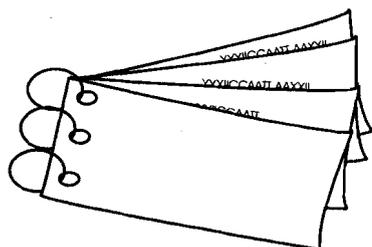


UNIT 2 MICROORGANISMS AND FOOD SAFETY



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- Microorganisms can be found everywhere in nature — even in our bodies.
- Microbes occur most abundantly where they find food, moisture and a temperature suitable for growth and multiplication.
- Microorganisms can be of different types. Bacteria, viruses, fungi, protozoa are some of the major groups of microorganisms posing food safety problems for us.
- It is important to know about the general characteristic of microbes in order to understand how they cause disease in man and animals. It also gives us an idea about how to prevent those diseases.

2.1 Bacteria

- Bacteria are single-celled microscopic organisms surviving in a wide range of temperature and pH conditions.
- Bacteria vary in size between 0.2 and 100 micrometers but most are approximately 0.5 to 1.0 micrometer in diameter. Some bacterial cells are surrounded by a viscous substance forming a covering or envelope around the cell wall. Some bacteria also have hair-like structures called flagella protruding through the cell wall helping the bacteria to move.
- Depending on the species, the bacteria may be spherical (cocci, singular coccus), rod-like (bacilli, singular bacillus) or helical (spirilla, singular spirillum) in shape. Furthermore, in some species of bacteria, cells are arranged in groups. Commonly found groupings: pairs (e.g. diplococcus), chains (e.g. streptococcus), clusters (e.g. staphylococcus), filaments (e.g. streptomyces).
- Bacteria exhibit wide differences with respect to the physical conditions favouring their growth such as temperature, pH, gaseous environment. Most

disease-causing bacteria grow best within a temperature range of 25°C to 40°C. Optimum pH lies between 6.5 and 7.5.

Hazardous bacteria

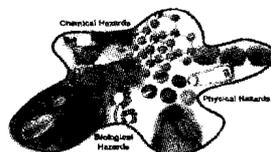
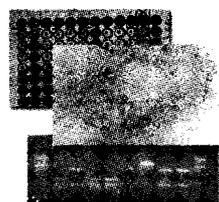
- A number of food-borne disease outbreaks are caused by bacteria. Some of these lead to loss of human life.
- Bacteria result in illness either by their action in the host's body or by producing toxins. Thus the food-borne disease can be because of infection (e.g. cholera, salmonella infection) or poisoning (e.g. toxins produced by *Clostridium botulinum* and *Staphylococcus aureus*)
- Pathogenic bacteria which have caused major food poisoning outbreaks are listed in the following table.

Table 2.1: Pathogenic Bacteria Causing Major Food Poisoning Outbreaks

| Bacteria | Mode of transmission | Reservoir/Carrier | Foods implicated | Symptoms of poisoning |
|---|---------------------------------|--|---|---|
| <i>Bacillus cereus</i> | Contaminated food and beverages | Soil | Cooked rice, cooked meats, vegetables, starch puddings, raw milk, dairy products | Diarrhoea, abdominal cramps, and nausea, vomiting, fever and body aches occasionally |
| <i>Staphylococcus aureus</i> | Contaminated food and beverages | Man | Raw milk, raw and cooked meats, custard or cream filled pastries, egg foods, cheese, prawns, salads | Nausea and vomiting with occasional abdominal cramping and diarrhoea. |
| <i>Escherichia coli</i> (several strains) | Contaminated food and water | Man | Raw milk, ground meat products, undercooked meat, cheese and raw vegetables | Diarrhoea, abdominal cramps, bloody stools and vomiting. Serious illness can result in renal failure in children. |
| <i>Campylobacter jejuni</i> | Contaminated food and water | Chickens, dogs, cats, cattle, pigs, wild birds | Fish, meat, vegetables | Diarrhoea, inflammation of the intestinal wall |
| <i>Clostridium botulinum</i> | Contaminated food and water | Soil, mammals, birds, fish | Cooked meat, fish and poultry, fruits, vegetables, | Severe form of food poisoning caused by neurotoxin, |

(Table contd.)

| Bacteria | Mode of transmission | Reservoir/Carrier | Foods implicated | Symptoms of poisoning |
|------------------------|-----------------------------|-------------------|---|--|
| | | | canned or bottled foods | which can result in death due to respiratory failure |
| <i>Salmonella spp.</i> | Contaminated food and water | Man and animals | Meat, poultry, raw milk, eggs | Gastroenteritis |
| <i>Shigella spp.</i> | Contaminated food and water | Man | Shellfish, raw vegetables, salads, cream filled bakery products, ice cream and cheese | Diarrhoea, stools containing blood, mucous and pus |
| <i>Vibrio cholerae</i> | Contaminated food and water | Man, marine life | Shellfish, salads | Cholera (rice water stools) |



2.2 Viruses

- Viruses are very small and can be seen only with an electron microscope and they cannot be grown on artificial laboratory media unlike bacteria which can be grown on such media. Viruses require living cells to grow and reproduce.
- Viruses are as small as 0.015 to 0.2 micrometers. Size and shape are characteristic properties of each type of virus.

Hazardous Viruses

- Viruses infecting our intestinal tract are shed in extremely high numbers in faeces of infected individuals. Viruses are therefore present in high numbers in raw waste water and current water treatment practices fail to ensure their complete removal.
- Exposure to enteric viruses occur through various routes: shellfish grown in contaminated waters, food crops grown on land irrigated with waste water and/or fertilized with sewage, sewage-polluted recreational waters (swimming pools) and contaminated drinking water.
- Viruses cause a wide variety of illnesses. The following table describes viruses that are hazardous for human health.

Table 2.2: Viruses Implicated in Food – borne Diseases

| Illness | Causative agent | Foods usually involved | Other modes of transmission | Signs and symptoms |
|------------------|--|---|-------------------------------------|--|
| Polio – myelitis | Poliovirus types I, II, III | Milk; possibly other beverages and prepared foods | Case or Carrier; contaminated water | Fever; vomiting; headache; pain in muscle groups; paralysis of leg |
| Hepatitis A | Hepatitis A Virus | Milk and other beverages; shellfish (raw oysters and clams) | Case or Carrier; contaminated water | Jaundice in approximately one – half of cases; loss of appetite; gastro – intestinal disturbance |
| Gastroenteritis | Norwalk or Norwalk-like viruses | Shellfish, salad ingredients, water, ice, eggs and ready-to-eat foods | Case or Carrier; contaminated water | Nausea, vomiting, diarrhoea, stomach cramps |
| | Enteric adenoviruses | Contaminated food or beverages | Case or Carrier; contaminated water | Persistent diarrhoea, nausea and vomiting |
| | Rotaviruses, Adenoviruses, Caliciviruses, Astroviruses | Contaminated food or beverages, raw shellfish | Case or Carrier; contaminated water | Fever, headache, abdominal pain, vomiting and watery diarrhoea |

2.3 Fungi

- Fungi comprise moulds and yeasts. Whereas moulds are multicellular, yeasts are usually unicellular.
- Moulds refer to multicellular, filamentous fungi. The moulds consist of a mass of branching, intertwined filaments called hyphae and the entire mass of these hyphae is known as the mycelium. The hyphae may grow within the food or into the air above the food.

- Moulds reproduce chiefly by means of spores. They survive difficult conditions and when conditions permit they germinate like seeds into new moulds.
- Food, moisture, warmth and oxygen are some of the basic requirements for growth of moulds. Mould growth is favoured only when moisture content of the food is more than 15 percent. Optimal temperature for most moulds to grow is between 25^o C to 30^o C. But moulds can grow at temperatures as low as -5 to -10^o C.
- Moulds take a longer time to start growing on a food as compared to bacteria and yeasts. So when conditions are favourable for growth of all three, moulds usually lose out in the competition. However, once they start growing, their spread is very rapid.
- *Hazardous moulds* produce toxic mycotoxins. Aflatoxin has been implicated as an agent causing liver damage and cancer. Ergot alkaloids cause ergotism with symptoms of nausea, vomiting, giddiness and sleepiness. Trichothecenes have been implicated in acute human diseases with symptoms of gastrointestinal upset, nausea, vomiting and diarrhoea. Fumonisin have been linked to cancer of the oesophagus. Zearalenone affects the reproductive system. Patulin irritates the stomach causing nausea, vomiting, haemorrhage and ulceration. Ochratoxin A is very toxic affecting mainly the kidneys. Mycotoxins that may be significant in food are described in the following table:

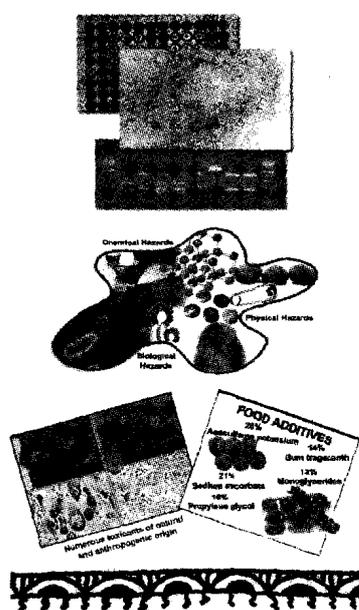


Table 2.3: Mycotoxins that may be significant in foods

| Mycotoxin | Some moulds producing the toxin | Foods or feeds isolated from |
|---|--|---|
| Aflatoxins | <i>Aspergillus flavus</i> , <i>A. parasiticus</i> , some <i>Penicillium</i> species | Barley, corn, cottonseed, millet, oats, peanuts, peanut meal, peanut butter, rice, soyabeans, wheat, spaghetti, cassava, cottonseed meal, cow – peas, sorghum, peas, sesame, soyabean meal, sweet potatoes. |
| Ergot alkaloids | <i>Claviceps</i> species | Pearl millet, wheat, sorghum and rye |
| Deoxynivalenol and other trichothecenes | <i>Fusarium</i> species | Grains like wheat, barley, oats, rye, maize, sorghum and rice |
| Fumonisin | <i>Fusarium</i> species | Maize |
| Zearalenone | <i>Fusarium</i> species | Cereals like wheat, barley, rice, maize, etc. |
| Patulin | Some <i>Penicillium</i> species | Apple sap, apple cider, apple juice |
| Ochratoxin A | Some <i>Aspergillus</i> and <i>Penicillium</i> species | Corn, wheat, barley, white beans, peanuts, dough, bread, hen's eggs |

2.4 Yeasts

- Yeasts are unicellular differing greatly in size and shape. Yeast growth on a food can be seen as either a film on the surface of liquids or coloured spots on food.
- Most common yeasts grow well when there is plenty of moisture available. They require less moisture as compared to bacteria but more moisture than most moulds. They are also able to grow in high concentrations of salt or sugar. The range of temperatures for growth of most yeasts is similar to that of moulds with optimum around 25°C to 30°C and maximum about 35 to 47°C. Yeasts grow best under aerobic conditions and in slightly acid medium (pH 4 to 4.5).
- A variety of yeasts cause spoilage of food products. *Torulopsis sphaerica* ferments lactose and may spoil milk products; *Candida* species spoil butter, margarine and foods high in acid and salt.
- *Rhodotorula* causes discolouration of a number of foods. *Saccharomyces* species of yeast cause spoilage of dry fruits, concentrated fruit juices, honey, maple syrup and other high sugar or salt solutions.

2.5 Protozoa

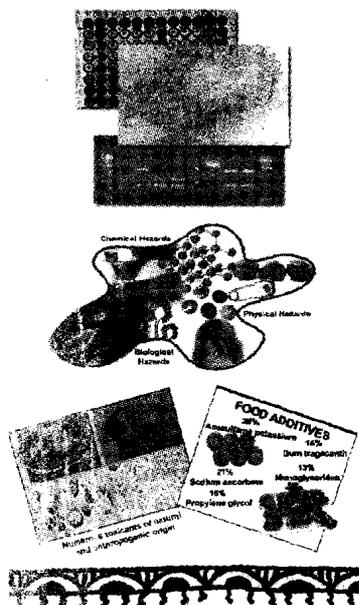
- Protozoa occur generally as single cells without cell walls. They have the ability to move at some stage of their life cycle.
- The size and shape of protozoans vary considerably. Size varies between 5 and 250 micrometers in diameter. Movement may be aided by contraction of fibrils or using cilia or flagella.
- Protozoa are found in all moist habitats. Moisture, temperature, light and available nutrients influence growth. For a majority of protozoa, a pH range of 6.0 to 8.0 and a temperature between 16 and 25°C is optimal for maximum metabolic activity. Most can survive adverse environmental conditions by forming a resistant cyst or going into a dormant stage.

Hazardous Protozoa

The following table describes the parasitic protozoa causing food safety problems.

Table 2.4: Parasitic Protozoa Causing Food Safety Problems

| Protozoa | Reservoir/Carrier | Transmission | Symptoms | Incriminated foods |
|-------------------------------|-------------------|---|---|----------------------------------|
| <i>Cryptosporidium parvum</i> | Man, animals | Contaminated food and water, person-to-person | Watery diarrhoea, abdominal cramping, and lack of appetite. | Raw milk, raw sausage |
| <i>Entamoeba histolytica</i> | Man | Contaminated food and water, person-to-person | Dysentery with diarrhoea, weakness, nausea and vomiting | Vegetables, fruits |
| <i>Giardia lamblia</i> | Man, animals | Contaminated food and water, person-to-person | Diarrhoea, flatulence, Greasy stools that tend to float, stomach cramps, nausea. | Vegetables, fruits |
| <i>Toxoplasma gondii</i> | Cats, pigs | Contaminated food and water, animal-to-man | Swollen lymph glands or muscle aches and pains, fever, damage to the brain, eyes, or other organs in severe infection | Undercooked meat, raw vegetables |



Some more details about these protozoa can be listed:

- Cryptosporidiosis is an illness in which the parasite *Cryptosporidium parvum* is present in the intestinal tract. The parasite produces cysts which are passed in the stool/ faeces. The protozoan can also spread directly or via objects contaminated with faeces. It can be transmitted by sexual contact.
- Amoebiasis is caused by *Entamoeba histolytica*. It is characterized by diarrhoea sometimes severe enough to cause death. The organism is usually transmitted by water or food contaminated with human faeces.
- Giardiasis is caused by the *Giardia* parasite which lives in the intestine of infected humans or animals. It is spread through contamination by faeces. Since the parasite is protected through an outer shell, it can survive outside the body and in the environment for long periods of time. Eating contaminated food or swallowing recreational water can cause infection.
- Toxoplasmosis caused by *Toxoplasma gondii* becomes serious in pregnant women or individuals with compromised immune systems. Touching hands to the mouth after coming into contact with cat faeces or handling undercooked meat or drinking water contaminated with the parasite can cause infection.

Key Terms

Aerobic: Requiring oxygen or air for survival and growth

Asexual reproduction: Not involving the fusion of male and female gametes

Carrier: Person harbouring the disease-causing microbe but not suffering from the disease

Case: Person suffering from a disease

Gastroenteritis: Inflammation of the stomach and intestines

Meiosis: Type of cell division that results in daughter cells with half the chromosome number of the parent cell

Mycotoxin: Toxic substances produced by moulds

Parasite: An organism living at the expense of another organism (called the host)

Pathogenic: Disease-causing

Reservoir: A reserve or source of microbes

Sauerkraut: Dish of chopped pickled cabbage



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