condition (e.g., weak, sluggish, including weight loss),
- Swellings or lumps,
- Hair loss,
- Blood, or discharges from the nose or mouth, and
- Abnormal behaviour – loss of fear of people, aggressiveness (see Table 19).

Table 19. Summary of diseases and abnormalities in game and wild birds

Bacteria

ORGANISMS	Disease	Visible signs	Animals	Is the meat edible?
Bacillus anthracis	**Anthrax**	Infected animals may appear distressed, weak, have difficulty breathing, stop eating and drinking, develop swelling under the jaw or lower abdomen, and have normal or elevated temperature The infected carcass may bloat and decompose quickly, may also leak bloody discharge from the mouth, nose, and anus	Wood bison, white-tailed deer, moose, bobcat, cougar, raccoon, mink, elk, and caribou	Meat is NOT safe to eat
Brucella	**Brucellosis**	Land mammals: Swollen leg joints (especially the front) causing limping, pus-filled swellings under the skin, in the meat, or the internal organs, and swollen testicles or womb Marine mammals do not usually show any external signs Internal signs are: Abscesses (filled with pus) in muktuk and reproductive organs	Land animals: Bison, elk, equid, caribou, reindeer, muskox, deer, moose, goat, wolves, fox, wild pigs, and cattle Marine animals: whale, sea lions, walrus, beluga, ringed and harp seals, and narwhal	√ Yes. Meat is safe to eat if cooked to recommended temperatures Freezing, smoking, drying and pickling do not kill the bacteria
Francisella tularensis	**Tularemia**	Tiny pale spots and thin white strands on the organs (e.g., liver, spleen or lung)	Wild animals: rodents, ground squirrels, muskrats, beavers, cottontail rabbits, hare rabbits, and muskrats	√ Yes. Trim off infected section Meat is safe to eat if cooked to recommended temperature
Salmonella	**Salmonellosis**	*Mammals may have:* lesions, bloody and inflamed intestines, enlargement of the spleen and lymph nodes or fluid and blood in organs (e.g., lungs), and liver damage *Birds may experience:* lesions, depression (may huddle together with ruffled feathers), unsteadiness, shivering, loss of appetite, increased or decreased thirst, rapid loss of weight, accelerated breathing, green or blood-tinged droppings, and closing of the eyes with swollen and pasted eyelids shortly before death. Feathers around the vent may become matted with faeces, enlarged liver and spleen, inflammation and haemorrhage of the intestinal tract, and thickening of the inner surface of the crop into a yellow, cheese-like membrane *If the nervous system is affected may experience:* blindness, incoordination, staggering, tremors, and convulsions	Wild/domestic mammals and birds (e.g., ducks, geese), fish (including eggs), shrimp, reptiles, food kept at room temperature for too long, and eggs (of chicken, goose)	√ Yes. Safe to eat if cooked to recommended temperatures

Parasites

ORGANISMS	Disease	Visible signs	Animals	Is the meat edible?
Anisakis simplex	**Anisakiasis**	Roundworm (nematode) in the gut of flesh/muscle	Fish (e.g., cod, haddock, flounder, halibut, salmon, pacific salmon, belly flaps, and monkfish), whales, dolphins, and squid, polar and grizzly bear	√ Yes. Meat is safe to eat if cooked to recommended temperatures
Echinococcus granulosus and E. multilocularis	**Echinococcosis, (also known as Hydatid disease or hydatidosis)**	Large fluid-filled cysts in the lungs or liver	Moose, caribou, elk, bighorn, fox, coyotes, muskrat, voles, and raccoon	√ Yes. Remove cysts before eating the meat Organs with cysts are not safe to eat
Fascioloides magna	**Liver fluke**	No external signs Internal signs: liver may be swollen and lumpy, purple-grey flat oval shaped worms (flukes)	Moose, elk, white-tailed deer, mule deer, caribou, and aquatic snails	√ Yes. Meat is safe to eat but NOT the infected liver
Taenia Ovis krabbei	**Taeniasis**	Tissue damage and loss of body condition in infected herbivores. Most infections are found during the butchering of animals	Wolves, coyotes, cougars, bears, cervids, caribou, and elk	√ Yes. Meat is safe to eat if it is cooked at proper temperature or frozen properly
Toxoplasma gondii	**Toxoplasmosis**	Cysts in the muscle and nervous tissues, lungs, liver, and kidneys	*Land animals:* rabbits, bears (more common in black bears) deer (e.g., white-tailed deer), moose, bison, caribou, muskoxen, cougar, pronghorn antelope, red fox, skunk, opossum, and mink *Marine animals:* harbour seals, hooded seals, bearded seals, ringed seals, grey seals, Pacific walruses, and sea otters	√ Yes. Meat is safe to eat if cooked to proper temperature (at least 67°C/153°F)
Trichinella nativa and spiralis	**Trichinellosis or Trichinosis**	*Muscle infection:* muscle pain, oedema (accumulation of fluids), fever, and cysts *Infection of the intestines:* haemorrhage	walrus, seal, cougar and bear (e.g., polar, grizzly, black and brown bears) rodents and mustelids , polar and red fox, wolf, wolverine, and lynx	√ Yes. Meat is safe if cooked to proper temperature

Viruses

ORGANISMS	Disease	Visible signs	Animals	Is the meat edible?
Avian influenza (viruses)	**Bird flu**	Haemorrhages on the hock, quietness and extreme depression, swelling of the skin under the eyes, and wattles and combs become swollen and congested	Chicken, turkey, quail, guinea fowl, wild birds, and wild waterfowl. Less common in mammals	√ Yes. Safe to eat if cooked to recommended temperatures
Papillo-mavirus	**Papillomavirus**	Hairless growth on skin, often found around the eyes, neck and sometimes on the body or legs	Mammals such as deer, elk and moose	√ Yes. Safe to eat after affected areas are trimmed off and meat is cooked properly to recommended temperatures
Parapox-virus	**Orf**	*May develop:* single or multiple crusty lumps on their lips, and lesions on the face, inside the mouth, the udder and above the hooves	Sheep (e.g., bighorn sheep) and mountain goats	√ Yes. Meat is safe to eat after affected parts are trimmed off or removed

Cont'd **Table 19.** **Summary of diseases and abnormalities in game and wild birds**

Viruses

ORGANISMS	Disease	Visible signs	Animals	Is the meat edible?
Rhabdo-viridae	Rabies	Unusual behaviour, weakness and excess saliva	Any mammals	Do not eat meat from animals suspected to have rabies

Fungi

ORGANISMS	Disease	Visible signs	Animals	Is the meat edible?
Aspergillus (e.g., A. fumigatus)	Aspergillosis	*May include :* depression, polyuria, diarrhea, anorexia, cyanosis, dyspnea, and open beak breathing	Waterfowl, ravens, and crows	Not safe to eat, discard infected birds as inhaling spores from air sacs and lungs while handling infected birds may cause disease in humans

Summary

To preserve the quality of game meat:

- Wash all utensils used to handle game in warm soapy water and rinse well,
- Wash hands before and after handling game,
- Trim fat and inedible parts from the carcass (contaminants are stored in the fat),
- Place the meat in clean plastic storage bags and refrigerate if it will be used within 2 to 3 days,
- Make sure game meat is thoroughly cooked before consumption,
- Wear gloves when handling any carcass that shows signs of spoilage,
- Never handle or eat animals that have died from unknown causes.

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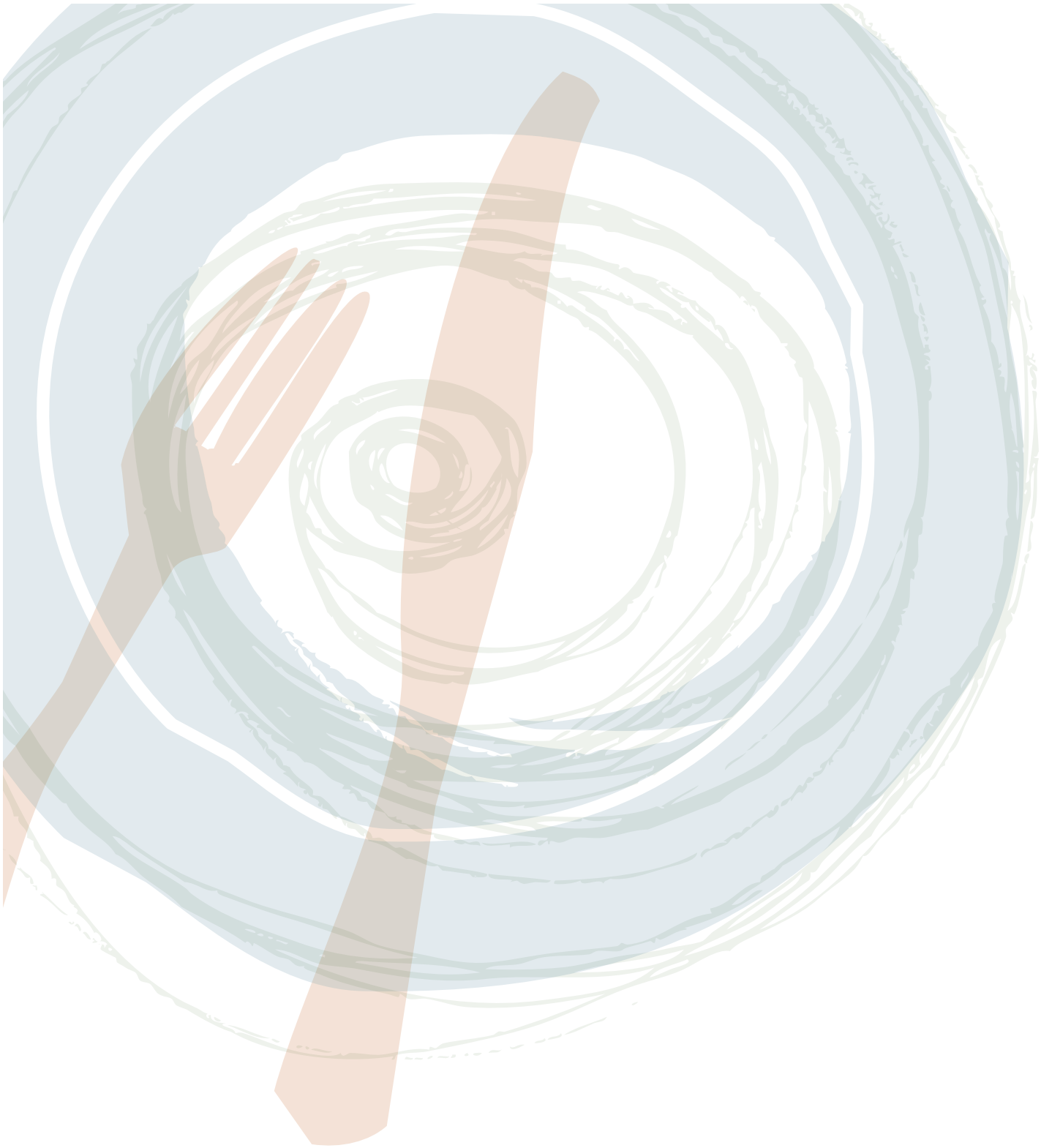

6. Harvesting Fish and Shellfish

Fish and shellfish are culturally important to First Nations people, and are an important part of their diet. They are an excellent source of nutrition, and provide an important source of protein, iron, B vitamins, and omega-3 fatty acids; they are also low in saturated fats and cholesterol (HC, 2008). The regular consumption of fish has also been associated with reduced risk of death from coronary heart disease.

While fish and shellfish are an important source of nutrition, environmental contaminants, toxins and harmful microorganisms may be present, and can pose certain health risks to humans. Because of its beneficial qualities, it is recommended that fish not be excluded from the diet but instead to reduce the consumption of fish that have been identified as having some levels of contaminants (HC, 2008). To avoid possible microbial growth that may cause toxin production and contamination, proper handling and preparation is necessary.

Salmon

6.1 Environmental contaminants in fish

Environmental contamination has affected, and continues to affect living marine resources, especially those species that inhabit the vulnerable coastal/estuarine zones (Sindermann, 1996).

Fish and shellfish can be a source of human exposure to various contaminants such as PCBs, dioxins and mercury. Fish accumulate contaminants mainly by eating contaminated foods. These contaminants are present at low levels in fresh waters and oceans, but bioconcentrate in the aquatic food chain, such that levels are generally highest in older and larger predatory fish and marine mammals.

The contaminant levels in fish vary, depending on the species, body of water the fish are from, and the size of fish. Different parts of the fish also contain different levels of contaminants. For example, POPs tend to accumulate in the fatty tissues of fish.

Effects of environmental contaminants in fish and marine mammals

Fish harvested from contaminated waters may contain varying amounts of industrial chemicals and pesticides which accumulate in fish at levels that could pose potential health risks to humans if consumed. These pesticides and other industrial chemicals can also be harmful to fish, shellfish, and aquatic plants.

The effects of pollution on marine animals vary and include:

- Reduction in the abundance of species,
- Suppression of the immune response in fish, thus increasing exposure of disease in fish,
- Slowed growth, and
- Developmental abnormalities (Sindermann, 1996).

Contaminants of concern in fish, shellfish, and marine mammals are those that are persistent, bioaccumulative, and toxic (also referred to as PBTs). PBTs are long-lasting substances that can build up in the food chain to levels that could be harmful to human health and the ecosystem. PBTs of concern include metals, such as mercury and lead and industrial chemicals such as polychlorinated biphenyls (PCBs) and dichloro-diphenyl-trichloro-ethane (DDT) (USEPA, 2010b). PCBs and mercury have long half-lives in the body and can accumulate in people who consume contaminated fish

frequently (Vermont Department of Environmental Conservation, 2010).

These contaminants are found in fish harvested from fresh water, estuaries, and near-shore coastal waters that are exposed to discharges, spills or run-off of industrial or agricultural waste chemicals, and pesticides. Rain can also wash contaminants from the land or air into the waters, where they are taken in by fish. Smaller and younger fish tend to contain lower concentrations of chemical contaminants than larger and older fish, such as lake trout, salmon, walleye, and bass.

Chemical contaminants in fish

Fish absorb PCBs from water, suspended sediments, and their food. In contaminated areas, fish that inhabit lower levels of the water column are more likely to have high levels of PCBs which normally settle to the bottom. PCBs bioaccumulate up the food web; older and bigger fish have higher concentrations than the younger and smaller ones (Virginia Department of Health, 2008).

Dioxins and PCBs accumulate in fat tissues and are found mainly in fatty fish and fish that live in fresh or coastal waters (e.g., striped bass, bluefish, lake trout and farmed Atlantic salmon). Once in the fish, these chemicals concentrate in the skin, organs and fatty tissues.

Perfluorinated chemicals such as perfluorooctane sulfonate or perflorooctanyl sulfonate (PFOS) have been detected in the environment and in organisms. PFOS is a persistent chemical and may bioaccumulate in certain living organisms.

DDT is also toxic to fish, and may cause disruption of normal hormone function affecting reproduction and development. Smaller fish are more susceptible than larger ones of the same species (ATSDR, 2002; USEPA, 2010a).

Mercury is found in the muscle of older predatory fish (e.g., shark, swordfish, king mackerel and tilefish). It accumulates in the lean tissue of fish, and cannot be removed by cleaning or cooking.

High-risk individuals

The low levels of exposure to contaminants in certain types of fish do not pose a safety concern to most fish consumers. However, the consumption of contaminated fish and shellfish are of particular concern to vulnerable populations, such as pregnant and nursing women, young children, and those with compromised immune systems. Developing foetuses and young children are more sensitive to the harmful health effects of contaminants such as mercury. For example, even in low amounts, mercury can cause learning problems in infants and children, while high levels can damage the nervous system. Consequently, women in their childbearing years should be aware of the risks associated with the consumption of foods with high level of contaminants (WHO, 2007). Consumption advice is available regarding the type of fish that is safe to eat, fish that should be eaten only in small amounts, and fish that should be avoided (HC, 2008). Sport fish consumption advice is available from local environmental health officers and many provincial and territorial governments.

Considerations for eating fish

When making choices on the fish you eat, keep in mind the following:

Size of fish

- Eat smaller fish; older and bigger fish tend to accumulate more contaminants in their bodies.

Consumption

- Eat a variety of different types of fish (species) from different water bodies.

Cooking

- Trim fat from the fish prior to cooking to reduce the amount of contaminants that may be present (MDH, 2009), and
- Prepare and cook foods such as meat and fish in ways that minimize exposure to fat.
  - For example, cook meat and fish using methods that allow the fat to drain such as broiling, baking, boiling or grilling the meat or fish. Any excess fat should be drained after cooking.

Water source

- Do not eat fish that are from waters known to have high levels of contaminants, and
- Follow any local, provincial, and territorial sport fish consumption advisories.

Biological hazards in fish

Fish from polluted waters are subject to an increased prevalence of diseases and infections. Some of these diseases can be transmitted to humans depending on several factors such as: type of microorganisms, susceptibility of the host, and environmental factors (SNSW, 2005). Some diseases that may be present in fish are caused by parasites, bacteria and viruses.

Parasitic diseases

Several parasites can infect humans as non-traditional hosts, and may enter humans when raw or undercooked infected fish is consumed. Infection can be caused by trematodes and nematodes. Clinical signs can include gastrointestinal, muscular aches and neurological disorders (NSW, n.d).

Fish from inland and coastal areas, haul out locations, and rookeries, often sustain heavier infections of parasites in their flesh. Parasites are common in fish and may cause illness in humans if eaten raw, undercooked, or lightly preserved (see Table 21). Fish is very delicate, and as a result, proper care and handling is important in reducing the risk of foodborne illnesses.

Parasitic diseases in fish are caused by small microorganisms or protozoa, which live in the aquatic environment. Protozoal parasites are usually found in the gills, and skin of fish, causing irritation, weight loss, and death. Harmful algae may also accumulate in shellfish (see Table 5, Chapter 2) (SNSW, 2005).

Some parasites (worms or cysts) found in the flesh of fish are considered safe to eat, provided the fish is cleaned well, thoroughly frozen and then cooked before eating.

Factors to consider when harvesting fish:

1. The type and size of fish harvested; parasites accumulate over time, therefore the size and age of the fish can be associated with the number of parasites present,
2. The feeding habits, and
3. The environment of the species selected.

Fish-borne parasites of human health concern include flukes, roundworms and tapeworms. More than 50 species of helminth parasites from fish and shellfish are known to cause diseases in humans. Most are rare and involve only slight to moderate injury but some pose serious potential health risks. Those typically found in Canada are (FAO, 2003):

Flukes or Trematodes *(Heterophyes spp., Nanophytes salmincola, and Paragonimus spp.)* are of most concern in seafood. Most of these parasites cause mild-to-moderate illness, though severe symptoms may occur (USDA, 2008). Flukes are found in the cysts of the flesh or internal organs, and are responsible for a variety of parasitic diseases, some of which are transmitted through the consumption of raw or undercooked contaminated fish and shellfish. Intestinal flukes *(Heterophyes spp., Metagonimus spp., and Nanophyetes salmincola)* may cause abdominal discomfort and diarrhea. Some intestinal flukes may also migrate to, and damage the heart and central nervous system. Liver flukes *(C.sinensis and Opisthorchis spp.)* and lung flukes *(Paragonimus spp)* may migrate to the liver and lung and sometimes cause serious problems in other vital organs (FAO, 2003; USDA, 2008).

Roundworm or Nematodes - While there are many species, *Anisakis* spp., and *Gnathostoma* spp., and *Angiostrongylus* spp., are the most common species found throughout the world (FAO, 2003). Roundworms may stick in the intestinal wall, causing nausea, vomiting, diarrhea and severe abdominal pain (FAO, 2003).

Anisakiasis – or herring-worm disease, results from the consumption of raw or undercooked seafood containing the Anisakis larvae. Anisakiasis in humans causes severe gastric and intestinal pain, vomiting and diarrhea. Symptoms usually subside in a few days, though abdominal pains may persist for weeks (CDC, 2011).

Gnathostoma – People become infected with *Gnathostoma* spp. by eating undercooked and raw infected freshwater fish. When contaminated fish is consumed, the *Gnathostoma* spp., parasite, moves through the wall of the stomach or intestine and liver. Symptoms are not common in the early phase though an individual may experience fever, excess tiredness, lack of appetite, nausea, vomiting, diarrhea, or abdominal pain for 2 or 3 weeks. If the parasite moves under the skin, people may experience swellings under the skin that may be painful, red, or itchy within 3 to 4 weeks after ingestion of the parasite, but can occur up to around 10 years after infection. These swellings typically last several weeks at a time and may move around the body. The Gnathostoma spp., parasite may also enter other parts of the body, and may result in the following: vision loss or blindness; severe nerve pain, followed by paralysis of the muscle controlled by the affected nerve; and headache, decreased consciousness, coma, and death (CDC, 2011).

Tapeworm or Cestodes (*Diphyllobothrium* spp) form cysts on or in the internal organs, or body cavity of fish.

The species of major concern associated with the consumption of fish are *Diphyllobothrium* spp, and *D. latun*. The Diphyllobothrium species occur in fresh water fish in the lakes of the northern hemisphere (subarctic) as well as in temperate zones, and causes human infection if fish is eaten raw, lightly marinated or undercooked. People infected with a few worms may not show any symptoms. Heavy *Diphyllobothrium latum* infection may cause abdominal discomfort, nausea, loss of appetite and weight loss which may lead to malnutrition, and anemia (FAO, 2003; CDC, 2011).

Controlling parasites in fish

Some parasites (worms or cysts) found in the flesh of fish are considered safe to eat, provided the fish is cleaned well, thoroughly frozen and then cooked before eating. Freezing fish to kill parasites depends on several factors such as: freezing temperature, length of time needed to freeze the fish tissue, the length of time fish is held frozen, and the type of parasite in the fish (USDA, 2011). Tapeworms are more susceptible to freezing than roundworm, while flukes appear to be more resistant to freezing than roundworms.

To avoid foodborne illness caused by parasites in fish, prepare fish safely by:

- cooking to an internal temperature of at least 63°C/145°F, and
- avoiding the consumption of raw fish, or raw fish dishes unless it has been chilled appropriately (refer to Chapter 8 freezing fish) (USDA, 2008; CDC, 2011).

Marinating, salt curing and smoking infected fish will not kill parasites.

Bacterial diseases

Fish are susceptible to a wide variety of bacterial pathogens. An example, *Vibrio* spp. contains at least twelve species pathogenic to humans, eight of which can cause or are associated with foodborne illness. *V. parahaemolyticus* is the species primarily associated with gastrointestinal illness (FAO, 2003) in Canadian waters (Refer to Bacteria section in Chapter 1).

Bacteria can affect the safety and quality of both fish and shellfish once the fish is removed from the water as bacteria multiply very quickly, and ensuring that fish is cooled or stored properly once it is harvested is critical (FAO, 2003).

Scombroid poisoning is the most common bacterial toxin linked to fish (see table below). It is produced from the conversion of the amino acid, histidine, to histamine by some bacteria in fish. Histamine-forming bacteria are found in the gills and gut of contaminated fish. The fish particularly affected are the Scombridae and Scomberesocidae families (e.g., tuna and mackerel), the Clupeidae (herring, sardines) and the Coryphaenidae (mahi-mahi/dolphinfish/dorado). Bacteria that transform histidine into histamine (mainly in oily fish) can be found in fish that is inadequately preserved or chilled. To slow the growth of bacteria that can cause scombroid poisoning, fish should be kept at 0°C/32°F or below (see Table 20). Scombrotoxin cannot be destroyed

by cooking, canning or freezing (CFIA, 2002; Omaye, 2004). To avoid cross-contamination, food handlers should wash their hands before and after handling fish.

Table 20. Bacterial intoxication association with fish

BACTERIA	Illness	Symptoms found in animals	Symptoms found in humans	Reaction time in humans	Associated foods/ animals
Histamine forming bacteria	Scombroid poisoning		May experience: • rash, flushed skin, facial swelling, nausea, vomiting, diarrhea, headache, dizziness, a peppery taste in the mouth, burning throat, stomach pain, itchy skin, tingling, and palpitations	Usually within minutes to several hours after eating spoiled fish	Tuna, mackerel, bonito, herring, sardines, mahi-mahi, and otters
Preventive measures	• Obtain fish from a reliable supplier • Chill fish rapidly		• Refrigerate or put on ice or in the freezer as soon as possible after catching or buying fish	• Food handlers with lesions on hands should ensure that their hands are properly covered (wear gloves to avoid contamination of food)	• Eviscerate and remove the gills to prevent spoilage • Do not eat decomposed fish

The consumption of raw or undercooked contaminated seafood can cause acute digestive disturbances in humans. Cooking fish well will destroy any bacteria that are present in fish.

Viral diseases

Viral diseases are more difficult to detect in fish than bacterial and parasitic diseases. Shellfish (e.g., oysters, mussels and clams) and fish can bioaccumulate viral pathogens from polluted waters. Viruses associated with seafood-borne diseases are found in the human gastro-intestinal tract, and their presence in water and seafood is a result of contaminated water (from sewage), or contamination by food handlers. Viruses linked to seafood-borne diseases are the Norwalk-like virus and Hepatitis A virus (refer to Virus section, Chapter 1).

There are other fish viruses that affect fish species but are not transmittable to humans. These fish viruses infect the fish's skin through contact with other infected fish during the spawning run, forming pale or white cauliflower-like growths (MNR, 1996). Examples of viral diseases in seafood include viral hemorrhagic septicemia (VHS) and lymphocystis. VHS is not transmittable to humans, and infected fish (e.g., freshwater drum, smallmouth bass, crappie, muskellunge, and bluegill) are safe to eat provided that they are well prepared.

Freshwater, estuarine, and marine fish in warm-water, cool-water, and cold-water environments are susceptible to lymphocystis, which is found in species of teleosts, such as herrings, perch, bass, flounder, snapper, and damselfish. Lymphocystis causes extreme enlargement of skin cells in many freshwater and marine fish and has been suggested to be associated with environmental stressors (Sindermann, 1996).

Fungal diseases

Fungal spores are common in the aquatic environment, but do not usually cause disease in healthy fish. Examples of aquatic fungi include *Saprolegnia, Achlya,* and *Aphanomyces*. Saprolegniasis affects all species and ages of freshwater and estuarine fish. Improper handling, bacterial or viral skin diseases, and trauma are the major causes of the disease, damaging the tissue on the exterior of the fish. Temperature has a significant effect on the development of infections; most epizootics occur when temperatures are below the optimal temperature range for that species of fish.

Table 21. Examples of diseases and abnormalities in fish

Bacterial Diseases

DISEASE/PARASITE	Observation	Comments	Is fish edible?
Furunculosis *Aeromonas salmonicida*	Ulcers on skin and muscle tissue; organ hemorrhages	Affects mainly trout or salmon	X No. Discard carcass.

Viral Diseases

DISEASES	Signs	Comments	Is fish edible?
Viral Hemorrhagic Septicemia (VHS)	*External signs:* • Bulging eyes • Pale gills • bleeding around the eyes, bases of the fins, sides and head • Darkening of overall colour • Distended belly (fluid-filled) • Corkscrew swimming behaviour *Internal signs (during acute outbreak):* • small hemorrhages are common in the musculature, gills, and visceral organs • During mid-stages of a disease outbreak, internal organs become very pale • In late stages of the disease, kidneys become swollen and discoloured	Occur most likely during the spring as temperatures fluctuate and fish are reproducing The virus does not affect humans, but is a threat to other fish species	√ Yes. Fish carrying the VHS virus are safe to handle and eat
Lymphocystis, Walleye dermal sarcoma	Lymphocystis *External signs:* cauliflower-like lesions on body surface, including mouth, fin and tail area *Internal signs:* nodular lesions in the spleen and gastrointestinal tract (not common) Dermal sarcoma *Internal signs:* virus infects the cells and causes growth under the skin that can be removed by skinning the fish	Affects mainly walleye and perch Does not kill affected fish Affects mainly walleye	√ Yes. Ensure that fish is properly cooked Infections occur at a much higher rate during cold periods in late winter and early spring

Parasitic Diseases

DISEASES	Signs	Comments	Is fish edible?
Ichthyophthirius multifiliis **which causes ichthyophthiriasis, (commonly referred to as ich or white spot) Ciliate**	*External signs:* • Small pinhead-size white spots on the skin of the fish with sometimes excessive mucus production (slime), and small black-to-purple spots under the skin or in the flesh or scale of fish *Internal signs:* • Abnormalities in the liver or intestine can be caused by parasites or tumors		√ Yes. Avoid eating raw fish or raw fish dishes
Black spot/grub ***Uvulifer ambloplitis*** **Digenetic trematoda (fluke)**	• Small pinhead-size black spots on the skin fins, in the flesh or scale of fish	Affects mainly Bass & Yellow perch. Black spot is one of the more frequent parasites seen. It is caused by larval flukes encysting under the skin or in the flesh, yellow grubs, leeches, fish lice, and gill flukes	√ Yes, fish is edible
Yellow grub ***Clinostomum complatanum*** **Digenetic trematode**	• Large nodules (3-8mm) appear under the skin and in the flesh	Parasites are highly visible after skinning the fish because of their yellow colour and size.	√ Yes. Remove parasites, and cook fish thoroughly prior to eating
Cestode or Tapeworm	Larval tapeworms form cysts on or in the internal organs or body cavity *D. latun* The plerocercoids lie unencysted in fish muscle *D. dendriticum* encyst within the viscera of the fish attached to the stomach, liver, gonads or intestine	*D. latun* is not easily seen in fish, and occurs mainly in pike, walleye, and perch *D. dendriticum* occurs mainly in whitefish and salmonids, including arctic char and trout	√ Yes. Clean fish well immediately after catching Cook fish well at 63°C/145°F to kill parasites Do not feed fresh fish or internal organs to dogs or other pets
Acanthocephalan or spiny-headed worm	*Internal signs:* • live in the intestines of the fish	Affects mainly walleye	√Yes. Clean and prepare as usual
Nematode or round worm	*External signs:* • roundworms are thread-like, red worms that can be seen extending from the anus *Internal signs:* • larvae may be found in cysts or coiled in or on the internal organs. Adult larvae are usually found in the intestines or coiled in the skin		√Yes. Avoid eating raw fish or raw fish dishes. Prepare fish accordingly: (refer to freezing fish section, Chapter 8), or cook fish thoroughly before eating (internal temperature of 63°C/145° F)
Copepods (e.g., anchor worm and fish louse)	*External signs:* • worm is embedded in the flesh, gills or mouth, and allows its body to hang free of the wound • fish louse feeds on the blood by piercing the skin (the bite can become infected)		√Yes. Clean fish thoroughly, and prepare accordingly

6.2 Preparing for the catch

To ensure a safe catch, it is important to plan ahead on how to catch, clean, chill and transport fish, and shellfish.

- Ensure you have the right tools:
  - Storage box or cooler filled with ice,
  - Sharp knives,
  - Clean cloth or paper towel,
  - Plastic gloves, and
  - Clean water (especially if cleaning fish on site).

After the catch

- wear disposable gloves to reduce risk of potential exposure to diseases
- check immediately for signs of disease or parasites,
- keep the fish cool (on ice in a cooler),
- do not place fish in a bucket of water as they use up oxygen quickly and may die, and
- keep out of direct sunlight or heat.

What to look for in healthy fish

- bright, clear eyes,
- skin is vivid and bright,
- firm flesh with no signs of discoloration,
- mild fresh smell with no strong odour,
- well-rounded stomachs and a well-proportioned body,
- outside skin should not be slimy, and
- if the fish has scales, scales should be flat and smooth.

What to look for in healthy live shellfish

- fresh salty sea-smell,
- lustrous and fresh looking shell,
- black and glossy eyes for mollusc crab (not dull or pale),
- no missing claws (lobsters and crabs), and
- fish and shellfish should be heavy (in proportion to their size)
- lobster tails that spring back into place after being uncurled,
- no sign of limpness (limp tail is a sign of deterioration), and
- bivalve mollusc shells are closed, and not gaping.

Ensuring safety

- Do not harvest fish and shellfish in closed harvest areas,
- Obtain fish from a reliable supplier, and
- Put fish on ice, refrigerate (for a maximum of 2-3 days) or freeze until ready to be prepared (refer to Chapter 8 for refrigeration and freezing time).

Cleaning

Fish can be cleaned on site, or transported whole and then cleaned once at the specific location. To clean fish:

- bleed and gut immediately (a plastic bag should be used when gutting fish and all internal organs disposed of appropriately, together with the bag),
- remove fatty parts of the fish,
- wash fish with clean water to rinse off any blood or other remains,
- place cleaned fish immediately on crushed ice and in a clean container to avoid any chances of spoilage, and
- do not place fish in plastic bags unless there is ice (plastic bags trap heat and accelerate spoilage).

Once the fish has been caught and cleaned, it is important to consider how to transport it in a safe way to avoid contaminating it.

Transportation

To transport safely:

- do not mix different species in the same container, and
- put on ice and away from direct sunlight.

6.3 Keeping fish and shellfish safe from contamination

From the time they are caught, to the time they are served fish and shellfish spoil very quickly if not handled properly. This can affect both the texture and taste and can cause foodborne illnesses.

Preparing fish safely

Wash fish in cool fresh water and repack on ice (properly cleaned and iced fish keeps for at least 3-4 days) until ready to be cooked or eaten. Prior to cooking, remove the fatty parts (fish accumulate more contaminants in these parts) of fish including the skin, guts, and fatty dark meat along the entire length of the fillet and all the belly fat.

Ensuring safety

- Wash hands before and after handling,
- Ensure that all surfaces are cleaned before and after fish have come into contact with them,
- Avoid cross-contamination with other foods,
- Remove the skin, fat and internal organs before cooking (contaminants tend to accumulate there),
- If fish is to be eaten raw, ensure that it is prepared safely (refer to Freezing fish section, Chapter 8)
- Cook fish well. Fish is cooked when the flesh turns opaque, and is still firm but moist,
- Reduce the consumption of fried or breaded fish (frying seals in the contaminants),
- Cook fish using methods that allow the fat to drain such as broiling, baking, boiling or grilling. Any excess fat should be drained off after cooking, and
- Discard any liquid used to cook fatty fish. Do not reuse the liquid for soups or gravies.

Preparing shellfish safely

Like fish, shellfish deteriorate quickly once they are dead, and proper handling, storage and use is necessary to maintain their quality and reduce the risk of contamination. Most shellfish can also be purchased in a frozen state.

Ensuring safety

- Wash hands before and after handling shellfish,
- Wash shellfish thoroughly prior to preparation to remove any surface contamination,
- Ensure that all surfaces are cleaned before and after shellfish have come into contact with them,
- Avoid cross-contamination with other foods,
- Do not eat shellfish such as clams and scallops that do not open during cooking, and
- Eat or refrigerate cooked shellfish immediately.

For live molluscs, it is important to ensure that:

- shells are tightly closed (this indicates whether they are live or not),
- they have a fresh sea-smell, and
- there is absence of excessive barnacles.

For cooked shellfish, it is important to ensure that:

- shellfish are heavy, in proportion to their size,
- shells are intact, with no visible damage, and
- there are no signs of discoloration or unpleasant smells (especially ammonia).

Cooking shellfish

- Boil: Add shellfish to boiling water and boil for an additional 3 to 5 minutes at boiling temperature after the shells open,
- Steam: Steam for 4 to 9 minutes in a steamer and throw out any shellfish that do not open,

Boil and steam shellfish in a single layer for even heating.

- Fry: Fry for at least 10 minutes at 190°C/375°F,
- Bake: Bake in a preheated oven for at least 10 minutes at 230°C/450°F (Fraser Health, 2009),
- Discard any molluscs that do not open once cooked, and
- Do not cook lobsters that are not alive.

Cooking does not destroy all toxins in fish and shellfish.

Storing shellfish safely

Shellfish are highly perishable, and require immediate storage once obtained, as spoilage can lead to contamination and increase the risk of possible food poisoning. In order to store shellfish safely, the following steps should be followed:

- Store live shellfish at a temperature of between 4°C/40°F or lower,
- Keep shellfish covered with wet cloths or sacking to retain moisture,
- Ensure that shellfish are alive prior to cooking,
- Cook and serve shellfish as soon as possible,
- Separate cooked and uncooked shellfish to avoid cross-contamination,
- Cooked shellfish should be covered and stored at 4°C/40°F or lower,
- Refrigerate and use cooked shellfish within 3 days,
- Frozen shellfish should be defrosted in the refrigerator overnight and used within a short period of time (approximately 12 hours), and
- Use frozen shellfish within 3 to 6 months.

There are various methods used to preserve fish. These include *freezing, salting, smoking, drying, fermenting, canning, and freezing* (refer to Chapter 8).

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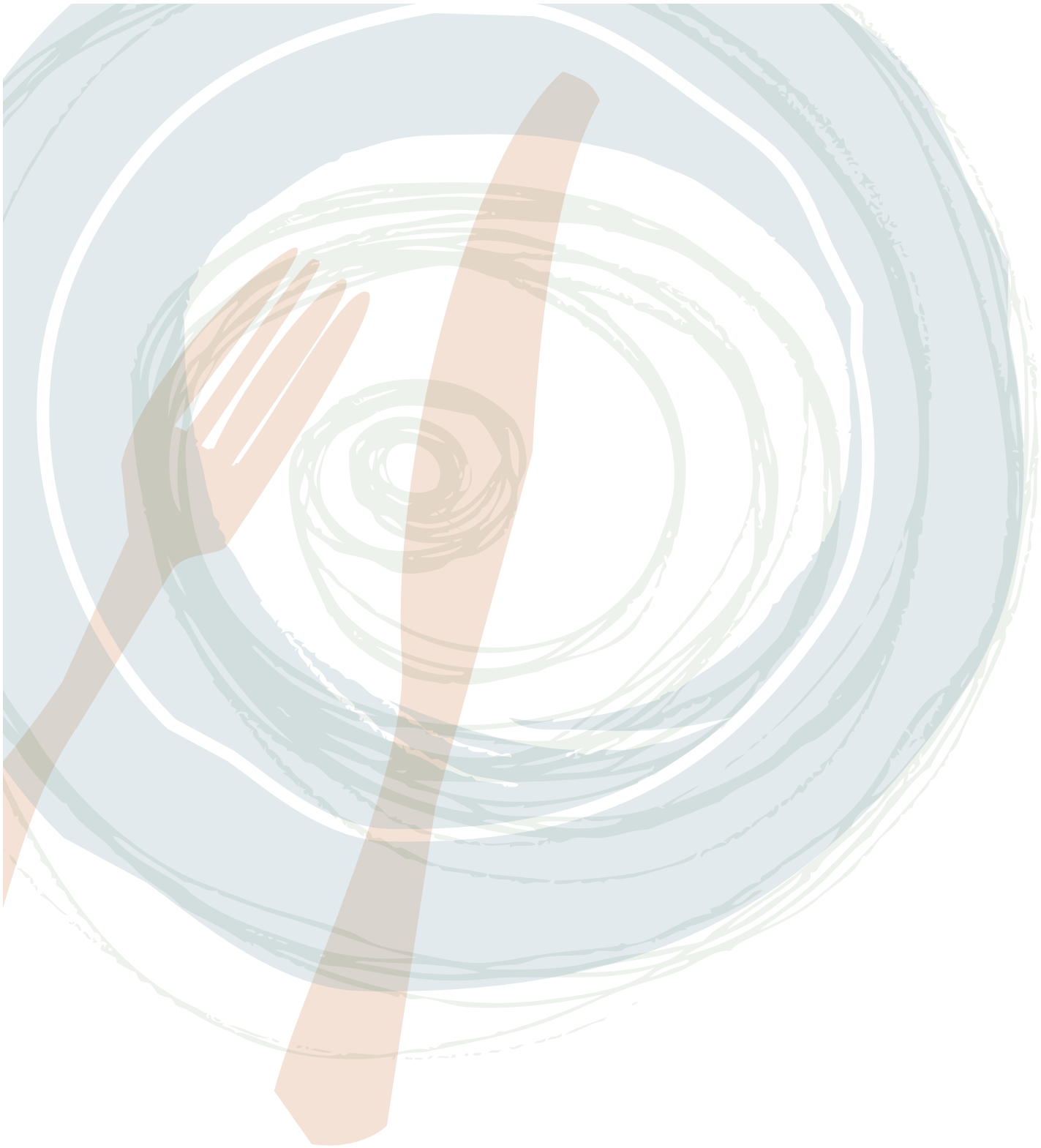

7. Picking Wild Plants and Buying Fruits and Vegetables

Wild edible plants are an excellent source of fibre, vitamins, and minerals and are low in calories, fat and sodium (LaBord, 2000). Wild plants include fruits, vegetables, roots, and tubers and inner bark tissue. Whether they are gathered in the field or bought at the grocery store, they should be handled properly to keep them fresh and safe for consumption.

Elderberries: Photo by AFN

7.1 Harvesting safely in the field

Harmful bacteria such as *E. coli, Listeria* and Salmonella may be in the soil or water where plants are grown and may come in contact with wild plants and contaminate them. Other potential sources of contamination are: "faeces, irrigation water, water used to apply fungicides and insecticides, dust, insects, inadequately composted manure, wild and domestic animals, and human handling" (Buck, 2003). Potential contamination of wild plants may also occur after they have been gathered through: "human handling, harvesting equipment, transport containers, … rinse water, ice, transport vehicles, and processing equipments" (Buck, 2003).

To ensure safety, prevent spoilage and minimize contamination while harvesting wild plants:

- Bring clean containers or bags to the field for gathering,
- Do not select any plants that have mould or an unusual smell,
- Avoid bruising fruits while picking them because bacteria can multiply in bruised areas (Garden-Robinson & Martin, n.d.),
- Do not put berries on dirty surfaces,
- Cool the berries quickly after harvesting to avoid spoilage,
- Do not gather plants that grow along the roadside because they may be contaminated with chemicals from car exhaust, oil, or gasoline,
- Do not gather plants that are grown along railways because they may be contaminated with chemicals associated with the railway, and
- Do not gather plants along cultivated fields, as the site might be contaminated with herbicides or pesticides.

7.2 Selecting fruits and vegetables at the grocery store

- Avoid fruits and vegetables which are not bruised, shrivelled, slimy, or damaged,
- Select fresh-cut produce (e.g., cut watermelons) that is refrigerated or surrounded by ice,
- Bag fruits and vegetables separately from meat, poultry and seafood and keep them separated in the shopping cart, and
- Buy perishable foods (e.g., vegetables) at the end of your shopping (CFIA, 2006; HC, 2009; LaBord, 2000; USFDA, 2009).

7.3 Safe preparation

At home, wild plants, and fruits and vegetables from the market need to be prepared and stored properly (LaBord, 2000; HC, 2009).

Preparing plants, fruits and vegetables:

- Wash hands in warm soapy water and rinse well before and after handling food,
- Remove and discard outer leaves that are wilted or brown,
- Wash leafy greens, fruits and vegetables under running water to remove dirt and bacteria,
- Use clean utensils and cutting boards to peel and cut produce,
- Cut away damaged or bruised areas with a clean knife,
- Use a clean produce brush to scrub firm fresh fruits and vegetables (e.g., melons, potatoes, cucumbers, and carrots) under running water to get rid of dirt and contamination on the outer skin right before use, as the brush can damage the skin and cause spoilage, and
- Wash and sanitize all equipment (e.g., counter tops, cutting boards and utensils) that come in contact with meat, poultry, and seafood before using them for raw fruits and vegetables (CFIA, 2006; Garden-Robinson & Martin, n.d.; HC, 2009; LaBord, 2000; USDA, 2008; USFDA, n.d. & 2009).

7.4 Storage

Storing plants, fruits, and vegetables properly is an important step in keeping them safe for consumption.

For proper storage:

- Store fruits and vegetables (e.g., strawberries, lettuce, herbs and mushrooms) in the refrigerator at 4°C/40°F or lower,
- Store whole fruits and vegetables such as potatoes, tomatoes, pears and melons in a clean, cool, dry place,
- Refrigerate any pre-cut and peeled fruits and vegetables,
- Cool blanched/cooked fruits and vegetables completely before storing them (packaging warm food causes sweating, which could provide moisture for mould growth),
- Pack foods in clean, dry, insect-proof and airtight containers, and
- Pack food in amounts that will be used for one meal (USFDA, n.d.).

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8. Food Preparation and Preservation

"Food by its nature begins to spoil the moment it is harvested. Food preservation enabled ancient man to make roots and live in one place and form a community. He no longer had to consume the kill or harvest immediately, but could preserve some for later use. Each culture preserved their local food sources using the same basic methods of food preservation" (Nummer, 2002).

Since most foods are perishable, it is necessary to find ways, or processes to store them safely so that they can be consumed at a later date. In the past, First Nations people mostly relied on what the land provided. Because there were no refrigerators or freezers, foods were kept outdoors in the winter, in a safe place or preserved using traditional methods, such as drying, smoking and salting.

Preservation techniques help stop or slow down the growth of bacteria and mould and any chemical changes (such as oxidation of fats) that can cause food spoilage.

Food preservation is the processing of food to maintain as much of its nutrition and edibility as possible, while keeping it safe to eat for extended periods of time (days, weeks and months). Food preservation enables people to store foods that are abundantly available at certain times of the year so that they can be consumed in times when food is scarce.

Pickling

8.1. Principles of food preservation

The underlying processes of food preservation are designed to prevent or slow spoilage, reduce contamination, and maintain nutritional value and edibility. Food preservation methods are intended to:

1. Control microorganisms by:
   - preventing contamination in foods,
   - removing them from contaminating food, and
   - slowing their growth and activity in foods.
2. Control enzymes by:
   - inactivating endogenous enzymes, and
   - preventing or delaying chemical reactions in the food.
3. Control insects, rodents and other physical causes of food deterioration by:
   - covering foods (e.g., cheesecloth or food screens).

Safe preservation methods require good hygiene, proper food handling and storage practices. For example, improper home-canning can cause botulism, a foodborne illness caused by a nerve poison that is produced by the bacterium, *Clostridium botulinum*.

8.2 Preservation methods

The choice of a preservation method depends on the final product that is desired, the packaging material, and storage facilities available.

Fermentation

Fermentation has been used for many centuries and is one of the major preservation methods used around the world. During the fermentation process, "good" microorganisms are helped to grow, while the growth of spoilage-causing microorganisms is prevented. Fermentation uses up food energy and makes conditions unsuitable for undesirable microorganisms.

During fermentation, salt, minimal oxygen and cool temperatures are necessary. Proper fermentation depends on correct proportions of salt and other ingredients. Once the food is salted, it is kept in a cool place with minimal oxygen. Salt is a critical ingredient used in fermenting foods, as it helps to prevent undesirable bacterial growth (Schafer, 2009).

Many years ago, with no refrigeration available, First Nations people stored food in caches along hunting routes. This food was retrieved in the winter months, as other food supplies ran low. Among the Inuit, holes were dug down into the permafrost (about 30 to 60 centimetres), and food was stored in the cold ground in bags of blubber. To remember where the food had been kept, an "*inukshuk*" was built (a landmark made with a pile of stones in the shape of a man, and built to point to the direction of the cache). The presence of an *inukshuk* indicated that food would be available.

Among First Nations people, common foods that are fermented include salmon heads, beaver tails, sea flippers, sea mammal meat (such as walrus and seal), and roe (commonly known as "*stink eggs*"). Two common delicacies are "*stinkhead*," made from the head of a King salmon, and "*stink eggs,*" made from salmon eggs (roe). In the past, the traditional method of preparing both delicacies was to wrap the fish head and eggs in long grasses, taken along the rivers and streams. They were then buried in the ground in a moss-lined pit for 4 to 6 weeks and allowed to age. The fish heads and eggs were left to ferment aerobically (allowing air to circulate) and slowly in shaded areas at cool temperatures. The fermented roe was then stored at room temperature and consumed within a few days.

When handled properly, fermented roe is as safe to eat as any other fish. The aim is to ensure that the food is kept cool and stored in a container that allows for proper air circulation. Bacteria become a problem when processing practices fail to eliminate *C. botulinum* spores from fermented food. For instance, if fish are prepared with insufficient salt or at pH higher than 4.5, *Clostridium botulinum* is encouraged to grow and produce toxins, which may cause botulism.

In traditional methods, the fermentation process is usually guided by experience, which determines whether or not the process has gone well (Maas-van Berkel, 2004).

Ensuring safety during the fermentation of foods

- Wash hands, containers, and food before preparing any food,
- Do not use plastic or glass containers, or plastic bags to ferment food, as these containers do not allow air to circulate and could cause botulism poisoning. Fermenting food in a plastic bag or plastic bucket with a lid speeds up the fermentation process, which means that the food could be ready in half the time. As bacteria thrive in warm temperatures, the result of these methods could cause an increased incidence of botulism,
- It is recommended that fermented food be boiled for about 10 minutes before consumption, as heat destroys *C. botulinum* that may be present,
- Store foods at cool temperatures during fermentation, as this ensures that the good bacteria grow and produce the needed acid and flavour compounds. Ideal temperatures for storage are below 3°C/37°F,
- If the product appears different than normal (colour or smell), it should not be eaten, and
- If in doubt, throw it out (CDC, 2001).

Curing

Curing involves removing moisture from meat by saturating it with salt, salt brine or nitrites. Meat saturated with salt has reduced water activity, which makes it unsuitable for bacterial growth. By salting food, storage life is prolonged. Salting is usually part of the preparation for drying and smoking. Curing processes are sometimes used in combination with other preservation methods such as smoking or drying.

There are various methods that are used for curing, such as:

- pickle curing (includes water and salt to make brine),

- dry-salt curing (involves rubbing and packing meat with salt),
- dry-sugar curing (involves the addition of salt and sugar), and
- injecting (helps distribute the brine solution directly into the meat).

Preparing salted meat:

- Use salt and clean water,
- Wet the meat before applying the salt to facilitate penetration into the muscle,
- Keep temperatures at less than 4°C/40°F. Temperature control is very important. It must be cold enough to prevent spoilage, but warm enough to allow the salt to penetrate the meat, and
- Keep meat in a cool place for several days to allow the salt to penetrate throughout the meat to avoid spoilage.

Preparing salted fish

- Prior to salting fish, ensure that the fish is soaked in clean cold water for at least 48 hours. (In warmer weather, the fish must not be left for longer),
- Replace the water several times with clean, fresh water,
- Prepare fish as desired (salted, dried and/or smoked), and
- Fish should be heated to an internal temperature of at least 100°C/212°F prior to being eaten (Maas-van Berkel, 2004).

Ensuring safety during the curing process

- Cure only properly butchered and cooled meat,
- Allow enough curing time for the meat to absorb the salt. If the curing time is short, the meat may spoil, and if left for too long, the meat loses quality,
- Persons suffering from high blood pressure should avoid eating foods that are salt-cured, as salty foods can affect the heart,
- Some salt-cured foods, such as meat can be soaked in water before consumption to reduce the salt content.

Sugaring

Sugaring is the process of packing food with sugar, honey, syrup or molasses. The purpose of sugaring, much like salt is to create an environment hostile to microbial life and prevent food spoilage. Sugaring is commonly used to preserve fruits. Adding sugar removes moisture (juice) from fruits to prevent spoilage and bacterial growth. Once sugar is added to fruits, it can be packed in freezer containers and then frozen.

Ensuring safety during the sugaring process

- Wash hands in warm soapy water, and rinse well,
- Wash foods under running water, and
- Wash containers in warm soapy water, and rinse well.

Salt is the most important ingredient that provides the cure, while the addition of sugar adds flavour and helps retard the hardening action of the salt.

Pickling

Pickling is an ancient preservation technique that began as a practical way to preserve the summer harvests through the winter months. It is the method by which food is placed in brine (salty substance) or vinegar, or both. The salt and acid (vinegar) used in pickling create an environment that inhibits the growth of microorganisms that are present on food. When the acidity of a pickled food is high, harmful bacteria, such as *Clostridium botulinum*, are unable to grow.

Types of pickling:

- In quick, unfermented pickling, the food is totally covered with vinegar (spices and seasonings may also be added); the acetic acid from the vinegar preserves the food.
- In long, fermentation-based pickling, the food undergoes a curing process in a brine solution for several weeks; the lactic acid produced during this process helps preserve the product.

Ensuring safety during the pickling process:

- Add enough acid to prevent bacterial growth,
- Keep pickled foods in a cool dark place,
- Use quickly pickled foods within 1 to 1½ years, and
- Use long, fermentation-based, pickled foods within 2 years.

Pickling fish

Pickling or brining may reduce the presence of parasites in fish, though does not eliminate them. For instance, Nematode larva may survive 28 days in a salinometer brine (21% salt by weight) (USDA, 2011).

Drying

Drying, like fermentation, is one of the oldest methods of food preservation. Long before any other method came into use, foods were dried under the sun, wind, and fire so that they could last longer. Common dried foods among First Nations peoples include fish, fish eggs, wild game, duck, seaweed, narwhal, beluga whale, char, walrus, fruits, and vegetables.

Drying removes most water or moisture content from foods, which reduces bacterial growth. Because drying involves the removal of water, it does not destroy as many nutrients as does canning or cooking. The process of drying also allows the draining out of excess fat, and as a result, dried foods are high in fibre and carbohydrates, but low in fat. To dry foods, warm temperatures, low humidity and good air circulation are essential (Clemson University, 1999a).

Foods can be dried in the sun, oven or a food dehydrator. Properly dried foods will have 80-90 percent of their water removed. When drying, it is important to remember to select fresh produce (fruits and vegetables should be firm and free from bruises), meats, and fish.

In some cases, foods may need to be blanched (Table 22), cooked or dipped in salts before drying.

Drying fruits

Fruits can be dried in the sun, the oven (see Table 23) or a food dehydrator. Outdoor sun drying requires warm days with minimum temperatures of 30°C/86°F or more and low humidity. To dry fruits in the oven the temperature should be set at 60°C/140°F or lower.

Drying salmon: Photo by AFN

Higher temperatures will cook the fruits instead of drying them. While some fruits (e.g., blueberries) can be dried whole, others should be cut in halves or thin slices. It takes longer to dry unpeeled and whole fruits.

Some cut or peeled fruits (e.g., apples, apricots, nectarines, pears, and peaches) darken when exposed to air. To prevent discolouration from oxidation, the fruit can be treated in a solution of ascorbic acid (vitamin C) at a concentration of 1 tsp or 3000 mg of ascorbic acid in 1 gallon of cold water, or citric acid, such as lemon juice. Vitamin C is available in powder or tablet form (Clemson, 1999b).

Drying vegetables

The low acid and sugar content of vegetables makes it unsafe to dry them outdoors. To sun-dry vegetables, outdoor temperatures must be above 38°C/100°F, and outdoor humidity must be low, to

avoid mould growth and an increased risk of spoilage. It is recommended that a food dehydrator or oven be used to dry vegetables (see Table 23). It is necessary to water- or steam-blanch (see Table 22) vegetables before drying them, with the exception of onions, peppers, herbs and mushrooms (Clemson University, 1999c). Blanching inactivates enzymes, destroys some microorganisms on the surface of the vegetables, brightens the colour and delays the loss of vitamins.

Drying herbs

Drying is the easiest method of preserving herbs. Leaves, flowers or seeds are exposed to warm, dry air and left in a well-ventilated area until the moisture evaporates (Clemson, 2007). Three methods of drying herbs are described in Table 23.

The dehydrator method is a fast and easy way to dry high quality herbs because the temperature and air circulation can be controlled. For air drying, sturdy herbs, such as sage, thyme, summer savory and parsley are easiest. Herbs are left indoors at room temperature, or outside. Sun drying is not a recommended method for drying herbs as the leaves tend to lose flavour and colour. Drying herbs takes about 2 to 4 weeks to become completely dry, depending upon temperature and moisture. More tender-leaf herbs, such as basil, tarragon, lemon balm and mints have higher moisture content; moulding may result if not dried quickly. Oven drying is great for mint, sage or bay leaf. For oven drying, it is best to dry the leaves separately. Drying with heat is faster, but if the herbs are desiccated too quickly at too high a temperature, much of the flavour, oils, and colour of the herbs can be lost. (Clemson, 2007; University of Illinois, 1997).

Herbs are dry when leaves or stems crumble or break easily.

> Warm temperatures, low humidity and good air circulation are essential to drying (UGA, 2000).

Table 22. Blanching vegetables

BLANCHING METHODS	Steps
Water-blanched	1. Fill a large pot that has a lid 2/3 full with water.
	2. Boil the water.
	3. Put vegetables in a wire basket or colander.
	4. Submerge into the boiling water.
	5. Cover the pot.
	6. Begin timing when the water starts boiling after having added the vegetables.
	7. Boil vegetables for recommended time (see Table 24).

Cont'd Table 22. Blanching vegetables

BLANCHING METHODS	Steps
Steam-blanched	1. Use a steamer or a deep pot (with a tight fitting-lid, and wire basket, colander or sieve).
	2. Add water to pot or steamer.
	3. Boil the water.
	4. Put vegetables loosely in the basket.
	5. Place the basket into the pot (the vegetables should not touch the water.
	5. Cover the pot or steamer.
	6. Steam the vegetables for the recommended time (see Table 24).

After blanching, remove the vegetables from the steamer or pot. Place them briefly in cold or ice water to cool them quickly to 49°C/120°F in order to stop the cooking process.

Table 23. Drying fruits, vegetables and herbs

DRYING FRUITS AND VEGETABLES			
METHODS	**Steps**	**Fruits**	**Vegetables**
Sun Drying	1. Prepare fruits for drying: - use fresh, firm and good quality products - wash fruits in clean running water.	√	
	2. Place fruits (whole or cut pieces) evenly on tray in the sun.	√	
	3. Cover tray with cheesecloth or screen (to protect from insects).	√	
	4. Spread fruit occasionally on tray to prevent mould growth and uneven drying.	√	
	5. Take tray inside at the end of the day	√	
	6. Repeat the process the next day until food is thoroughly dried.	√	
Oven Drying	1. Prepare fruits/vegetables for drying: - use fresh, firm and good quality products - wash fruits in clean running water - cut in halves or thin slices and blanch (as needed)	√	√
	2. Place drained, blanched vegetables on the drying tray in a single layer.		√
	3. Spread the fruits/vegetables in a thin layer on clean racks/trays with space around them to allow moisture to escape. Do not use trays or screens made from copper, as they destroy vitamin C, aluminium, as it discolours and corrodes, or coated with cadmium or zinc, as they can oxidize fruits/vegetables.	√	√
	4. Place the tray or pan in the oven	√	√
	5. Oven door should remain open 5-15 cm (2-6 inches) to allow air to circulate.	√	√
	6. Turn fruits and vegetables occasionally, for even drying.	√	√
	7. Dry until brittle or crisp.	√	√

Food Dehydrator	1. Prepare fruits and vegetables (blanched) for drying.	√	√
	2. Place in a single layer on individual trays leaving some space around each piece.	√	√
	3. Place the tray in the dehydrator.	√	√
	4. Turn the dehydrator on.		
	5. Dry until brittle or crisp.	√	√
	6. Fruits retain 20% of their moisture after drying.	√	

DRYING HERBS	
METHODS	**Steps**
Sun Drying	Not recommended as herbs can lose flavour and colour
Dehydrator	1. Pre-heat dehydrator at 35°C - 46°C/95°F - 115°F (or as high as 107°C/225°F in high humidity areas)
	2. Rinse under cool running water
	3. Shake or pat dry with paper towel to remove excess moisture
	4. Discard any bruised leaves/stems
	5. Place herbs in single layer on dehydrator trays
	6. Drying varies from 1-4 hours
Air drying	1. Air drying can be done indoors or outdoors (indoor drying produces better results – in colour and flavour retention)
	2. Rinse under cool running water
	3. Shake or pat dry with paper towel to remove excess moisture
	4. Discard any bruised leaves/stems
	5. Tie into small bundles of 5 – 8 stems
	6. For the sturdy herbs, hang (outdoors or indoors) to dry
	7. For the tender-leaf herbs, place bundles into a brown paper bag with the stems extending out of the open end
	8. Tie end of bag at stems
	9. Punch small holes in the bag
	10. Hang the bag in a warm, dark place (21°C - 27°C/70°F - 80°F) where air is allowed to circulate in bag.
	11. Allow 2 to 4 weeks for herbs to dry
Oven drying	1. Remove leaves from stems
	2. Place the leaves or stems on a cookie sheet or shallow pan (leaves should not touch)
	3. Place in oven and warm at no more than 82°C/180°F for 3 to 4 hours with the oven door open

Ensuring safety during sun-drying of fruits and vegetables

- Cover the tray of food with cheesecloth or screen to protect it from insects, and
- Food should be completely dry before it is stored so that bacteria are not allowed to grow.

After the sun-drying process, treat sun-dried fruits and vegetables by:

- Sealing fruits or vegetables in freezer bags and put them in the freezer for at least 48 hours (at -18°C/0°F or lower), or
- Heating fruit at 71°C/160°F for 15 minutes in a tray or shallow pan, and
- Heating vegetables to 66°C/150°F for 30 minutes or 71°C/160°F/ for at least 10 minutes in a tray or shallow pan (UGA, 2000).

Table 24. Recommended blanching time for some vegetables (UGA, 2000)

VEGETABLE	Blanching Method	Processing time (minutes)
Asparagus	Steam	4-5
	Water	3½-4½
Artichokes	Steam	Not necessary
	Water	6-8
Green beans	Steam	2-2½
	Water	2
Broccoli	Steam	3-3 ½
	Water	2
Beets	Cook as usual before drying	
Beans	Steam	2
	Water	2-2½
Brussels sprouts	Steam	6-7
	Water	4½-5½
Cabbage	Steam	2½-3
	Water	1½-2
Carrots	Steam	3-3 ½
	Water	3 ½
Cauliflower	Steam	4-5
	Water	3-4
Celery	Steam	2
	Water	2
Corn on cob	Steam	5-6
	Water	4-5

VEGETABLE	Blanching Method	Processing time (minutes)
Corn	Steam	2-2½
	Water	1½
Eggplant	Steam	3½
	Water	3
Green peas	Steam	3
	Water	2
Chard, turnip, spinach, kale	Steam	2-2½
	Water	1½
Potatoes	Steam	6-8
	Water	5-6
Peppers	Not necessary	
Summer squash	Steam	2 ½-3
	Water	1 ½
Pumpkin and Hubbard squash	Steam	2½ -3
	Water	1
Summer squash	Steam	2½-3
	Water	1½
Winter squash	Steam	2 ½-3
	Water	1
Tomatoes (for stew)	Steam	3
	Water	1

Drying meat/fish

- Fillet and cut into small pieces,
- Salt meat or fish accordingly,
- Remove any excess water (use paper towel to pat dry), and
- Place meat/fish on a clean, level surface and press as flat as possible (use a brick or sheets of wood for weighing down).

Sun drying/Outdoor hanging

Hang meat outdoors to drain and air the meat; to avoid spoilage drying must take place carefully and uniformly.

- The best results for drying outdoors are achieved in dry weather and lots of wind,
- Avoid direct sunlight at the start of the drying process as this causes overheating and a crust may form on the surface, leaving the inner part moist, which may make it spoil quickly,
- If drying racks are used, rack should be at least one metre above the ground to protect the food from insects,
- Place a net above the food to protect from insects (net should not touch the food being dried), and

- For uniform drying turn the pieces of meat or fish frequently (every two hours) (Maas-van Berkel, 2004).

Food Dehydrator

It is recommended to use an oven or a food dehydrator to dry meat, since outdoor heat and humidity cannot often be controlled, and the high protein content in meat facilitates bacterial growth.

Storing dried foods

It is important to ensure that food is completely dry before it is stored, so that bacteria and mould are not allowed to grow. Dried fruits and herbs can last for about a year, while vegetables and some meat can last for about 6 months. Dried foods can be eaten dry or reconstituted by adding water. Once dried, the foods should be:

- wrapped in small quantities,
- kept in small, airtight containers, and
- kept in a cool dark place.

Best-Before Dates

Many market foods that are pre-packaged have a short shelf-life, and are required to have a 'best-before' date indicated on the package. A "**best-before**" date is required on foods to indicate how long an unopened food will retain its freshness, quality and nutritional value when it is stored under conditions appropriate for the particular product (store/cupboard, refrigerator or freezer). "Best Before" dates are required on prepackaged foods with a durable life of 90 days or less, except prepackaged fresh fruits and vegetables. *Once a package is opened, the "best before" date no longer applies*. In general, after opening, refrigerated ready-to-eat (RTE) foods should not be stored in the refrigerator for longer than 4 days and preferably only 2-3 days (HC, 2010).

Smoking

Smoking is a technique in which smoke is used to saturate the food while drying it, giving it a smoky flavour. In the past, smoking was used as a means of preserving foods; now it is used to enhance flavours of meat. Smoking is the most popular method used for preservation of fish and game. Game meat and fish may be preserved and flavoured with smoke, using a wood fire (without cooking). Smoking prevents oxidation and reduces the meat's humidity level, a factor that contributes to the inhibition of bacterial growth by protecting the surface of the meat, including fish.

There are three common ingredients required for smoking:

- smoke,
- salt, and
- heat.

Heat, combined with salt and aromatic hydrocarbons from the smoke, preserves the food. The temperature in a smokehouse is critical and varies between 45°C-85°C/113°F-185°F (Maas-van Berkel, 2004); otherwise, the heat will destroy the enzymes in the meat that develop the aged flavour. Foods commonly smoked include moose, deer, salmon, herring and oolichan, and berries. Meat can be smoked in cold weather, late in the fall or in early spring when outdoor temperatures are cooler.

Different types of wood are used to smoke food, depending on the desired flavour; each leaves a distinct flavour. Hardwood is recommended, as soft wood contains resin, which can produce an "off" flavour.

Smoking salmon: Photo by AFN

Woods used for smoking

Maple, oak, alder, hickory, birch, and fruit woods are all good smoking woods, whereas wood from

conifers leaves an unpleasant taste. Fir, spruce, pine or cedar should not be used (Hilderbrand, 2003).

The following are examples of commonly used woods:

- Alder has a light delicate flavour, and is the traditional wood used for smoking salmon in the Pacific Northwest. Alder is suitable for fish and poultry.
- Apple produces a slightly sweet, fruity smoke that is mild for either poultry or pork.
- Cherry or chokecherry has a sweet mild flavour, and is one of the most popular woods for smoking most types of meat, with the exception of seafood.
- Hickory has a strong smoky flavour. Hickory is suitable for red meat and poultry, but not seafood.
- Maple is mildly sweet and is suitable for poultry and ham.
- Mesquite has a very strong flavour and is good for grilling, though only for short periods as it becomes bitter if cooked for extended periods. Mesquite may be used for game and seafood.
- Oak is considered one of the most versatile woods, as it blends well with a wide range of flavours. Oak is suitable for game.
- Pecan is a subtle version of hickory. Pecan burns cool and provides a delicate flavour.

Smoking game

Preparing the meat for smoking:

- use fresh, good quality meat,
- clean meat (remove all visible fat as fat becomes rancid),
- saturate with salt (which helps absorb moisture),
- cut meat into equal strips,
- dry meat before smoking,
- hang the meat on the racks of a smoke house, and
- refrigerate meat once it is smoked.

Depending on the size of the meat and outdoor temperatures, lightly smoke the meat for 2 to 3 days while keeping the fire going at all times (no flames).

Insert a meat thermometer in the thickest part of the meat to verify the internal temperature. Once the meat has been smoked, it should be refrigerated.

Smoking fish

Preparing the fish for smoking:

- Use fresh, cleaned, good quality fish, removing any bruised or damaged flesh,
- Cut fish into uniform sizes,
- Rinse and air dry (cool, dry air) all fish before smoking. This helps to prevent surface spoilage during smoking,
- Prepare a salt-water brine of 2 ½ tablespoons plain salt to 1 cup of water,
- Place fish in brine for 15 minutes per 1-2.5 cm (½ -1 inch) thickness of the fish,
- Remove fish from brine and rinse with cold water,
- If desired, additional spices or seasoning can be added to the fish prior to smoking,
- Place fish, skin side down on oiled smoker rack,
- Keep the temperature low, around 66°C/150°F, for the first 2 hours,
- Increase heat after the first 2 hours to approx. 93°C-104°C/200°F-220°F,

Bacteria such as *Clostridium botulinum* are able to survive smoking and could start to grow if smoked foods are not stored properly (Hilderbrand, 2003).

- Smoke fish for at least 3 hours, plus 30 minutes per pound of fish,
- Continue smoking until fish is flaky and cooked through, and
- If the smokehouse does not provide a temperature of 93°C-104°C/200°F-220°F, the final product can be cooked in a kitchen oven (Hilderbrand, 2003).

Storing smoked meat and fish

- Smoked meat and fish need to be dried completely before they are stored.
- Smoked fish has a short shelf-life, and if refrigerated, should be consumed within 2 to 3 weeks.
- For long-term storage, smoked meat or fish must be frozen or canned (Hilderbrand, 2003).
- Smoked birds should be kept in the refrigerator, at 4°C/40°F or lower, or in the freezer, at -18°C/0°F or lower.
- Properly smoked and refrigerated birds can be kept for 3 and up to 4 weeks.
- Smoked birds can be frozen for up to 6 months.

Ensuring safety of smoked foods

- Ensure personal hygiene and cleanliness of all utensils during the smoking process,
- Ensure that there is no moisture left in the fish or meat. If not properly dried, any amount of moisture will encourage growth of bacteria,
- Smoked fish or meat should be served immediately, or covered properly and kept in a cool dry place, refrigerated, or frozen,
- Refrigerated fish should be consumed within one month, and
- If the fish is not consumed within a couple of days, wrap it tightly and put it in the freezer.

Freezing

Freezing is the best preservation method for foods, because it is quick and safe. The recommended freezing temperature is -18°C/0°F or lower (see Tables 25 & 26 for recommended storage time).

Freezing is based on two principles:

- Very low temperatures which slow down the growth of microorganisms and chemical changes that cause spoilage in food.
- The formation of ice crystals which draws away the water that is in the food, and prevents the growth of microorganisms.

Freezing does not kill bacteria; it only stops their growth.

Table 25. Recommended storage time for game, fish and shellfish

(Kendall & Dimond, n.d.; Van Laanen, n.d.)

FOOD	Refrigerator (4°C/40°F)	Freezer (-18°C/0°F)
Small game such as rabbit, and squirrel	1-2 days	6-12 month
Raw wild birds such as whole duck, pheasant, goose, and ptarmigan	1-2 days	6 months
Cooked duck or goose	3-4 days	2-3 months
Raw giblets	1-2 days	3-4 months
Big game such as venison (e.g., deer, elk, moose, caribou/ reindeer, antelope and pronghorn) and bison	2-4 days	6-12 months
Ground meat from game	1-2 days	2-3 months
Game stew, soup or casseroles	3-4 days	2-3 months
Opened canned game products (e.g., soup, stew)	3-4 days	2-3 months

FOOD	Refrigerator (4°C/40°F)	Freezer (-18°C/0°F)
Opened canned fish or seafood	1 day	Not recommended
De-shelled (shucked) clams, mussels, oysters, and scallops	1-2 days	3-4 months
Live mussels and clams	2-3 days	Not recommended
Live oysters	7-10 days	Not recommended
Cooked fish	1-2 days	1 month
Cooked shrimp	3-4 days	3 months
Raw Crab	1-2 days	2 months
Cooked Crab	3-5 days	2 months
Fatty fish: mullet, ocean and sea perch, char, sea trout, striped bass, salmon, mackerel, and tuna	1-2 days	2-3 month
Fresh lean fish: cod, flounder, haddock, halibut, and perch	1-2 days	4-6 months
Fillets - fresh water fish	1-2 days	6-9 months
Lobster	1-2 days	6-12 months
Salmon steak	1-2 days	2 months
Shrimp	1-2 days	6-12 months
Smoked fish	1-2 weeks	4-5 weeks

Table 26. Recommended storage time for market foods

FOOD	Refrigerator (4°C/40°F)	Freezer (-18°C/0°F)
Hot dogs - opened package - unopened package	Use by 'Best Before' date 1 week 2 weeks	 1- 2 months 1- 2 months
Luncheon meat - opened package - unopened package	Use by 'Best Before' date 3- 5 days 2 weeks	 1- 2 months 1- 2 months
Bacon and sausages - bacon - raw sausage (chicken, turkey, pork, and beef)	Use by 'Best Before' date 7 days 1-2 days	 1 month 1-2 months
Ham - cooked whole ham - cooked half ham - cooked slices	 7 days 3-5 days 3-4 days	 1-2 months 1-2 months 1-2 months
Hamburger and stew meat	1-2 days	3-4 months
Ground turkey, veal, pork, and lamb	1-2 days	3-4 months

Cont'd Table 26. Recommended storage time for market foods

FOOD	Refrigerator (4°C/40°F)	Freezer (-18°C/0°F)
Fresh beef, veal, lamb, and pork - steaks - chops - roasts	 3-5 days 3-5 days 3-5 days	 6-12 months 4-6 months 4-12 months
Variety meats: tongue, liver, heart, and kidneys	1-2 days	3-4 months
Soups and stews (with meat or vegetables)	3-4 days	2-3 months
Chicken and turkey - whole - pieces	 1-2 days 1-2 days	 1 year 9 months
Giblets	1-2 days	3-4 months
Eggs - fresh raw - fresh yolk & white - hard cooked eggs	 Use by 'Best Before' date 2-4 days 1 week	 4 months (blended eggs) 4 months Not recommended
Prepared salads - macaroni salad and tuna salad	3-5 days	Not recommended. (Does not freeze well)
Leftover cooked meat and poultry - meat and casseroles - gravy and meat broth - fried chicken - poultry casseroles - plain poultry pieces - pieces covered with broth or gravy	 3-4 days 3-4 days 3-4 days 3-4 days 3-4 days 3-4 days	 2-3 months 2-3 months 4 months 4-6 months 4 months 6 months
Pizza	3-4 days	1-2 months
Cooked stuffing	3-4 days	1 month
Butter	1-3 months	6-9 months
Hard cheese (e.g., Swiss, Cheddar) - opened - unopened	 3-4 weeks 6 months	 6 months
Soft cheese (e.g., brie)	1 week	6 months
Cottage cheese and ricotta	1 week	Does not freeze well
Cream cheese	2 weeks Use by 'Best Before' date	Does not freeze well
Milk	7 days Use by 'Best Before' date	3 months
Yogurt	7-14 days Use by 'Best Before' date	1-2 months
Cod, flounder, haddock, halibut, and sole	1-2 days	6-8 months
Pollock, Ocean Perch, and Sea Trout	1-2 days	4 months

FOOD	Refrigerator (4°C/40°F)	Freezer (-18°C/0°F)
Mackerel, bluefish, mullet, salmon, and tuna	1-2 days	2-3 months
Cooked fish	3-4 days	1-2 months
Smoked herring	3-4 days	2 months
Cold-smoked salmon and white fish	5-8 days	2 months
Hot-smoked salmon and white fish	14 days	6 months
Shrimp, scallops, crayfish, and squid	1 to 2 days	3 to 6 months
Shucked clams, mussels, and oysters	1 to 2 days	3 to 4 months
Fresh crab meat	1 to 2 days	4 months
Live clams, mussels, crab, and oysters	1 to 2 days	2 months
Live lobster	1 to 2 days	2 to 3 months
Lobster tails	1 to 2 days	6 months
Cooked shellfish	3 to 4 days	3 months

Freezing Fruits and Vegetables

Only fresh and firm fruits and vegetables should be frozen. Freezing inactivates the enzymes in fruits and vegetables to prevent the loss of nutrients and colour and flavour changes. Use moisture- and vapour-proof freezer bags, freezer containers, and freezer jars (e.g., heavy-weight aluminium foil, plastic, coated freezer paper and plastic wrap) to freeze fruits and vegetables. Do not use plastic sandwich bags and bread wrappers to freeze fruits and vegetables because they do not protect/seal the food properly and may cause freezer burn.

Fruits and vegetables are prepared and packaged differently for freezing.

Packaging fruits for the freezer

There are 3 ways to pack fruits for freezing: sugar-pack, syrup-pack, and unsweetened pack.

Sugar Pack

To freeze fruits using the sugar-pack method:

- Dissolve 1500 mg (1/2 teaspoon) of ascorbic acid in 2-3 tablespoons of cold water (or juice) for every 454mg (1lb) of sugar,
- Sprinkle the fruits with ascorbic acid before adding the sugar. Cut them into a clean bowl or shallow pan,
- Sprinkle sugar over the cut fruits,
- Stir with a clean long-handled spoon until the pieces are coated and the sugar is dissolved,
- Pack fruits and juice (drawn out of the fruits) in a container leaving 1-2.5 cm (½ - 1 inch) head space, and
- Freeze.

Syrup pack

To freeze fruits in syrup:

- Add 1500 mg (½ teaspoon) of powdered ascorbic acid to each quart of packing syrup before using it. To make sugar syrup, dissolve the amount of sugar needed in water, making sure it is mixed properly. Keep the syrup refrigerated until it is ready to be used,
- Pack the fruits into freezer containers,
- Leave 1-2.5 cm (½ -1 inch) headspace,
- Cover the fruits with syrup, and
- Freeze.

Packed blackberries: Photo by AFN

Unsweetened pack

To freeze fruits unsweetened:

- Add 3000 mg (1 teaspoon) of ascorbic acid to each quart of clean water,
- Spread sliced or cut fruits in a single layer on shallow trays,
- Sprinkle ascorbic acid mixture to fruits on trays,
- Place the trays in the freezer,
- Once the fruits are frozen, package the fruits, using clean utensils, and
- Return the packages to the freezer.

Thaw home-frozen fruits at room temperature or submerge packaged fruits in cool lukewarm water (if the package is airtight).

- For the container, leave 1 cm (½ inch) headspace at the top and seal, and
- For freezer bags, press air out after filling them, leaving about 7.5 cm (3 inches) from the top, and twist, fasten or tie about 2-2.5 cm (½ to ¾ inch) from food. This allows enough space for the food to expand.

To tray-pack:

- Place single pieces of blanched vegetables in a tray or shallow pan,
- Place the tray with the vegetables into the freezer,
- Remove the tray from the freezer once the individual pieces of vegetables are frozen,
- Place the vegetables into a freezer bag or container, leaving no head space,
- Seal the bags or containers, and
- Return the packages to the freezer.

Label the packages with the date and content before freezing. Properly frozen fruits can be kept for 8 to 12 months and vegetables for 12 to 18 months.

Most foods (other than combination foods such as stews, soups and casseroles) can be refrozen if ice crystals are still present and there is no odour being released. Foods thawed in cold water or the microwave should not be re-frozen unless they have been cooked prior to re-freezing.

Packaging vegetables for the freezer

There are two ways to pack vegetables for freezing: dry-pack and tray-pack. Vegetables need to be blanched for both packing methods (see Table 24 for drying method and blanching).

To dry-pack vegetables:

- Place drained blanched vegetables into containers or freezer bags,
- Pack the vegetables tightly into freezer bags or containers to reduce the amount of air in the bag/container,

Freezing game meat

To freeze game meat properly:

- Divide meat and package parts into small quantities, as it is easier to fit small packages in a freezer. Cut or rinse out bloody spots with cold water before freezing parts,
- Freeze carcasses or parts as soon as possible while they are still fresh,
- Use proper freezer bags to avoid "freezer burn",

- Wrap the meat tightly, pressing out as much air as possible before sealing and putting it in the freezer,
- Label packages with contents and dates, and
- Freeze and store meat at -18°C/0°F or lower.

Prior to freezing, it is important to package the meat properly, and in the right container to retain flavour, moisture, colour and nutrients. Use rigid containers with tightly fitted covers or flexible bags/wrappings that are:

- Durable and leak proof,
- Resistant to low temperatures, oil, grease, water, moisture, and vapour (e.g., waxed paper, laminated freezer wrap, heavy-duty aluminium foil, plastic freezer storage bags),
- Able to protect foods from off-flavours or odours, and
- Easy to seal and label.

If wrapped properly, frozen fresh game meat can be kept for between 9 and 12 months, frozen seasoned or cured game for up to 4 months, and frozen birds for up to 6 months.

Freezing fish

Preparing fish for freezing:

- Use only fresh, gutted, good quality, thoroughly cleaned fish,
- Raw fish should be separated to prevent cross-contamination,
- Cut and package fish in meal-size portions,
- Use waxed paper or freezer bag to freeze fish,
- Label and date the bag prior to freezing, and
- Freeze and store meat at -18°C/0°F or lower.

If fish is to be served raw, it is recommended to freeze it first to kill any parasites that may be present in the fish.

- freeze and store fish at -20°C/-4°F or colder for at least 7 days, or
- freeze and store at -35°C/-31°F or below for at least 15 hours
- freeze at -35°C/-31°F or below, and store at a temperature of -20°C/-4°F or below for 24 hours (Fraser, 2003, and USDA, 2011).

It is important to note that these conditions may not be suitable for fish with a thickness of 15cm (6 inches) or greater (USDA, n.d).

Freezing does not kill *all* the microorgamisms in fish; some are prevented from growing, but will grow back once the food is thawed. When food is being thawed, it is important to follow proper thawing methods (see Chapter 3).

Table 27. Recommended storage life for frozen fish

FISH	Recommended period for storage
Salmon, char, and trout	3 months
Cod, pike, and fish fillets	6 months
Northern pike, lake trout, and smelt	4 to 6 months
Bluegills, bass, crappies, and sunfish	7 to 9 months
Walleye and yellow perch	9 to 12 months

Canning/Bottling

The process of canning or bottling is sometimes called sterilization, because heat treatment of the food eliminates the microorganisms that can spoil the food. Sterilization uses a combination of high temperature and time to destroy nearly all microorganisms present in food. This process can affect the appearance, taste and nutritional content of the food. Canning is the most complicated method of preserving as there are greater chances of food spoilage if it is not done properly. Processing methods and times vary, depending on the ingredients, size of jar and even the altitude.

To can foods safely at home, use a boiling water-bath canner or a pressure canner (see Table 29). Any big metal container with a tight-fitting lid and a metal rack may be used as a boiling water-bath canner as long as it is deep enough for the water to cover the jars by at least 2.5 cm (1 inch) and still allow enough space (5-10 cm (2-4 inches) above the jar tops) for the water to boil them. Improper canning/bottling techniques can facilitate the growth of microorganisms such as mould and bacteria.

In canned foods, the most dangerous organisms are able to grow without air. The particular bacterium of concern is *Clostridium botulinum*. Botulism is the deadliest and rarest kind of foodborne illness and occurs every year in Canada. The toxin can be present without showing any signs of food spoilage.

To destroy *Clostridium botulinum*, low-acid foods such as game meat and vegetables (including vegetable mixtures, poultry, seafood, soups, stews, tomatoes, sauces, etc.) need to be heat-processed at temperatures of 116°C/240°F, and high-acid foods (fruits, fruit juices, jams, jellies, and other fruit spreads, tomatoes with added acid, pickles, relishes, etc.) at 100°C/212°F for the recommended time. A boiling water-bath can attain a heat level of only 100°C/212°F; therefore, a pressure canner should be used to can low-acid foods (vegetables and meats).

Important steps to consider when canning

- Use special jars made for canning (e.g., mason jars, as they have special caps/lids or jar rubbers that allow proper sealing),
- Inspect canning jars for signs of cracks or chips,
- Ensure that the jars are thoroughly washed in hot soapy water and rinsed well,
- Boil jars for 10 minutes to sterilize them if they are to be processed in a boiling water bath for less than 10 minutes,
- Jars that will be processed in the boiling water bath or pressure canner (for at least 10 minutes) do not need to be sterilized but must be washed in hot soapy water then rinsed and kept hot until filled and placed in the canner,
- Use a rack to prevent the jars from touching the bottom of the canner,
- Jars should be heated prior to filling them with hot food,
- Foods must be heated after they have been placed in the jars, as heat pushes out excess air out from the jars, which may prevent growth of some microorganisms,
- Ensure that jars are sealed properly,
- Once jars have been sealed, cool upright for at least 24 hours in a draft free place, on racks, dry towels, boards or newspapers,
- Contact with cold surfaces may cause the jars to break,
- Label jars with content and date, and
- Store in a cool, dry place.

Canning fruits and vegetables

Fruits and vegetables can be raw-packed or hot-packed in water, juice or syrup for canning (see table 28) (Clemson University, 2010; USDA, 2009; University of Georgia, 2000).

To make syrup packs:

- Mix water or juice extracted from some of the fruits with sugar and heat up to dissolve the sugar.
- Keep the syrup hot until it is ready to be used.
- Unsweetened commercial apple, pineapple or white grape juice diluted with water can be used to pack some fruits.

Table 28. Packing methods for canning fruits

STEPS	Canning Packing Methods	
	Raw-pack	Hot-pack
Place raw fruits tightly into jars.	√	
Cover the content of the jars with hot syrup, juice or water.	√	
Heat the fruits in syrup, water or juice briefly (for 2-5 minutes).		√
Make sure the solution reaches boiling or is close to boiling temperatures before adding the fruits.		√
Pack them loosely into the jars while they are still very hot.		√
Cover the content of the jars with syrup, water, or juice.	√	√
Leave at least 1 cm (½ inch) headspace between the food/liquid and the top of the jar.	√	√
Use a clean spatula around the inside of the jars to remove air bubbles.		√
Wipe the rims with a clean damp towel.	√	√
Place the lids on the jars.	√	√
Screw the metal screw bands on the jars.	√	√
Place the filled jars on a rack.	√	√
Preheat the water in the water bath canner to 60°C/140°F.	√	
Preheat the water in the water bath canner to 82°C/180°F.		√
Place the rack into the water-bath canner containing the hot or simmering water. For raw-pack, the water should not be boiling. Add boiling or simmering water to the water-bath canner to bring it to 2-5 cm (1-2 inches) over the top of the jars.	√	√
Cover the canner.	√	√
Start counting processing time after the water starts boiling.	√	√
Boil for the recommended time.	√	√
Remove the jars from the canner immediately after processing time is over.	√	√

While both the water bath canner and a pressure canner can be used to can fruits, only a pressure canner can be used to can vegetables safely (Table 29) (Clemson University, 2010; USDA, 2009; University of Georgia, 2000).

Table 29. Canning methods for fruits and vegetables

CANNING			
Canning methods	**Steps**	**Fruits**	**Vegetables**
Boiling water-bath	1. Assemble equipment and ingredients 2. Check canning jars (e.g., mason jars) for nicks, cracks, uneven rims or sharp edges that may prevent sealing or cause breakage 3. Check screw bands for proper fitting on the jars 4. Check SNAP Lids for scratches 5. Wash jars and lids in warm, soapy water 6. Rinse the jars well (See step 1- 5 from water bath 7. Place jars and lids on a rack in a boiling water bath canner 8. Cover jars with water and heat water to a simmer 180°F/82°C (not boiling) 9. Keep jars and lids hot 180°F/82°C until ready to be used 10. Prepare the food 11. Place the food into the jar 12. Leaving 2-3 cm (1-1¼) inches head space between the content of the jars and their lids 13. Remove air bubbles in the jars with a rubber spatula by sliding it between the jar and its content 14. Leave some headspace after removing air bubbles 15. Place the SNAP lids on the jars 16. Wipe the jars with a clean damp towel 17. Apply screw bands evenly and firmly 18. Place jars on the rack in 5-8 cm (2-3 inches) of water in the pressure canner into the boiling water canner 19. Make sure the water covers the jars by at least 2.5 cm (1 inch) 20. Place lid on canner and heat-process to recommended temperatures 21. Begin counting processing time once the water starts boiling 22. Turn off the heat once processing time is over 23. Remove the jars from the canner immediately (without tilting them)after the processing time is over	√	
Pressure Canner	1. Assemble equipment and ingredients 2. Check canning jars (e.g., mason jars) for nicks, cracks, uneven rims or sharp edges that may prevent sealing or cause breakage 3. Check screw bands for proper fitting on the jars 4. Check SNAP Lids for scratches 5. Wash jars and lids in hot, soapy water 6. Rinse the jars well 7. Verify the pressure canner to ensure that lid and gasket have airtight seal 8. Place rack in pressure canner 9. Add 5-7.5 cm (2-3 inches) of water 10. Place jars in canner 11. Heat the water to a gentle boil (180°F/82°C) 12. Keep jars in the hot water until ready to be used 13. Prepare food 14. Heat SNAP Lids in hot water (180°F/82°C). 15. Keep SNAP Lids hot until ready to be used 16. Pack food into the hot jars leaving 3 cm (1¼ inch) head space 17. Remove air bubbles in the jars with a non metallic utensil (e.g., rubber spatula) by sliding it between the jar and its contents 18. Readjust head space if required after removing air bubbles 19. Place SNAP lids on the jars 20. Wipe jar with a clean damp towel 21. Apply screw bands evenly and firmly 22. Place jars on rack in 5-7.5 cm (2-3 inches) of water in the pressure canner 23. Make sure the water covers the jars by at least 2.5 cm (1 inch) 24. Cover the canner with its lid and lock it leaving the vent open 25. Place the canner over a high heat source.	√	√

CANNING			
Canning methods	**Steps**	**Fruits**	**Vegetables**
Pressure Canner	**26. Heat up to at least 116°C/240°F (10 pounds pressure at sea level)** **27. Begin counting processing time once the water starts boiling** **28. Allow steam to escape steadily for 10 minutes (venting canner)** **29. Close the vent as described by the manufacturer** **30. Reduce the heat gradually to achieve and maintain the recommended pressure** **31. When processing time is complete, remove canner from heat source** **32. Let canner stand until the pressure drops to zero** **33. Remove the lid from the canner** **34. Remove the jars (without tilting them) from the canner.**	√	√

Canning game

Some foods contain high acid levels naturally while others such as meat, fish and poultry do not. Low-acid foods should be canned in a pressure canner to kill harmful bacteria. Bacterial cells are killed at boiling temperatures; however, spores can survive these temperatures. These spores grow well in canned low acidic foods which, when they germinate, can grow to high numbers producing botulinum toxins which can only be destroyed at pressure canner temperatures of 115°C-121°C/240°F-250°F (Maas-van Berkel, 2004). To can low-acid foods in a pressure canner, place jars of food in 5-7.5 cm (2-3 inches) of water in the canner. Heat the water to a minimum temperature of 116°C/240°F. For raw-packed foods, the water should be hot but not boiling. For hot-packed foods the water should be hot or gently boiling. Only game meat that was properly dressed and cooled should be canned.

Low acid foods include:

- Meat,
- Poultry,
- Fish and seafood,
- Soups and stews, and
- Vegetables.

High acid foods include:

- Fruits,
- Jams, jellies, marmalade, fruit spreads, sauces,
- Pickles, relish, salsa, chutneys, and
- Tomatoes.

Canning fish

- Use fresh, thoroughly cleaned, good-quality fish, removing any bruised or damaged flesh,
- Cut fish into sizes that will be able to fit in the jars,
- Pack solidly into clean, 1-quart jars, leaving at least 2.5 cm (1-inch) headspace between the jar sealing edge and the top of the food or liquid,
- Run a plastic knife around the inside of the jar to align the product; this allows firm packing of the fish,
- For most fish, it is not necessary to add liquid, salt or spices – although seasonings or salt may be added for flavour,
- Prior to sealing the jar, carefully clean the jar, wiping the edge with a damp paper towel,
- Wipe with a dry paper towel to remove any fish oil,
- Attach jar lids and rings, tightening the jar lids properly (if the rings are too loose, liquid may escape from the jars during processing, and seals may fail, and if the rings are too tight, air cannot vent during the processing resulting in discolouration during storage), and
- Over-tightening may also cause the lids to buckle and jars to break.

Ensuring safety while canning

- Fish to be canned needs to be prepared as quickly as possible, as fatty fish spoils quickly due to oxidative rancidity (Maas-van Berkel, 2004),

- Can fruits and vegetables within 6-12 hours after harvest,
- Do not use the open-kettle method or the microwave to can foods,
- Do not use store-bought food jars (e.g., mayonnaise or coffee jars) or lids from commercially canned foods to can food at home as they may break easily and not seal properly,
- Do not re-use the sealing lids to can foods because they become indented during the first use,
- Do not use jars with bails or glass caps to can food (these do not seal properly),
- Do not use one-piece, zinc porcelain-lined caps,
- Do not store jars above 32°C/90°F or near hot pipes, furnace, insulated attic, or direct sunlight, and
- Do not store jars in damp areas, as dampness may corrode metal lids, break seals, and may cause contamination.

Storing canned foods

- Home-canned food should be stored in a cool, dark place and at a temperature between 10°C-21°C/50°F-70°F. Storing in temperatures that are higher can lower the quality of the food.
- Date and label all foods.
- Foods preserved by canning or bottling are at immediate risk of spoilage once the can or bottle has been opened.
- Refrigerate cans, once opened.

Preserved Salmon

- Unopened canned foods can be stored for at least 1 year (use the 'first-in, first-out' rule meaning that the oldest cans should be used first)

Safety tips to consider

When canned foods are first opened there should be a popping sound. This indicates that the can was sealed properly. Before opening canned jars or eating from canned foods, check carefully for:

- Broken seal,
- Bulging lid,
- Leakage,
- Gas bubbles,
- Mould,
- Cloudy liquid,
- Unnatural colour,
- Unnatural smell,
- Soft, mushy or slimy food,
- Foaming or bad odour during cooking,
- Do not taste, or use food that shows any kind of spoilage, and
- When in doubt, throw it out!

Canned food should be heated before eating it to kill any bacteria that could be present such as Clostridium botulinum.

Aging

Aging helps enhance the flavour and tenderness of wild game. To age meat, the carcass or pieces of meat should be held at low, controlled temperatures 1°C-3°C/34°F-37°F for a maximum of two weeks to avoid bacterial growth. The number of days for aging varies on the type and the size of the animal. For instance, deer can be aged for 7 days and bull elk for 14 days. Avoid direct sunlight and age the carcass in the shade (Benson, 2003) and trim fat once the aging process is completed to avoid undesirable flavours associated with the fat.

Aging is not recommended when the animal:

- is not chilled rapidly and properly when it is shot in warm weather,
- is under 1 year of age,

- has little or no fat covering (may cause the carcass to dry out during aging), or
- was severely stressed prior to being killed (animal does not die immediately after killing).

To age meat with the hide on, use properly chilled game meat. Aged meat that has been skinned may become dry and lose weight.

In the winter, if the internal muscle temperature drops to 0°C/32°F within 12 hours of the kill, the frozen carcasses should first be thawed, and then aged at 1°C/34°F for 14 days.

To age wild birds, hang them by their feet in a cool dry and well-ventilated place for 2 to 3 days (below 4°C/40°F).

Summary

In summary, safe preservation methods require good hygiene and proper food handling, food preparation, food preservation and food storage practices.

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9. Preparing Foods for Large Groups

Cooking large quantities of food for large groups has its challenges. It is important to handle food properly to protect family members, friends, neighbours and clients. The improper handling of food may cause serious public health issues and can result in foodborne illnesses. Extra care should be taken to ensure that there is no potential foodborne illness outbreak at food establishments and during family or community gatherings (e.g., potlatchs, pow-wows, treaty days and sport competitions) (USDA, 2010).

Planning is an integral part of the preparation of cooking for large groups, and should be considered prior to obtaining (purchasing/gathering/hunting) and preparing food. It is essential to keep in mind what food will be cooked, where and how it will be cooked, and how and where it will be stored and served.

9.1 Obtaining Food

Purchasing

- Always buy food from a reliable supplier,
- Select cold foods last (e.g., meat, poultry, and eggs),
- Check foods for their expiry or "sell-by/use-by" dates,
- Check for foods that are properly packaged (leaking or torn packages may cross-contaminate other foods),
- Select frozen food that is properly frozen,
- Select cold food that is refrigerated and feels cold to touch,
- Buy clean and un-cracked eggs before the "sell-by/expiry" date,
- Buy only fresh fruits or vegetables,
- Buy fresh-cut fruits (e.g., melons, cantaloupe) that are on ice,
- Place meat, poultry, and seafood in plastic bags before placing them into the cart in order to prevent their juices from dripping to other food products,
- Keep raw meat, poultry, and seafood separate from other foods,
- Use clean bags or boxes to transport foods from the store/market,
- Use insulated bags to transport cold food (or a cooler if the drive back home will be over 2 hours, or 1 hour if temperature is above 32°C/90°F), and
- Refrigerate all perishable food within 2 hours of grocery shopping (USDA, 2008).

Wild game

- For game meat, ensure that the animal was properly dressed, stored, and transported safely to where it is being prepared, and
- Ensure that there are no signs of spoilage prior to preparing the meat.

9.2 Storage/holding

- Keep all foods in proper storage facilities as soon as they are received (store or refrigerator),
- Store cooked and raw food separately,
- Perishable and high-risk foods should be kept at the recommended temperatures that will protect against spoilage,
- Ensure that there is adequate refrigeration available for perishable foods, and
- Refrigerate perishable and high-risk foods immediately.

Potentially hazardous foods should be maintained at 4°C/40°F or lower or at 60°C/140°F or higher.

9.3 Preparation

In order to keep food safe, during preparation: clean, separate, cook, and chill foods properly (see Chapter

3). Good personal hygiene, proper, cooking and cooling practices should be followed.

Good hygiene for food handlers includes:

- Wearing clean clothes, aprons, and disposable gloves and hair nets (gloves must be changed when they are ripped or worn out),
- Washing hands and exposed areas of the arms with soap and warm running water for at least 20 seconds:
  - before, during, and after handling food,
  - when switching from raw to ready-to-eat foods,
  - when switching from raw to cooked foods,
  - after using the washroom, changing a child's diaper, smoking, or coming in from the outside,
  - after coughing, sneezing, or blowing the nose, and touching the hair and face,
  - after handling garbage and pets, and
  - after handling money.

Cross-contamination of foods occurs when foods are contaminated by other foods, culinary equipment, working surfaces and people.

Prevent cross-contamination

- Keep raw meat, poultry, seafood and their juices separated from raw (i.e., vegetables, fruit) and cooked or ready-to-eat foods,
- Limit food preparation areas to food handlers only,
- Use one cutting board for raw meat, poultry and seafood, and a second one for fruits, and vegetables,
- Store raw meat, poultry, and seafood separately, and in sealed containers (to prevent their juices from dripping on other food) in the refrigerator,
- Do not re-use marinating sauces that were used on raw meat, poultry or seafood on cooked foods unless these sauces have been boiled,
- Do not use the same spoon to taste and stir food. Wash it with hot soapy water before using it again, or use another spoon (CFIA, 2009; USDA, 2008),
- Avoid touching foods directly with bare hands. Use clean utensils, such as tongs, spatulas, and wooden spoons,
- Wash all cooking equipment, utensils, or food contact surfaces in hot soapy water and rinse well (including cutting/chopping boards), and
- Use clean paper towels or cloth to wipe spills.

9.4 Cooking

When cooking large quantities of food, it is essential to:

- Cook small quantities at a time, or ensure even cooking if using a large pot,
- Ensure that the food is cooked at the appropriate temperatures,
- Use a thermometer to measure the internal temperature of food (see Chapter 3), and
- Once the food is cooked, serve immediately, or cool it properly to reduce the chances of bacterial growth.

9.5 Cooling

To cool food safely and quickly:

- Cut large pieces into smaller pieces,
- Divide batch of food into smaller ones,
- Refrigerate food in shallow containers not more than 7-10 cm (3-4 inches) deep,

Placing too much hot food in the refrigerator can raise the temperature and prevent proper and fast cooling. To avoid this situation, use an ice-water bath to cool large amounts of food before refrigeration.

- Do not cover food right away during the initial cooling; it prevents fast cooling because heat and steam cannot escape from the food,
- Chill all ingredients of cold food (e.g., potato salad) before mixing them,
- Do not stack food containers for cooling; steam and heat cannot escape,
- Maintain the refrigerator temperature at 4°C/40°F or lower
- For large quantities of food, set the refrigerator at 0°C/32°F, and
- High-risk-foods should not be kept at room temperature for more than 2 hours (this includes preparation and serving time).

Ensure that the perishables are stored in a refrigerator as soon as possible (minimize the time spent in the car during shopping/transport). If possible, transport cold foods home in freezer bags/boxes, etc.

9.6 Transporting

If the food is not being served at the location where it is prepared, it is very important to ensure that safe food and handling practices are followed during transportation.

- Use insulated, closed carrying containers (e.g., ice sheets for cold foods),
- Vehicles used to transport foods should be in clean condition (food should not be transported in vehicles that have carried pets), and
- Once food is at the location, follow proper storage practices and re-heating/cooling practices until it is served.

9.7 Serving

Food should always be served at the right temperatures as warm foods facilitate bacterial growth. For safety and public health reasons, it is important to **hold hot foods hot** (60°C/140°F or higher), especially "high-risk foods" and **cold foods cold** (4°C/40°F or lower) until served.

Hot holding

To keep hot foods hot, use either:

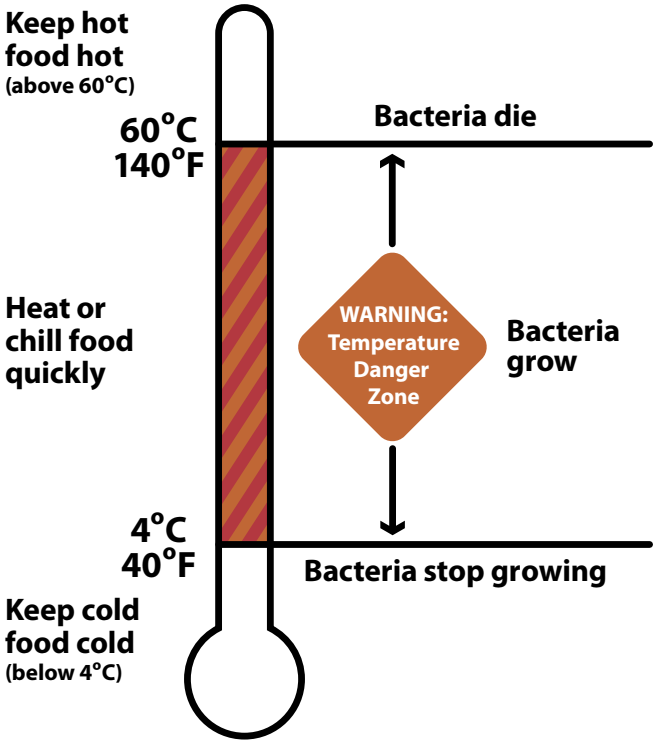
- electric hot trays,
- chafing dishes,
- steam tables,
- double boilers,
- heated cabinets, or
- bain maries.

Small candle warming units may not keep foods hot enough.

Ensuring safety of hot foods

- To maintain foods at 60°C/140°F, the temperature of the hot holding equipments/units needs to be higher,
- To ensure that the food stays at the recommended temperature throughout the event, use a food thermometer,
- Prepare "high-risk foods" no more than three hours before serving or reheat to the appropriate temperatures,

The temperature danger zone for food



- High-protein cooked foods such as meat, poultry, seafood and eggs should not be kept at room temperature for more than two hours (this includes the preparation, storage and serving time),
- Casseroles, gravies and meats are safest if they are maintained at a minimum temperature of 74°C/165°F or above,
- Reheat foods to an internal temperature of at least 74°C/165°F or higher and transfer them to the holding equipment, and
- Do not keep foods on hot holding for more than 2 hours.

Cold holding

To keep cold foods cold:

- Keep refrigerated until they are ready to be served,
- Place food (in container) on ice while it is being served, and
- Replace ice frequently and drain water.

Ensuring safety of cold foods

- Cold, ready-to-eat food should be put on a tray/pan before being put on ice,
- Keep ready-to-eat "high-risk foods" cold to keep dangerous bacteria from growing and making them unsafe for consumption, and
- Cold foods should not be left at room temperature for more than two hours (this includes the preparation, storage and serving time).

Safe serving

To serve foods safely:

- Use clean containers and utensils,
- Do not leave prepared foods in open containers for long periods of time,
- Replace foods often,
- Do not add fresh foods to foods that have been left sitting at room temperatures for long periods,
- Use gloves to handle utensils, cutlery, plates and cups,
- Do not use the same plates or platters that held raw meat, poultry or seafood to serve foods, and

Ice should be made with clean water or purchased from a reliable supplier.

- Do not leave cooked food at room temperature for more than 2 hours (1 hour when temperatures are at 32°C/90°F or higher).

9.8 Leftover foods

Leftover foods should be properly reheated to 74°C/165°F and kept or served at 60°C/140°F. Discard any food that has been left at room temperature for more than 2 hours (an hour if outdoor temperatures are at 32°C/90°F or higher).

To store leftovers:

- Divide large amounts of leftovers into small shallow containers, and refrigerate or freeze,
- Remove stuffing from stuffed poultry or meat, and refrigerate or freeze, and

Keep hot foods hot, and cold foods cold.

- Do not mix leftovers with fresh portions of food.

To reheat leftovers:

- Eat or use any leftovers kept in the refrigerator within 2 to 4 days (USDA, 2006),
- Reheat leftover foods at recommended temperatures,
- It is not recommended to reheat leftovers in slow cookers, steam tables or chafing dishes, and

- Reheated food should be served or held at 60°C/140°F until served.

Summary

It is important to prepare and serve foods safely for large groups during community gatherings, such as pow-wows, since food that is not handled properly can lead to serious foodborne illnesses (see Appendix A for a list of contacts in case of a foodborne illness outbreak).

Some of the leading causes of foodborne illness outbreaks when preparing for large groups include:

- Using foods from unknown/unsafe sources,
- Improper cooling of foods,
- Improper hot or cold holding (food not held at recommended temperature),
- Cross-contamination of foods (such as mixing of raw and cooked foods, and using unclean utensils to prepare foods),
- Improper re-heating of foods,
- Preparation of foods too early in advance,
- Foods left in the danger zone for a long period,
- Infected food handlers who practice poor personal hygiene, and
- Poor personal hygiene practices (NDSU, 2007).

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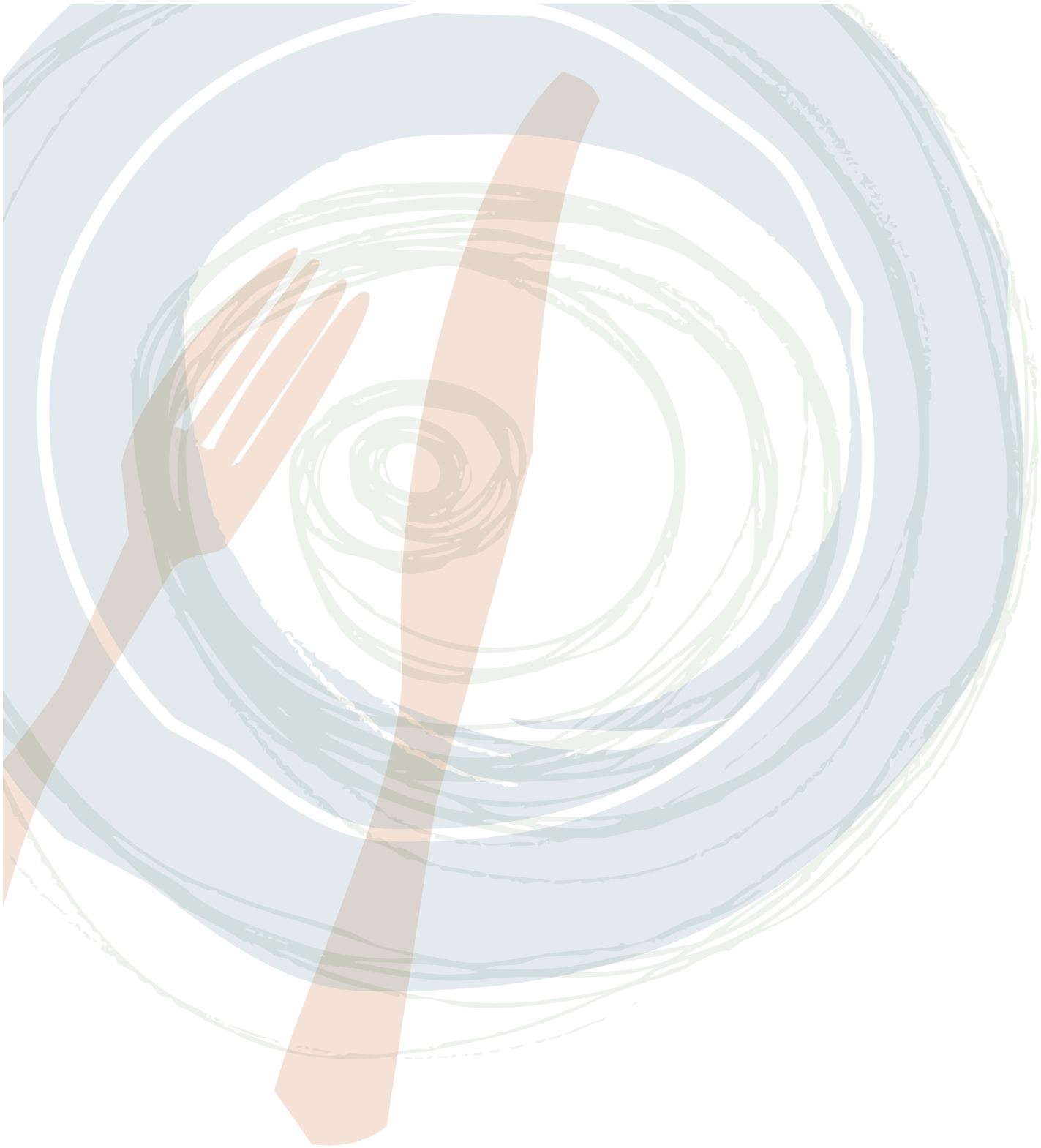

Appendix A

Contact List for the Canadian Food Inspection Agency

Office of Food Safety and Recall (OFSR)

Emergency number (613) 720-5087

Incoming fax: (613) 773-5999

Outgoing fax: (613) 773-5513

Mailing address: Canadian Food Inspection Agency, 1400 Merrivale Rd, Tower 1, Floor 7, Ottawa ON, K1A 0Y9

Area/Regional Recall Coordinators (ARC/RRC)

AREA / REGION	Emergency #	Fax #
Ontario	(416) 665-5049	(416) 665-5048
Manitoba	(204) 797-4501	(204) 984-6008
Saskatchewan	(306) 529-0671	(306) 780-5177
Quebec	1-866-806-4115	(514) 283-2163
Atlantic	(506) 381-7683	(506) 851-2801
Western - B.C. - Yukon	(604) 978-1120	(604) 666-9289
Western AB - N&S, NWT & Nunavut	(403) 661-7505	(403) 292-5692

Visit the CFIA website for more information on Food Recall and Emergency Responses at http://www.inspection.gc.ca/english/fssa/recarapp/recarappe.shtml

Glossary

Aerobic: Requires oxygen for growth and survival (e.g., *aerobic bacteria*).

Algal Bloom: The quick growth of certain types of microscopic algae on the surface of a body of water.

Anaerobic: Does not require oxygen for growth (e.g., *anaerobic bacteria*).

Ataxia: Loss of the ability to coordinate muscular movement.

Amebomas: An inflamed, tumour-like, spreading nodule that occasionally develops in chronic amebiasis, often in the wall of the colon. Also called *amoebic granuloma*.

Anthropogenic chemicals: Synthetic/Man-made chemicals.

Bacteraemia: The presence of bacteria in the blood.

Bioaccumulation: The increase in the concentration of a substance, especially a contaminant, in an organism or the food chain over time.

Bioavailability: The rate at which a substance is absorbed.

Biomagnification: The increase in the concentration of a substance, such as DDT, in the tissue of organisms at higher levels in the food chain.

Biota: The combined flora and fauna of a region.

Contaminant: The presence of an undesirable substance (physical, chemical or biological) that has found its way into foods and can pose health risks in certain amounts.

Cross-contamination: Transfer of harmful bacteria, parasites and viruses from a person, object or food preparation area onto food.

Danger Zone: The temperature range in which foodborne bacteria can grow. This is between 4°C-60°C/40°F-140°F.

Dysarthria: Difficulty in articulating words, caused by impairment of the muscles used in speech.

Dysentery: An inflammatory disorder of the lower intestinal tract, usually caused by a bacterial, parasitic, or protozoan infection and resulting in pain, fever, and severe diarrhea, often accompanied by the passage of blood and mucus.

Encephalitis: Inflammation of the brain.

Endotoxin: A toxin produced by certain bacteria and released upon destruction of the bacterial cell.

Enteritis: Inflammation of the intestinal tract, especially of the small intestine.

Exotoxin: A toxin secreted by microorganisms (e.g., bacteria) and released into the medium in which it grows.

Facultative: Used of certain organisms, such as bacteria that can live with or without oxygen.

Foodborne illness: Sickness caused by the ingestion of food containing microbial, chemical or physical hazards.

Foodborne Infection: Infection caused by the ingestion of food containing harmful microorganisms such as bacteria, which then grow in the intestinal tract and cause illness.

Foodborne Intoxication: Illness resulting from the consumption of foods that contain toxins.

Gastroenteritis: Inflammation of the stomach and intestinal tract that usually results in diarrhea.

Haul-out locations: A haul-out location is a coastal area where groups of pinnipeds (a family of animals with fin feet including seals, sea lions and walruses) habitually use to "haul" themselves out of the water. The area is used for rest and social interaction.

Harmful Algal Bloom: The excessive growth of certain types of microscopic algae, forming visible patches on the surface of a body of water, that may be harmful to the environment, plants and animals.

Helminth: A parasitic roundworm or tapeworm.

Histamine: A chemical released by cells that causes allergy-like symptoms.

Immune system: A protection mechanism in the body that defends against disease.

Immunocompromised: Incapable of developing a normal immune response, usually as a result of disease, malnutrition, or immunosuppressive therapy.

Incubation period: The time between the exposure to a pathogen or toxin and the onset of symptoms.

Jaundice: Yellowish discoloration of the whites of the eyes, skin, and mucous membranescaused by deposition of bile salts in these tissues. It occurs as a symptom of variousdiseases such as hepatitis, which affects the processing of bile.

Lacrimation: Secretion of tears, especially in excess.

Liver abscess: A pus-filled mass inside or attached to the liver.

Meningitis: Inflammation of the meninges of the brain and the spinal cord, most often caused by a bacterial or viral infection and characterized by fever, vomiting, intense headache, and stiff neck.

Myalgia: Muscular pain or tenderness, especially when diffuse and non-specific.

Mycotoxin: A toxin produced by a fungus, especially by mould.

Mydriasis: Prolonged abnormal dilation of the pupil of the eye caused by a disease or a drug.

Oedema: An excessive accumulation of fluid in tissue spaces or a body cavity.

Paraesthesia: A tingling sensation felt in a part of the body numbed from lack of circulation.

Parasite: An organism that lives on or in a host.

Pathogen: A germ (bacteria, viruses, parasites, fungus or prion) that causes illness

Peritonitis: Inflammation of the peritoneum, often accompanied by pain and tenderness in the abdomen, vomiting, constipation, and moderate fever.

Persistent Organic Pollutant: Chemicals that are not broken down over a period of time, usually measured in decades or more.

Phycotoxin: A toxin which is produced by an algae.

Phytoplankton: A microscopic algae that is usually unicellular.

Prion: An abnormal protein in the brain which is thought to be a transmissible agent responsible for certain spongiform encephalopathies, such as chronic wasting disease (CWD).

Psychotropic: Having an altering effect on perception, emotion, or behaviour.

Radionuclide: Any man-made or natural element which emits radiation in the form of alpha or beta particles, or as gamma rays.

Rookeries: Breeding places for sea birds or other marine mammals.

Sanitize: To kill or remove germs by cleaning or disinfecting.

Septic Shock: A condition of physiologic shock caused by an infection, especially sepsis or septicemia.

Septicemia: A systemic disease caused by pathogenic organisms or their toxins in the bloodstream; also called blood poisoning.

Shelf-life: The length of time in which a processed food remains fresh, before it begins to deteriorate.

Siphon: A tubular organ, in aquatic invertebrates such as squids or clams, where water is taken in or expelled.

Tachycardia: A rapid heart rate, especially one above 100 beats per minute in an adult.

Tenesmus: A straining to urinate or defecate, without the ability to do so.

Tomalley: The soft, green liver of cooked lobster, considered a delicacy.

Tonic-clonic: A type of generalized seizure that affects the entire brain.

Toxins: Poisonous substances.

Viscera: The soft internal organs of the body, especially those contained within the abdominal and thoracic cavities; the intestines.

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