9 Food Spoilage and Food Poisoning

Food Science and Technology Strand
9 Food Spoilage and Food Poisoning

9.1 Causes of food spoilage

9.1.1 Natural decay

9.1.2 Contamination by micro-organisms

9.2 Causes of food poisoning

9.2.1 Biological food poisoning

9.2.2 Bacterial food poisoning

9.2.3 Chemical food poisoning
9 Food Spoilage and Food Poisoning

Food Spoilage

Food spoilage can be defined as any decay or undesirable decomposition of constituents by excessive growth of micro-organisms or by other natural causes (physical or chemical changes). If food spoilage occurs, the food is unpalatable because the colour, taste and appearance have been changed, although the food may be unsafe.

9.1 Causes of food spoilage

The major causes of food deterioration can be classified as natural decay and contamination by micro-organisms.

9.1.1 Natural decay

(A) Moisture loss (dehydration)

When food is exposed to air for a long period of time, loss of moisture will occur due to evaporation. Excessive loss of moisture from foods causes dehydration, which affects both the appearance and texture of foods.

(B) Enzymatic activity

Enzymes produced by living things are protein in nature, which catalyse chemical reactions. Enzymes are present in any fresh foods that have living tissue, such as meat, fish, fruits and vegetables. They are also present in milk and eggs. Enzymatic activity is important for ripening of fruits and vegetables. Up to certain stages, enzymatic actions may be desirable, but its continuous action ultimately renders the food non-edible by bringing undesirable changes in food. These actions include browning of cut surfaces and development of off-flavours.

(i) Proteolysis

Cells contain proteolytic enzymes which hydrolyse proteins into amino acids, which is responsible for the ageing and spoilage of foods. Suitable action of proteolytic enzymes on meat produces tendering effect, which improve meat quality. However undesirable action of this enzyme causes spoilage of meat and production of off-flavour, which make food non-edible.
(ii) Enzymatic Browning

The phenomenon of some fruits and vegetables turning brown when damaged or when their cut is exposed to air is called enzymatic browning. Enzymatic browning of fruits and vegetables is a kind of enzyme-involved oxidation, which is due to the presence of enzymes, such as polyphenol oxidase (PPO). PPO converts polyphenol, which is naturally present in all kinds of fruits and vegetables, into a brown pigment called melanin. PPO is naturally separated from polyphenol in the intact cells. Damage or cut destroys cell structure and mixes the PPO and polyphenol together. With the presence of oxygen in the air, PPO converts polyphenol into melanin pigment. Therefore brown surfaces are formed.

(C) Chemical degradation within foods

Food will deteriorate through a series of chemical reactions, which are not catalysed by enzymes of tissues or micro-organisms. Atmospheric oxygen and even sunlight cause certain foods to undergo various undesirable chemical changes. Spoilage of lipids or lipid content of food is called rancidity. Oxidative rancidity is a reaction between unsaturated fatty acids in the triglycerides and oxygen from the air. Oxygen attacks the double bond of triglyceride and a variety of compounds are formed including aldehydes and ketones, which give rise to an unpleasant rancid smell. The reaction is accelerated by heat, light and traces of metals, such as copper and iron. Rancidity can be reduced by storing lipids in a cool, dark place in a non-metal container that is air-tight.

9.1.2 Contamination by micro-organisms

Food microbiology is the study of relationship between micro-organisms and food. Micro-organisms are very small, usually single-celled, organisms which are not individually visible to the naked eye. They can only be seen with the aid of a microscope. Micro-organisms are present in air, water, on most of the foods and our hands etc. Some of them, if present in food in large enough numbers, can cause food poisoning.

Micro-organisms are the main cause of food spoilage. However, not all micro-organisms are undesirable. In fact, they are essential to all forms of life since they break down complex organic matter and return nutrients to soil. Micro-organisms are used by man in production of certain foods, e.g. bread and yoghurt.

(A) Classification of micro-organisms

(i) Biological types:

The biological classification is based on their structure and they can be classified into 5 groups. It is sometimes more convenient to classify them according to their role in relation to human beings.
(ii) Functional types:

In functional classification, they can be classified into 4 groups:

❖ Pathogens

These are micro-organisms which cause disease. All viruses are pathogenic but only some are pathogenic to humans. Certain bacteria also cause disease in human. Some of these diseases can be transmitted by food, e.g. food poisoning, cholera and typhoid.

❖ Spoilage micro-organisms

These micro-organisms do not cause disease but they spoil food by growing in the food and producing substances which alter the colour, texture and odour of the food, making it unsafe or unsuitable for human consumption. Examples of food spoilage include the souring of milk, the growth of mould on bread and the rotting of fruits and vegetables.

❖ Beneficial micro-organisms

Many micro-organisms have a beneficial effect and can be used to serve humans. The important part that these micro-organisms play in our everyday life may not be realised by us.

❖ Micro-organisms are essential to life since they are responsible for the rotting or decay of organic matter. The complex organic components of dead plant and animals are broken down by microbial activity into simpler, inorganic compounds which are made available for new plant growth, and the whole cycle of life is able to continue.

❖ Micro-organisms are used at various stages during the manufacture of certain foods. Their activities are essential in the production of foods such as bread, beer, wine, cheese and yoghurt.
Food Spoilage and Food Poisoning

- Antibiotics, such as penicillin, are substances used to destroy pathogens in the body. Many are produced as a result of microbial activity. For example, penicillin is obtained from a mould called *Penicillium*.

- Inert micro-organisms

  This group includes those micro-organisms which are neither harmful nor beneficial to humans. Commensals are organisms which live in humans but do not cause disease in the part of the body where they are normally present. For example, *Streptococcus faecalis* is a bacterium which is harmless in its normal habitat, the large intestine. However, some commensals can be pathogenic if they are spread to areas of the body where they are not normally found. *Streptococcus faecalis*, for example, causes disease if it infects the kidneys.

Although it is convenient to use a functional classification, it must be emphasised that this is not always appropriate. An individual micro-organism may, in different circumstances, fall into each of the four groups. For example, the bacterium *Escherichia coli* is generally considered to be inert. However, in some cases it may be pathogenic since it can cause food poisoning. Certain strains of *E. coli* can cause food spoilage without causing illness.

**(B) Bacteria**

Bacteria are living single-celled organisms and are generally considered to be the most important causative agents of foodborne illnesses. Bacteria grow fast in foods that are warm, moist, protein-rich and low in acid, such as milk, eggs, poultry, fish, meat and shellfish. Most bacteria are not harmful to us while some can make people ill by living and multiplying inside human bodies (e.g. *Salmonella, Listeria monocytogenes*). Others (e.g. *Staphylococcus aureus, Bacillus cereus*) produce toxins in foods and people fall ill because of the toxins when they eat the foods. However, the mere presence of the organism in food may not cause the disease. The amount of organism present is important.

Bacteria are the most common causes of food spoilage, which are more difficult to be killed than moulds and yeast. They are present in active form (vegetative stage) or resting form (spore stage). In vegetative stage, bacteria are destroyed at boiling temperature but spores are difficult to be destroyed and require application of heat for a long time. Heating for 6 hours at boiling temperature (100°C) may be required to destroy the spores or they can be killed in 30 mins at 121°C under 10 lbs pressure.

In foods with high-acid content (all fruits, tomatoes, pickles etc), all forms of bacteria are sensitive to acids and can be killed easily in acidic pH at a temperature of boiling water. So foods with high-acid content are processed at 100°C whereas low-acid foods such as meat, corn, peas, beans and all vegetables except tomatoes have to be processed at a higher temperature (116°C) in pressurized steam to kill bacteria at a faster rate. The temperature maintained and the length of time the food is held vary with each kind of food. Some of the moist heat-resistant bacteria are present in the soil, hence, preparation and processing of root vegetables require special care. *Clostridium botulinum* causes spoilage in canned foods.
Bacteria are destroyed under different temperature/time combination. In general, cooking food to an internal temperature of 75°C for at least 30 seconds can kill most of the pathogenic bacteria (but not the spore form).

(i) Factors influencing the bacterial growth

Environmental factors that influence the growth of bacteria are:

❖ Food: Each kind of bacteria has a definite range of food requirements. For some species, the range is wide and growth takes place in a variety of substances, e.g. coliform bacteria, whereas for other bacteria the range is narrow and they can grow in only a limited number of food substances, e.g. many of the pathogenic bacteria.

❖ Moisture: Concentration of moisture in food is an important factor in preventing or allowing the bacterial growth in the food. Bacteria require more moisture than yeasts or moulds.

❖ Temperature: Each bacteria has an optimal temperature at which it grows best. Temperature below and above the optimum adversely affects the growth of bacteria. There are three types of bacteria according to temperature tolerance:

  ✤ Psychrophilic – which grows well at refrigerator temperature (below 10°C)
  ✤ Mesophilic – grows best at medium temperature between 16°C and 38°C.
  ✤ Thermophilic – the term thermophilic means ‘heat loving’. These are found in soils, in manure and compost, etc. These are spore-forming bacteria. They can grow best at temperature as high as 82°C and they can grow slowly up to 100°C.

❖ Hydrogen ion concentration or pH: pH determines the kind of bacteria to grow in the food and the changes produced. Most bacteria grow best at pH near neutral while some can grow in an acidic pH. A few kinds of bacteria can grow in either fairly acidic or alkaline media.

❖ Oxidation reduction potential

On the basis of their process of respiration bacteria are classified as:

  ✤ Aerobic bacteria: They must require free oxygen for growth.
  ✤ Anaerobic bacteria: They do not require free oxygen and grow better in the absence of oxygen.
  ✤ Facultative bacteria: They can grow either with or without free oxygen.
  ✤ Microaerophilic bacteria: They require definite, but small amount of free oxygen.
Inhibitory substances

During the process of growth, bacteria produce certain substances which will in time slow down or stop the growth of bacteria and may inhibit the multiplication of other organisms. Inhibitory substances added during the processing of foods may check the growth of most micro-organisms or at least the undesirable ones, e.g. propionates added to bread inhibit the growth of bacteria.

(C) Yeasts

These are microscopic unicellular organisms which are non-motile round or oval. Fungi are usually known as yeast. Yeasts reproduce or multiply by a characteristic process of "budding". The bud when fully mature, breaks away from the mother cell and becomes independent and repeats the process of multiplication. Yeasts require less moisture and acidic pH to grow and do not grow in alkaline medium. They grow well in diluted sugar solution and acidic medium.

Yeasts are very useful in making bread, beer, wine, vinegar and many other fermented products. The yeast causes fermentation of sugars and converts them into alcohol and CO$_2$. This property is very important in the preparation of alcoholic beverages and in baking.

\[
\text{Yeast} \xrightarrow{\text{Fermentation}} \text{CO}_2 + \text{C}_2\text{H}_5\text{OH}
\]

Yeasts are responsible for fermentation of fruits and fruit products, e.g. sometimes the cork of a juice bottle is popped out or the juice bottle is shattered to pieces with great force, it is due to CO$_2$ generated in the process of fermentation. So yeasts are undesirable when they grow on fruits, juices, sharbat, honey, etc. They spoil the appearance, taste, texture and wholesomeness of fruits and fruit products. During active fermentation, yeast can be recognised by formation of bubbles or foam on the surface of the product. Some of the yeasts which grow on fruits are Saccharomyces, Candida, etc. Yeasts grow very well under moderate temperature (25-30°C) in solution containing sugar and plenty of water. Most of the yeasts usually do not grow in media containing more than 65% of sugar or 0.5% acetic acid. Heating at 60°C for a few minutes is sufficient to destroy most species of yeasts. Boiling destroys yeast cells and spore effectively.

(D) Moulds

Moulding of food is quite common. A slice of moist bread or a piece of orange left for a time will be covered with a whitish or greyish cottony matter. This is mould. They are larger and more complex in structure than bacteria or yeast. Moulds are made up of mycelia and spores. They grow in a network of hair like fibres called mycelia that form fruiting bodies to yield spores.

They thrive best in close, damp and dark situation and require adequate supply of warmth, moisture and air for growth. They are aerobic in nature (require free oxygen)
and require less available moisture and can grow well at 25-30°C. Moulds prefer sugar containing substances like jam, jelly, preserves and other sweet based products. They can grow at a wide range of pH (2 – 8.5) but the majority grow well at acidic pH. Therefore, they grow nicely on pickles, juices etc. They can grow on many kinds of food especially when temperature, air and humidity are favourable. Their growth can be seen only on the surface of food; they do not only consume nutrients present in the food thereby lowering the food value but also produce undesirable by-product which spoil the flavour, taste and texture of food hence changing the quality attributes of the entire product.

The majority of moulds are sensitive to heat and are destroyed at 60°C when heated for 30 mins. Boiling quickly destroys both mould and their spores. Some of the common moulds are Aspergillus, Penicillium, Rhizopus and Helminthosporium.

(E) Infestation by insects, parasites and rodents

Insects, worms, bugs and fruit flies may damage food stuffs such as cereal grains and fruits and vegetables and render them unsafe or unsuitable for human consumption. The injuries caused by these insects serve as pathways by which micro-organisms reach the inner tissue and cause spoilage in the food.

Parasites are organisms that live in or on another living organism, which is called the host. Parasites include single-celled organisms and worms. Human beings may be infected with single-celled parasites (e.g. Giardia lamblia) through consumption of contaminated water and food such as raw vegetables. Parasitic worms have more complex life cycles. Immature worms need to pass through an animal host (e.g. freshwater fish and snails) before it can infect the final host (e.g. human beings, dogs and cats). Human beings may get infected with parasitic worms through consumption of undercooked meat, freshwater fish and freshwater snails. Examples are tapeworms, Clonorchis sinesis and Angiostrongylus cantonensis respectively.

(F) Physical/ Mechanical damages

Physical damages of foods can be caused by freezing, poor selection of packaging material, poor handling during transportation and storage. Sometimes fruits are bruised and scratched during harvesting and transportation. If precautions are not taken, the injured spots may become points of entrance to micro-organisms which cause spoilage.

Though heat and cold play a role in food preservation, they will contribute to deterioration of food if not controlled. Excessive heat brings about protein denaturation and destruction of vitamins. Several fruits and vegetables deteriorate even at the temperature of refrigerator (4°C). Sometimes some fruits and vegetables at refrigerated temperature deteriorate in a way called “chill injury”. Chill injury is characterised by development of mealiness (perhaps courseness), accelerated softening and non-uniform surface colour development, and usually becomes apparent only after later exposure to higher temperatures. Freezing may also cause deterioration of liquid foods, for example, the emulsion in milk will be broken down and water and fat will be separated. Freezing also denatures the milk protein by clotting the protein into small clumps.
(G) Control of micro-organisms

The most important means of controlling the growth of bacteria, yeast and mould are by heat, low temperature, drying, acid, sugar, salt, smoking, chemicals and radiation.

Foods can be classified into three groups based on the ease of spoilage.

<table>
<thead>
<tr>
<th>Class</th>
<th>Examples:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stable or non-perishable</td>
<td>Sugar, salt, flour, grains and dry products</td>
</tr>
<tr>
<td>Semi-perishable foods</td>
<td>Potatoes, onions, breads</td>
</tr>
<tr>
<td>Perishable foods</td>
<td>Meat, fish, poultry, eggs, milk, some fruits and vegetables</td>
</tr>
</tbody>
</table>

Food poisoning

Food poisoning is caused by the consumption of food or drinks contaminated with pathogens (including bacteria, viruses and parasites), bacterial or biochemical toxins or toxic chemicals. Affected persons usually show gastrointestinal symptoms like nausea, abdominal pain, diarrhoea and vomiting, although other symptoms like fever may also develop. The incubation period varies from hours to days depending on the causative agent. Food which can cause food poisoning may appear harmless, i.e. the colour, taste and appearance are normal and there is no evidence of spoilage.

9.2 Causes of food poisoning

There are three causes of food poisoning:

- Biological - Poisonous Food
- Bacterial - Microbes
- Chemical

9.2.1 Biological food poisoning

Foods containing harmful substances can be poisonous. There are many species of poisonous mushrooms, they may cause illness and in some cases death. These mushrooms are very similar in appearance to the edible variety and may easily be eaten by mistake.

Deadly nightshade, which grows throughout Europe and Asia, contains a drug belladonna in all parts of the plant. The drug is used to relieve illness such as asthma, bronchitis and heart disease. However, it may be lethal if this medicine is taken in large doses and there were cases where children have been poisoned by eating the berries of the plant.
Potatoes are also members of the nightshade family and green potatoes contain a substance called solanine which causes illness or even death if eaten in large quantities. Therefore, green potatoes should always be discarded.

Raw red kidney beans contain a toxic substance called haemagglutinin. A number of cases of poisoning have occurred as a result of cooking the beans in a slow cooker at an insufficient high temperature. Boiling the beans for 10 minutes destroys the toxin. Canned kidney beans are heated sufficiently during processing and are therefore safe.

Certain moulds are capable of causing illness by producing toxins in foods known as mycotoxins. The mould *Aspergillus flavus* produces aflatoxins. This has been found in groundnuts (peanuts), figs, cereals and some other foods. High level of aflatoxin consumption is associated with liver cancer.

Some ciguatera fish contains biochemical toxin, such as marine coral reef fish. Consumption of such biochemical toxin may cause numbness in limbs, face, tongue or around the mouth, cold objects perceived as hot and vice versa, dizziness, palpitation and chest pain.

### 9.2.2 Bacterial food poisoning

Bacterial food poisoning is an acute illness caused by the consumption of food contaminated by bacterial pathogens. It is the most common cause of food poisoning and stringent hygiene precautions must be taken in order to prevent outbreaks of this type of illness. Since most food poisoning incidents occur as a result of unhygienic practices, this means that they are preventable.

**(A) Three main types of bacterial food poisoning include:**

(i) The infective type which is caused by eating food containing a large number of living bacteria. After being eaten, the bacteria establish themselves in the alimentary canal and when they die they release an endotoxin (e.g. *Salmonella* poisoning).

(ii) The toxin type which is caused by eating food containing exotoxin. The toxin is released into food while the bacteria are growing and multiplying in the food. The bacteria themselves may be dead when the food is eaten. (e.g. *Staphylococcal* poisoning).

(iii) The third type is also caused by toxin. The toxin is not produced in the food but is released into the alimentary canal after the bacteria have been eaten and while they are growing in the alimentary canal. (e.g. *Clostridium perfringens* poisoning)
Although there are various kinds of bacterial food poisoning, the following are the most prevalent:

<table>
<thead>
<tr>
<th>Pathogenic Bacteria</th>
<th>Growth Temperature Range*</th>
<th>Common Foods Involved</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salmonella spp.</td>
<td>6.5 – 47°C (35 - 37°C)</td>
<td>Raw or undercooked egg and egg products (e.g. Tiramisu); undercooked meat, poultry and their products (e.g. barbecued and preserved meat, goose intestines, etc.).</td>
</tr>
<tr>
<td>Staphylococcus aureus</td>
<td>7 – 45°C (37°C)</td>
<td>Foods which have been subject to a large amount of handling with no subsequent cooking or reheating (e.g. lunch boxes, cakes, pastries, sandwiches, etc.).</td>
</tr>
<tr>
<td>Vibrio parahaemolyticus</td>
<td>12.8 – 40°C (37°C)</td>
<td>Raw or undercooked seafood, shellfish, marine products and salted food (e.g. jellyfish, cuttlefish, salted vegetables and smoked knuckles, etc.).</td>
</tr>
<tr>
<td>Bacillus cereus</td>
<td>10 – 49°C (30 - 37°C)</td>
<td>Leftover cooked rice, fried rice, meat products and vegetables.</td>
</tr>
<tr>
<td>Clostridium perfringens</td>
<td>10 – 52°C (43 - 47°C)</td>
<td>Cross-contaminated and inadequately cooked meat and meat products (e.g. stew and meat pies, etc.).</td>
</tr>
</tbody>
</table>

* Optimal growth temperatures are shown in brackets
[Note: For further details about the above bacterial food poisoning and other types of food poisoning, please refer to Table 9.2]

(B) Common Contributing Factors to Bacterial Food Poisoning

(i) Contamination of Cooked Food

Cooked food has been contaminated by food handlers, raw food or pests.

(ii) Improper Storage of Cooked Food

Cooked food has been stored between 4°C and 60°C for a prolonged period.

(iii) Inadequate Cooking of Food

Raw food has not been cooked thoroughly to reduce any pathogen present.
(iv) **Inadequate Reheating of Cooked Food**

Cooked food has not been reheated to 75°C.

(v) **Inadequate Thawing of Food Before Cooking**

Partially thawed food still has a high bacterial count or pathogen content and which needs a longer time to reach the temperature that kills the bacteria and pathogens in cooking, has not been cooked for sufficiently long time.

(vi) **Preparation of Food Too Early In Advance**

Food has been prepared too early in advance but has not been stored under proper controlled temperature.

(vii) **Infected Food Handlers**

Food handlers infected with communicable diseases have engaged in handling food.

(viii) **Consumption of Raw Food**

Raw food that usually has a high bacterial count or pathogen content has been eaten.

(ix) **Use of Unsafe Food Source**

Food has been purchased from an unauthorised or unreliable source such as hawkers.

(x) **Use of Leftovers**

Use of leftover foods (e.g. cooked rice) that have been stored between 4°C to 60°C for a prolonged period.

9.2.3 **Chemical food poisoning**

Chemical food poisoning is caused by the presence of toxic chemicals in food. These substances may be agricultural chemicals, which are used intentionally in crop production. The use of weedkillers and insecticides is essential to ensure food yields. However, some of these substances may be dangerous if used indiscriminately, since they may be toxic if they are consumed in large doses. Weedkillers and insecticides are tested very thoroughly before they are placed on the market and farmers are given detailed instructions as to their proper use.

Poisoning may also be caused by the accumulation of certain metals (e.g. lead, mercury and cadmium) in the body. High levels of mercury and cadmium have been found in fish taken from waters polluted by industrial waste. Cases of lead poisoning have arisen as a result of drinking water that has passed through lead pipes.
In addition, food poisoning may be caused by organic mercury compounds, notably methyl mercury. Between 1953 and 1960, 52 people in the Japanese town of Minamata died and about 100 suffered serious brain damage as a result of eating fish containing high levels of methyl mercury. Investigations showed that the source of mercury was effluent from a local chemical factory. The effluent contained inorganic mercury but this was converted into methyl mercury accumulated in the fish and shellfish living in the bay. Altogether about 900 people showed symptoms of methyl mercury poisoning, as well as many of the seabirds and cats of the area.

Outbreak of organic mercury poisoning have also occurred in Iraq and Guatemala where farmers who had received grain seeds treated with an organic mercury fungicide ate the seeds instead of planting them.

In Spain, during 1981 and 1982, over 350 people died and 20,000 were ill as a result of consuming olive oil which was deliberately contaminated with a chemical.

<table>
<thead>
<tr>
<th>Types of Food Poisoning</th>
<th>Causative Agent</th>
<th>Incubation / Onset Period</th>
<th>Symptoms</th>
<th>Source</th>
<th>Common Foods Involved</th>
<th>Prevention</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bacterial Food Poisoning</td>
<td>Vibrio parahaemolyticus</td>
<td>usually 12-24 hours, range 4-30 hours</td>
<td>diarrhoea, abdominal pain, nausea, vomiting, fever</td>
<td>marine environment, seafood, shellfish</td>
<td>raw or undercooked seafood, shellfish, marine products and salted food (e.g. jellyfish, cuttlefish, salted vegetables and smoked knuckles, etc.)</td>
<td>proper storage, temperature and duration of display, thoroughly cook seafood, avoid eating raw seafood, proper storage of cooked food to avoid cross-contamination</td>
</tr>
<tr>
<td></td>
<td>Salmonella spp.</td>
<td>usually 12-36 hours, range 6-72 hours</td>
<td>abdominal pain, diarrhoea, nausea, vomiting, fever</td>
<td>domestic and wild animals, poultry, pigs, cattle, eggs</td>
<td>raw or undercooked egg and egg products (e.g. Tiramisu), undercooked meat, poultry and their products (e.g. barbecued and preserved meat, goose intestines, etc.)</td>
<td>thorough cooking, avoid using unpasteurised eggs to make pastry and desserts</td>
</tr>
<tr>
<td>Types of Food Poisoning</td>
<td>Causative Agent</td>
<td>Incubation / Onset Period</td>
<td>Symptoms</td>
<td>Source</td>
<td>Common Foods Involved</td>
<td>Prevention</td>
</tr>
<tr>
<td>-------------------------</td>
<td>----------------</td>
<td>--------------------------</td>
<td>----------</td>
<td>--------</td>
<td>------------------------</td>
<td>------------</td>
</tr>
<tr>
<td>Bacterial Food Poisoning</td>
<td>Staphylococcus aureus</td>
<td>usually 2-4 hours, range 30 minutes to 8 hours</td>
<td>nausea and vomiting (prominent), abdominal pain, diarrhoea</td>
<td>human skin, hair, nasal cavity, throat, wounds</td>
<td>foods which have been subject to a large amount of handling; with no subsequent cooking and reheating (e.g. lunch boxes, cakes, pastries, sandwiches, etc.)</td>
<td>✴ strict compliance to good food, personal and environmental hygiene</td>
</tr>
<tr>
<td></td>
<td>Bacillus cereus</td>
<td>1-6 hours if vomiting is predominant; 6-24 hours if diarrhoea is predominant</td>
<td>nausea and vomiting; or diarrhoea and abdominal pain</td>
<td>an ubiquitous organism in soil and environment</td>
<td>leftover cooked rice, fried rice, meat products and vegetables</td>
<td>✴ refrigerate leftovers promptly</td>
</tr>
<tr>
<td></td>
<td>Clostridium perfringens</td>
<td>usually 10-12 hours, range 6-24 hours</td>
<td>diarrhoea, abdominal pain, nausea</td>
<td>soil, gastrointestinal tract of healthy people and animals</td>
<td>inadequately cooked meat and meat products (e.g. stew and meat pies, etc.)</td>
<td>✴ proper storage temperature</td>
</tr>
<tr>
<td></td>
<td>Clostridium botulinum</td>
<td>usually 12-36 hours for foodborne botulism</td>
<td>blurred or double vision, dysphagia, dry mouth, paralysis; vomiting and constipation / diarrhoea</td>
<td>soil, gastrointestinal tract of animals</td>
<td>canned food and meat products</td>
<td>✴ proper processing and preparation of canned and preserved foods</td>
</tr>
<tr>
<td></td>
<td>Campylobacter spp.</td>
<td>usually 2 to 5 days, range 1 to 10 days</td>
<td>diarrhoea, abdominal pain, malaise, fever, nausea and vomiting</td>
<td>animals, mostly found in poultry and cattle</td>
<td>undercooked chicken and pork, unpasteurised milk</td>
<td>✴ thorough cooking, ✴ use pasteurised milk</td>
</tr>
<tr>
<td></td>
<td>E. coli O157:H7</td>
<td>1-10 days (median 3-4 days)</td>
<td>severe watery diarrhoea, bloody diarrhoea, fever, abdominal cramps or vomiting</td>
<td>mostly found in cattle, intestines of humans and mammals like deer</td>
<td>food and water can be contaminated with E. coli O157:H7 due to contact with cattle faeces, undercooked and raw foods, such as minced beef, hamburgers, unpasteurised dairy products, vegetables and alfalfa sprouts etc.</td>
<td>✴ ensure that vegetables for raw consumption are obtained from reliable sources, ✴ the outer leaves from vegetables such as lettuce and cabbage should be discarded prior to washing. They should then be immersed in water for an hour and washed thoroughly, ✴ thorough cooking, ✴ good personal hygiene and proper food handling techniques will minimise the chance of transmitting this bacteria via the faecal-oral route.</td>
</tr>
<tr>
<td>Types of Food Poisoning</td>
<td>Causative Agent</td>
<td>Incubation / Onset Period</td>
<td>Symptoms</td>
<td>Source</td>
<td>Common Foods Involved</td>
<td>Prevention</td>
</tr>
<tr>
<td>------------------------</td>
<td>-----------------</td>
<td>--------------------------</td>
<td>----------</td>
<td>--------</td>
<td>-----------------------</td>
<td>------------</td>
</tr>
</tbody>
</table>
| **Bacterial Food Poisoning** | Listeria monocytogenes | 3 to 70 days, median 3 weeks | meningoencephalitis and / or septicemia, particularly in newborn, elderly and immunocompromised people; fever and abortion in pregnant women | soil, forage, water, mud and silage; infected domestic and wild mammals, fowl and people; asymptomatic carrier in human | unprocessed or contaminated milk, soft cheese, vegetables and ready-to-eat meat, salad, cold food dishes | - pregnant women and immunocompromised individuals should avoid soft cheese and cold cut  
- use only properly cooked meat and pasteurized dairy products |
| **Viral Food Poisoning** | Norwalk-like viruses (Norovirus) | usually 24-48 hours, range 10-50 hours | nausea, vomiting, diarrhoea, abdominal pain, fever | contaminated water or shellfish, particularly filter feeders such as oysters and clams | raw or partially cooked shellfish | - proper storage temperature and duration of display  
- thoroughly cook shellfish  
- avoid eating raw shellfish  
- proper storage of cooked food to avoid cross-contamination |
| **Chemical Food Poisoning** | Clenbuterol | 30 minutes to 6 hours | tachycardia, tremor, hypertension, and muscle-relaxing effects | veterinary drug | contaminated pig’s offal or pork | - purchase pig’s offal or pork from licensed and reputable suppliers |
| **Pesticide Poisoning** | Organophosphorus e.g. Methamidophos | up to 12 hours, usually within 6 hours; onset is often fast | mild exposure: headache, fatigue, dizziness, loss of appetite with nausea, stomach cramps and diarrhoea, blurred vision associated with excessive tearing, rippling of surface muscles just under the skin severe poisoning: incontinence, unconsciousness and seizures | vegetables and fruits contaminated by agricultural pesticides | agricultural commodities such as leafy vegetables and fruits | - buy vegetables and fruits from reputable shops  
- wash and immerse vegetables and fruits in clean water for 1 hour |
<p>| | Carbamates | | | | | |
| | Organochlorine | can occur soon after exposure | nausea and vomiting, apprehension, excitability, dizziness, headache, disorientation, weakness, a tingling or pricking sensation on the skin and muscle twitching | | | |
| | Pyrethroids (synthetic) | onset is often fast (the main effects of Pyrethroids have been shown to be reversible) | skin irritation like stinging, burning; very large doses may rarely cause muscle incoordination, tremors, salivation, vomiting, diarrhoea and irritability to sound and touch | | | |</p>
<table>
<thead>
<tr>
<th>Types of Food Poisoning</th>
<th>Causative Agent</th>
<th>Incubation / Onset Period</th>
<th>Symptoms</th>
<th>Source</th>
<th>Common Foods Involved</th>
<th>Prevention</th>
</tr>
</thead>
</table>
| Paralytic Shellfish Poisoning  
( most common shellfish poisoning) | Toxic Algae  
-Dinoflagellates:  
Alexandrium spp.,  
Gymnodinium catenatum,  
Pyrodinium bahamense that produce saxitoxin, neosaxitoxin | onset of symptoms is rapid; there are some severe cases that may result in respiratory arrest within 24 hours of consumption of the toxic shellfish | tingling, numbness, and burning of the perioral region, ataxia, fever, rash and staggering | shellfish contaminated with phycotoxins that are produced by free-living micro-algae, upon which the shellfish feed | bivalve shellfish such as oysters, clams, mussels, fan shells, scallops, etc. | - buy shellfish from reputable and licensed seafood shops  
- eat a smaller amount of shellfish in one meal  
- avoid eating the viscera, gonad and roe |
| Diarrheic Shellfish Poisoning | Toxic Algae  
-Dinoflagellates:  
Dinophysis spp., and Prorocentrum lima that produce okadaic acid and dinophysistoxin-1 | symptoms usually begin within 30 minutes to a few hours after consuming contaminated shellfish | diarrhoea, nausea, vomiting, chills, and moderate to severe abdominal pain and cramps | shellfish contaminated with okadaic acid and dinophysistoxin-1 |
| Neurotoxic Shellfish Poisoning | Toxic Algae  
-Dinoflagellates:  
Gymnodinium breve that produces brevetoxins | after 3 to 6 hours, symptoms tend to be mild and may resolve quickly | tingling of facial muscles, cold and hot sensory reversal, bradyardia and dilation of pupils | shellfish contaminated with brevetoxins |
| Amnesic Shellfish Poisoning | Marine diatoms:  
Nitzschia (or Pseudonitzschia) – P. pungens, P. australis and P. pseudodelicatissima that produce domoic acid | 15 minutes to 36 hours | vomiting, abdominal cramps, diarrhoea, headache and in particular a short-term memory loss | shellfish contaminated with domoic acid |
<table>
<thead>
<tr>
<th>Types of Food Poisoning</th>
<th>Causative Agent</th>
<th>Incubation / Onset Period</th>
<th>Symptoms</th>
<th>Source</th>
<th>Common Foods Involved</th>
<th>Prevention</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ciguatera Fish Poisoning</td>
<td>Toxic Algae -Dinoflagellates: possible Gambierdiscus toxicus produces ciguatoxin</td>
<td>several hours after consuming toxic fish</td>
<td>vomiting, diarrhoea, numbness of extremities, mouth and lips, reversal of hot and cold sensation, as well as muscle and joint aches</td>
<td>fish containing ciguatoxin (usually, fish feed and dwell at coral reef are more likely to contain ciguatoxin)</td>
<td>most common in grouper, snapper, barracuda, kahala, and moray eel</td>
<td>✗ eat fewer coral reef fish &lt;br&gt; ✗ eat small amount of coral reef fish at any one meal &lt;br&gt; ✗ avoid eating the roe, liver, guts, head and skin of coral reef fish &lt;br&gt; ✗ avoid consuming alcoholic beverages, nuts and seeds when eating coral reef fish or when suffering from ciguatera fish poisoning &lt;br&gt; ✗ buy coral reef fish from reputable and licensed seafood shops and those caught from safe harvesting area</td>
</tr>
<tr>
<td>Scombroid Fish Poisoning</td>
<td>Histamine</td>
<td>a few minutes to an hour after consuming the affected fish</td>
<td>metallic, sharp or peppery taste, intense headache, dizziness, nausea, vomiting, facial swelling and flushing, burning throat and diarrhoea</td>
<td>fish containing histamine, deteriorated fish because of failed temperature control at some point between capture and consumption</td>
<td>most common in the member of Scombroidea family (tunas and mackerels)</td>
<td>✗ buy fish from reputable and licensed seafood shops &lt;br&gt; ✗ proper handling of fish, including rapid chilling of fish after death, maintenance of low temperature during storage and where possible during processing</td>
</tr>
</tbody>
</table>
Food Spoilage and Food Poisoning
1 Family and Lifestyle
2 Consumer Behaviour in Food Choices and Implications
3 Health and Nutrition
4 Chemistry of Foods
5 Diet and Meal Planning
6 Food Commodities
7 Food Preparation Technology
8 Food Hygiene
9 Food Spoilage and Food Poisoning
10 Food Preservation Technology
11 Food Culture
12 Food Science and Technology Extended Study
13 Food Product Development