UNIT 5 FOOD HAZARDS OF MICROBIAL ORIGIN

Structure

5.1 INTRODUCTION

Food is liable for contamination during the various stages of production to consumption cycle i.e. growth, harvesting, procuring, transporting or even during storage and distribution. The contaminant can be a physical agent, a chemical agent or a biological agent as you may recall studying in Unit 2. The consumption of such contaminated foods is likely to cause adverse health effects to the consumers and hence referred to as "food hazards". It is found that most of the food borne diseases are due to microbiological contamination of the food. In recent years, a number of bacteria, viruses and parasites have emerged as food borne pathogens which have resulted in numerous food borne disease outbreaks. These outbreaks have had a major impact in terms of loss of human lives and economic costs. In this unit, we will try to

understand about the food borne diseases and their causative agents, how to control them and how to investigate and report a food borne disease.

Objectives

After studying this unit, you will be able to:

- classify and describe the food borne diseases,
- enumerate the various food borne infections, intoxications and toxic infections,
- discuss about the causative agents and methods to control them, and
- report and investigate the food borne diseases.

5.2 FOOD BORNE DISEASES

Food borne diseases are caused by the ingestion of foods containing toxic or infectious agents. In India, the diseases transmitted by food are commonly referred to as *food poisoning*. *Food poisoning,* in other words, is the term used to refer to *the harmful effects of consuming food contaminated by microorganisms.*

Food borne disease outbreaks in the community are of common occurrence, both in the developed and developing countries. A food borne disease outbreak is defined as *an incident in which two or more persons experience a similar illness, usually, gastrointestinal, after the ingestion of a common food which is identified as the source of food borne illness.* You would be interested to know that more than 250 different food borne diseases have been described. Most of these diseases are infections, caused by a variety of bacteria, viruses and parasites that can be food borne. Other diseases are poisonings, caused by harmful toxins or chemicals that have contaminated the food, for example, poisonous mushrooms. Certain moulds also produce toxins, called *mycotoxins*, in the food they attack. All these can lead to illness. Food borne disease has been termed as the most widespread health problem in the contemporary world and an important cause of reduced economic prosperity. It is said that occurrence of a number of food borne diseases is next only to common cold. In developing countries, the exact magnitude of the problem of food borne diseases is not fully recognized. It is estimated by the World Health Organization (WHO) that the ratio of actual to reported cases of food borne diseases varies from 25:1 to 100:1.

In India, the food borne diseases are rarely recorded and when recorded, most often they are categorized under *gastroenteritis* (inflammation of the stomach and small and large intestines). As the effects of food borne diseases are mild and relatively of short duration, the affected persons ignore them and are not aware of the linkage of their illness to the foods consumed. On most occasions, they do not take medical help. Even if they seek medical aid, it will be on an individual basis, except in rare cases, where a large number of people are affected simultaneously.

How then can we recognize a food borne disease? What are its usual symptoms? Food borne diseases, generally involves a disturbance of the gastrointestinal tract, with abdominal pain, diarrhoea and sometimes vomiting. Symptoms of food borne illness range from mild gastroenteritis to life-threatening neurologic, hepatic and renal syndromes.

Next, what are the different types of food borne diseases? What are the factors responsible for the outbreak of these diseases? In the subsequent sub-section, we will learn about these crucial aspects.

5.2.1 Types of Food Borne Diseases

You already know that food borne diseases or food poisoning is a condition resulting from eating contaminated food. The disease causing culprits are the microorganisms

or pathogens including fungi, bacteria, parasite or virus. You would realize that some pathogens produce toxins in food which when consumed can cause illness. On the other hand, pathogens may be present in food, which when consumed, may produce a toxin in the gut or invade and destroy the healthy tissues. Accordingly, food borne diseases are classified into three categories, namely:

i) food intoxications

ii) food infections, and

iii) food borne toxic infections.

Food infection generally involves microorganisms present in the food at the time it is consumed. Once inside the human body, they begin to grow and cause disease. *Salmonellosis,* caused by the bacteria *Salmonella,* commonly associated with chicken or egg, is an example of food borne infection. *Food intoxication*, on the other hand, involves toxic substances produced in the food by microorganisms, before it is consumed. The toxin present in the food makes the person feel sick. *Staphylococcus aureus* food borne disease is an example of illness that results from the consumption of toxins in food. The third category i.e. *food borne toxic infections* are caused by the ingestion of a large number of enterotoxigenic strains of bacteria which, while multiplying in the intestine produce and release enterotoxins in the intestines.

Apart from the three categories given herewith, you would come across certain moulds and fungus which produce toxins in the food they attack. The toxins produced by the moulds are called *mycotoxins*. Poisoning caused by ingestion of a food or feed that contains a mycotoxin is called *mycotoxicosis*. Examples include aflatoxins found in peanuts and sometimes in maize, rice and sorghum. Ergot fungus is associated with bajra, jowar and rye. This fungus produces toxins which result in *ergotism*. In addition, there are a few naturally occurring toxins in food which can cause illness. We shall study in details about these food borne diseases in the next section/sub-sections, starting with food intoxicants.

5.3 FOOD BORNE INTOXICATIONS

Food borne intoxications or poisonings are caused by either the:

i) ingestion of toxicants that are found in the tissues of certain plants or animals, or

ii) toxins formed and excreted by bacteria and fungi while they multiply on or in foods, as well as toxins formed and excreted by algae and ingested and concentrated by shell fish during their growth in sea water, or

iii) poisonous substances that may be intentionally or incidentally added to foods during producing, processing, transporting or storing.

The most important bacterial food borne intoxications are: (a) *Staphylococcal* poisoning (b) *Bacillus cereus* poisoning, and (c) *Botulism.* Let us learn about these intoxications.

5.3.1 Staphylococcal Poisoning

Staphylococcal food poisoning is one of the most frequently reported food borne diseases, which is common throughout the world. The disease is caused by the ingestion of the enterotoxin formed in food, during the growth of certain strains of *Staphylococcus aureus,* as they multiply in protein-rich foods. The toxin is referred to as *enterotoxin*, because it is a toxin produced by bacteria that is specific for intestinal cells and causes gastroenteritis i.e., inflammation of the lining of the intestinal tract.

Staphylococcus aureus is a small, 0.5-1.0 mm in diameter, gram-positive, non-motile, non-spore forming, coccus or a spherical cell, which divides to form irregular clusters of cells resembling bunches of grapes as you can see in the Figure 5.1. It is aerobic and facultative anaerobic, with an optimum growth temperature around 35°C- 37°C and is capable of growing within the temperature range of 7°C-48°C.

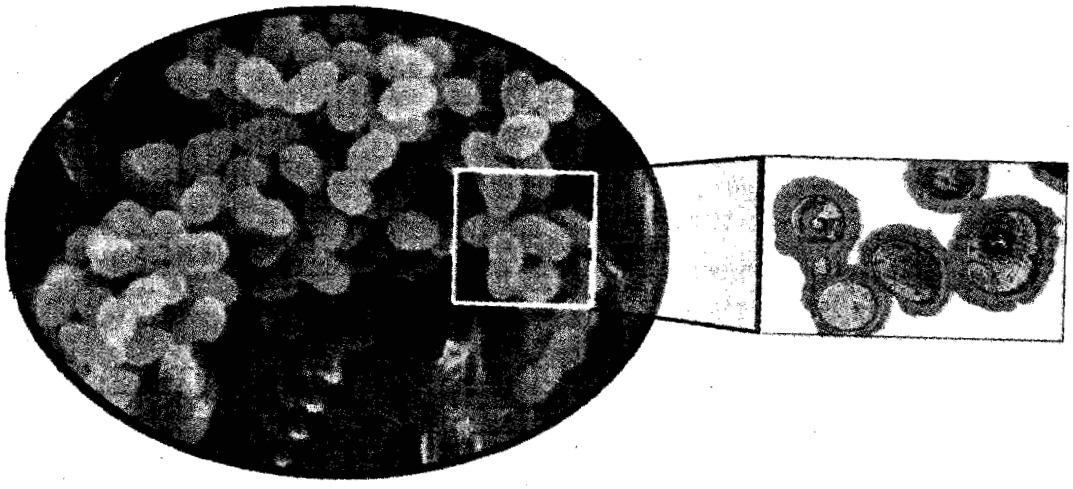

Figure 5.1: Staphylococcus aureus

Under optimal conditions, the organism doubles every 20 minutes after one hour lag. *Staphylococcus aureus* can tolerate foods containing 15% - 20% salt, as it has a low water activity (a_w) level (0.86). Enterotoxin produced by it are designated as A, B, C_1, C_2, D and E, the commonly identified toxins involved in the outbreaks are A and D. The toxins can be detected only during the late exponential or stationary phase of growth. Small amounts of toxin, about 1 gm, can cause the illness in sensitive persons.

The toxins are heat stable in their crude form. They are able to withstand boiling temperatures in a food for several minutes upto 30 minutes. A number of commercial sterilization processes such as normal cooling process, spray-drying and pasteurization have found not to inactivate the toxin. The organism itself is not heat-resistant and will be destroyed by pasteurization.

After the ingestion of a contaminated food, the symptoms appear within 1 to 6 hours and in most cases, between 2 to 4 hours. The period is dependent on the dose ingested, greater the enterotoxin ingested, shorter is the time for appearance of the symptoms. Onset is heralded by nausea followed by vomiting and abdominal cramping. Other symptoms may include fever and chills, weakness and headache, but do not last for long, usually from less than one day to two days. Mortality in the case of *Staphylococcus aureus* toxin is low, but a few fatal cases have been recorded in the children and elderly. The treatment for poisoning is usually symptomatic, which includes oral or intravenous administration of fluids.

The most important source of *Staphylococcus aureus* is man. The principal reservoir is the nose, followed by hair. It is harboured on human skin especially on cuts, burns, boils etc. which can cause contamination of foods. So its *presence in cooked or processed foods can serve to indicate poor hygiene among food handlers*. The foods involved in *S. aureus* food poisoning are typically those that have been handled and then temperature-abused prior to consumption. The common foods implicated in the outbreaks are raw milk, raw meat, custard, cream, bakery foods, poultry and ham, egg foods, fermented meat and dairy products. In India, the dairy product "khoa", the major sweet base, has been involved in several outbreaks.

Animals can also act as a source of *S. aureus*. The udder and teat canal in cows and buffaloes are the common sites of the organism.

It is not possible to totally eliminate the *Staphylococci* out of foods, as they are present almost everywhere. Therefore, only preventive measures have to be undertaken to minimize the risk by inhibition of *Staphylococci* from multiplying and producing the toxin. Some strains of *S. aureus* are capable of producing heat stable toxins in food. It is this toxin that causes the typical symptoms associated with food poisoning, which we had studied earlier. So let us now look at some of the measures which could decrease the risk of infection. These are:

1) Keep the handling of cooked foods to a minimum.
2) Once the food is prepared, it should be held at temperatures above 56°C.
3) Cooling of foods rapidly and storing chilled foods in shallow containers at temperatures below 7°C.
4) Processing of foods within a time span of 1 to 2 hours, in which *Staphylococci* are in the lag phase.
5) Minimizing the cross-contamination from raw to cooked foods and also by taking precautions to avoid contamination from working surfaces, equipments and utensils.
6) The personnel handling the foods have to take good personal care adopting hygienic practices. They should wear disposable gloves, wherever possible.

With this we come to end of our discussion about Staphylococcal poisoning. Next, we shall get to know about *Bacillus cereus* poisoning.

5.3.2 *Bacillus Cereus* Poisoning

Bacillus cereus poisoning is caused by the organism which is a large (3-5 μm long and 1-4 μm wide), gram positive, motile and spore-forming rod, as shown in the Figure 5.2. *B. cereus* is an aerobic organism but is also capable of growing under anaerobic conditions. Mesophilic strains of *B. cereus* grow between temperatures of 10-45°C, with an optimum growth temperature range being 20-35°C. The psychrotrophic strains, however, grow and produce toxins at temperatures as low as 4°C. Further, since it is a spore-former, the heat resistant spores can survive the cooking process. Hence, it requires a severe heat process to destroy the spores.

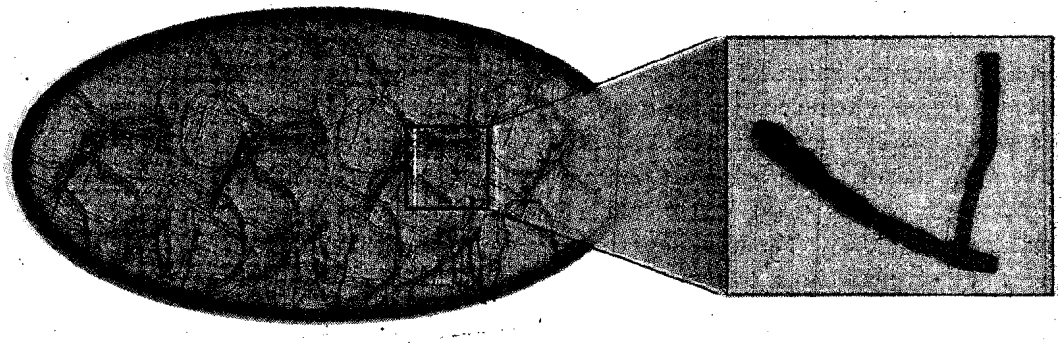

Figure 5.2: Bacillus cereus

Bacillus cereus can cause two distinctive forms of food poisoning, which differ both in their incubation time and the symptoms they elicit in the victim. Some of the strains produce and release a toxin which causes diarrhoea, while some other strains produce an emetic toxin in the intestine which causes nausea and vomiting in the person consuming food containing the toxin, 2-5 hours after food ingestion.

The diarrhoeagenic toxin is relatively heat-sensitive and is destroyed in 30 minutes at 56°C and in 20 minutes at 60°C. The emetic toxin, however, is capable of tolerating high temperatures (126°C) for 90 minutes. The vomiting (emetic) type, of illness

exhibits the symptoms in a shorter time, usually between 1-5 hours and occasionally anywhere between 15 minutes to 11 hours. The symptoms observed are general malaise, acute attack of nausea and vomiting. Diarrhoea is also observed in some cases. The other form of illness is characterized by acute abdominal pain, profuse watery diarrhoea, nausea, vomiting, fever, chills and body aches. The incubation period is anywhere between 8-16 hours and lasts for less than 24 hours. The treatment for the *B. cereus* food poisoning is symptomatic.

Being ubiquitous in nature, *B. cereus* is commonly found in soil and in vegetables and grains. The prepared foods, which are the vehicles of diarrhoeal form of illness, include cereal dishes, puddings, milk and dairy products, mashed potatoes, sauces, vegetable and chicken soups and meat and rice dishes. The usage of spices in preparation of meat dishes adds the *B. cereus* spores to the dishes, as spices harbour spore-bearing bacilli. If the preparations like mutton and chicken *biryani* are not adequately heated, it allows the spores to germinate during the subsequent holding of the prepared food at room temperature for longer periods. This leads to a heavy growth of the vegetative cells. The other type of illness, the vomiting (emetic) type, results from the consumption of fried rice. The rice is usually prepared in large quantities and allowed to cool at the room temperature, which is an ideal condition for the germination of surviving spores. The rice is fried just before serving. The heating process generally reduces the bacteria but depending on the microbial load, the person consuming the food may get affected.

B. cereus is normally found on or in the foods. There is a possibility that the spores produced by the psychrotrophic strains, survive the cooking temperatures and germinate at room temperatures. Therefore, prevention of illness through foods can be minimized by following certain precautionary measures, which include:

i) The rice cooked for preparation of fried rice should be boiled in small quantities whenever required, depending on the customer inflow, which helps in reducing the holding period of cooked rice.

ii) If the rice has to be cooked in large portions, care should be taken to ensure that the hot rice is held at temperature not less than 63°C. For any reason, if this is not possible, the cooled food should be divided into small portions, cooled quickly in shallow containers and transferred to the refrigerator and held at temperature less than 7°C. This should be carried out within 2 hours of cooking.

iii) Always avoid holding the cooked rice at room temperature. This is highly essential in avoiding *B. cereus* food poisoning.

Having studied about *Bacillus cereus* poisoning finally we move in to the third food borne intoxication i.e. Botulism.

5.3.3 Botulism

Botulism is an extremely serious neurological illness. It is caused by the ingestion of improperly preserved canned foods, containing a neurotoxin produced by *Clostridium botulinum*. This is generally a fatal disease and carries a high risk of mortality (35-40%), although its occurrence is rare in India.

The *Clostridium botulinum* is an obligate, anaerobic, mesophilic, motile and gram-positive rod (4-8 μm by 0.9-1.2 μm), which produces a heat stable spore. Refer Figure 5.3 to see how it looks like. Some strains of *C. botulinum* are psychrotrophic which are capable of slow growth and produce toxin at low temperatures (3.3°C).

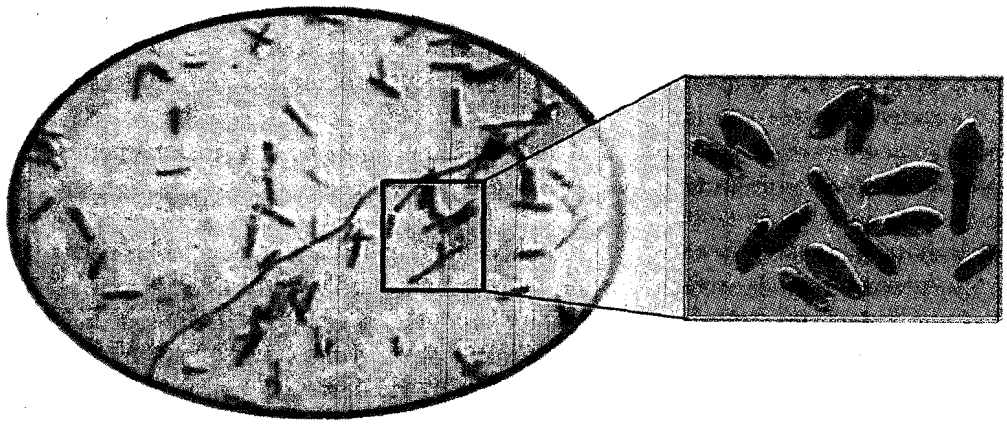

Figure 5.3: Clostridium botulinum

There are eight types of toxins produced by it and are designated as A, B, C_1, C_2, D, E, F and G. All the strains do not produce single toxins, as some produce mixed toxins like C_1, which produces C_2 toxin but also some D toxins. Most human cases of botulism have been reported to be caused by A, B and E toxins. The toxins are called *'neurotoxins'*, as they act upon peripheral nerves of the involuntary muscles of the body. The toxins A and B can be inactivated by heat treatment at 80°C for 10 minutes while the E-toxin can be destroyed by heating for 5 minutes at 60°C. The incubation period of the disease ranges from 2 hours to 14 days after the ingestion of contaminated food. The first symptoms appear between 18-36 hours and the signs and symptoms depend upon the type of toxin. Generally, the symptoms are nausea and vomiting, occasionally, diarrhoea, headache, dizziness and persistent constipation followed by blurred vision.

Clostriduim botulinum is widely distributed in soil and marine sediments throughout the world. It is also found in the intestinal tract of animals, including fish. Most of the outbreaks of botulism have been associated with the *products of fish or marine animals, meat, fruits and vegetables, including mushrooms*. Insufficiently heated canned and bottled foods are at a high risk as these provide the anaerobic (without air) environment required by the organism to grow. The types of foods which have acted as vehicles of infection differ from country to country. Generally, the toxins A and B have been implicated in improperly home canned foods. The type E outbreaks have occurred by the ingestion of fermented or smoked marine products, fruits and vegetables-including mushrooms. Home cured ham and other meat products have been implicated in the outbreaks reported from Western Europe. The organism can be isolated occasionally from many foods because of its widespread occurrence in the environment. However, it is interesting to note that because of their non-proteolytic characteristics, their growth in foods cannot be detected by off-odours and off-flavours.

Botulinum produces preformed toxins. Remember, it is the ingestion of the preformed toxin, which is the most potent natural toxin known to man that causes the illness known as *botulism*. Ingestion of live organisms of *C. botulinum* is not the cause for foodborne botulism. The toxin can be destroyed by heat treatment (800°C or above) for only a few seconds. The botulism can be prevented by killing *C. botulinum* spores in foods through following these steps: (i) processing (ii) eliminating the recontamination of processed foods (iii) destroying the toxin by proper heating of the processed food before serving (iv) proper storage (v) discarding the product that has developed signs of spoilage (e.g., off-odour, bulging cans and gas bubbles on opening the can), and (vi) avoiding tasting of suspected food unless it is heated to 100°C. A heat process called *'Botulinum Cook'* is commonly recommended for low - acid canned products.

In conclusion, botulism is an extremely serious food borne disease, and unless recognized and treated promptly, it carries a high risk of mortality (35-40%). It is the most severe form of food poisoning.

Check Your Progress Exercise 1

1) Fill in the blanks:

   a) Moulds produce toxin called ..... .

   b) Food borne diseases are classified as food ..... , food ..... and ..... infections.

   c) The most frequently reported food borne disease is ..... food poisoning.

   d) Strains of *Bacillus cereus* produces two types of toxins, namely ..... and .....

   e) Botulism is caused by the ingestion of .....

2) Define the following:

   a) Food Poisoning

   .....

   .....

   b) Food borne disease

   .....

   .....

   c) Neurotoxins

   .....

   .....

3) List five common foods implicated in the outbreak of staphylococcal poisoning.

   .....

   .....

4) Give a few preventive measures to inhibit the multiplication of:

   a) *Staphylococcus*

   .....

   .....

   b) *B. cereus*

   .....

   .....

   c) *C. botulinum*

   .....

   .....

5.4 FOOD BORNE INFECTIONS

Food borne infections, as you may recall reading earlier, are caused by the ingestion of pathogenic microorganisms that penetrate the intestinal mucosa and multiply or migrate into other tissues where they multiply. Common food borne infections include *Salmonellosis, Shigellosis*, *Vibrio parahaemolyticus* gastroenteritis, *E. coli* diarrhoea, infective hepatitis etc. Let us study about a few of these infections.

5.4.1 Salmonellosis

Salmonellosis is a common food borne disease all over the world. There are approximately 1600 different strains (sero types) of *Salmonella.* The most common of the species is *Salmonella typhimurium* which causes typhoid. Figure 5.4 illustrates the *Salmonella* organism. The members of the genus *Salmonella* are short (1-2 μm), motile, gram-negative and non-sporing rods. They are aerobic and facultative anaerobic. Several of the serotypes have been named after the place from where they were first isolated like *S. newport* etc. These organisms grow best at around 38°C, however, the growth is slow at temperatures below 10°C. They are heat sensitive and are destroyed by pasteurization and heat treatments at 60°C in 15-20 minutes.

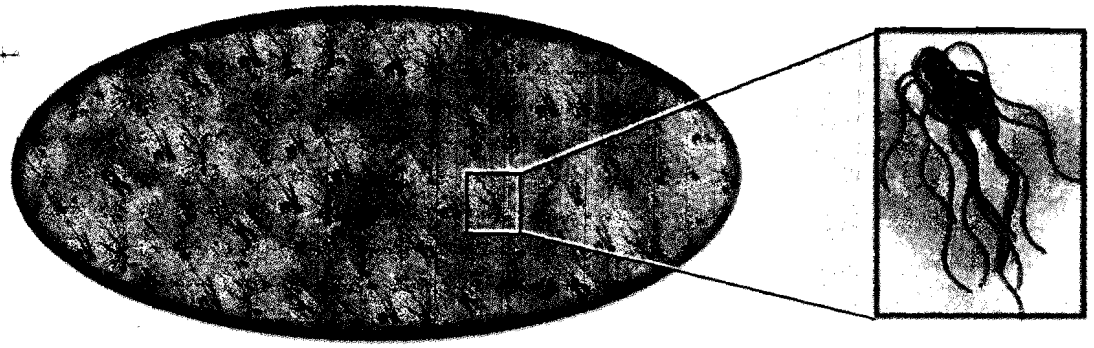

Figure 5.4: Salmonella typhi

Salmonellosis occurs following the ingestion of viable cells of the organisms and is the most common type of food borne illness. The occurrence of the disease is largely dependent on the resistance of the individual, the strain involved and the number of bacteria ingested, which varies. *S. enteritides* and *S. typhimurium* are the frequently implicated organisms in cases of salmonellosis, other serotypes have also been involved in food poisoning from strain to strain. The incubation period varies from 6 hours to 3 days but is normally between 12 to 36 hours. The symptoms are nausea, diarrhoea, abdominal pain, vomiting and fever. In some cases, this may be preceded by chills and headache. Although death from the disease is rare, it can occur in 'at-risk' groups e.g. infants, elderly and the immuno-compromised. The illness usually lasts for several days.

The prime source for *Salmonella* is the animal but human beings are also indirectly the source after once becoming infested and are known as *carriers*. The domestic animal food sources like chicken, pigs, turkey etc. are the main reservoirs of the organisms. The organisms spread from carcass to carcass at the slaughter house. The types of foods involved in food borne salmonellosis have been wide-ranging and involve mainly cereal and grain products, desiccated coconut, chocolate and dairy products. The egg and egg products which have not been pasteurized were implicated in several outbreaks. Meat and meat products also are the vehicles of food borne disease outbreaks. Milk and milk products like fermented milks, ice cream, cheese etc., have also been responsible for diseases. Foods such as desiccated coconut, chocolate and dairy products are also involved in food borne diseases. In kitchen, the foods may get cross contaminated by the equipments and utensils.

The prevention of salmonellosis involves adopting several precautionary steps which include:

i) Checking of the animal to be free from contamination.

ii) Avoiding cross-contamination from raw to cooked foods.

iii) Destruction of *Salmonella* by proper cooking.

iv) Cooling the prepared foods rapidly to below 7°C and storing within the refrigerators or freezers or held at a temperature above 60°C

v) Removing food handlers who are carriers from the food preparation area, and

vi) Improving general sanitary conditions of the premises and ensuring better pest control.

Next, let us get to know shigegellosis, the food borne infection caused by *Shigella.*

5.4.2 Shigellosis (Bacillary dysentry)

Shigellosis is caused by the genus *Shigella* and is a common enteric (intestinal) infection. The genus has four serological groups, of which *S. sonnei* (Subgroup D) and *S. flexneri* (sub-group B) are the important ones. The *Shigellae* are non-motile, aerobic and facultative anaerobic, non-sporulating gram-negative rods in the family *Enterobacteriaceae.* Figure 5.5 illustrates the Shigella organism. The optimum temperature for the growth is 37°C with a temperature range of 10 to 40°C. They can withstand salt concentrations of up to 6% and are heat-sensitive. They utilize glucose and other carbohydrates and are inhibited by potassium cyanide.

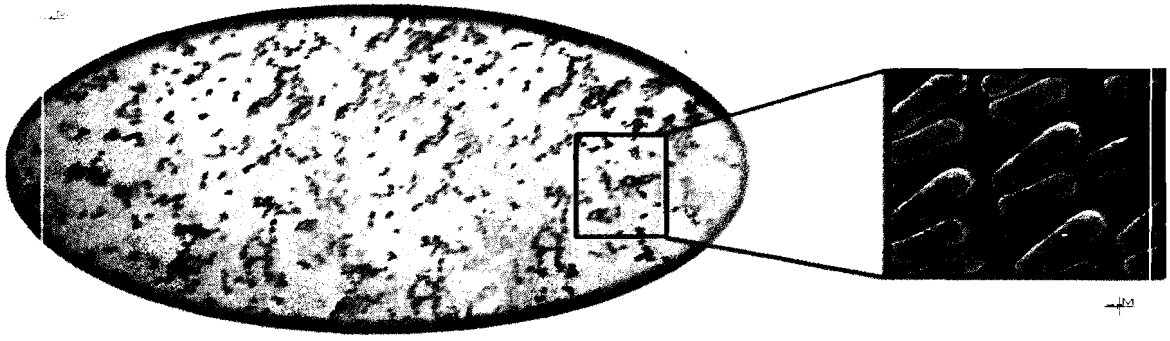

Figure 5.5: Shigella

The number of organisms to cause illness is low and the main mode of transmission is from human to human. The incubation period depends upon the organism, the affected person's age and the health status. The incubation period is usually short, ranging from 1-7 days (usually 1-3 days). The symptoms are diarrhoea, accompanied by fever, nausea and sometimes vomiting and cramps. The stools of the affected person may contain blood, mucus and pus. Although shigellosis is usually transmitted by contaminated water, where food has been involved, the vehicles of infection are milk, shellfish, raw vegetables, Mexican dishes and various salad preparations. The infection is transmitted by the food handler with poor personal hygiene and acts as a carrier. The food handlers contaminate the food or food preparation surfaces. The following measures help to minimize the problem.

i) The food handler who is the primary carrier, has to be educated regarding safe handling of foods and made to follow strict personal hygiene practices, like washing hands after visiting the toilet.

ii) The left-over foods have to be chilled rapidly or held at temperatures at which *Shigella* cannot grow (above 40°C).

iii) Cooking and reheating of foods to safe temperatures is also essential for preventing *shigellosis.*

From the discussion above, it is evident, that food handlers with poor personal hygiene are one of the main causative agents of shigellosis. Next, let us get to know about the outbreaks of illnesses associated with Vibrio parahaemolyticus.

5.4.3 *Vibrio Parahaemolyticus* Gastroenteritis

Outbreaks of illness associated with *Vibrio parahaemolyticus* are frequently reported from Japan. V. parahaemolyticus– associated gastroenteritis is the name of the infection caused by this organism. The organism is a facultative anaerobe, straight or slightly curved, motile, gram-negative rod with a single polar flagellum as illustrated in Figure 5.6. It is also slightly halophilic (salt-lover) and can grow in 8% NaCl but grows ideally between 2-4%. The optimum temperature at which it can grow is 35-37°C but exhibits growth trends over a wide range of temperatures from 8°C-44°C.

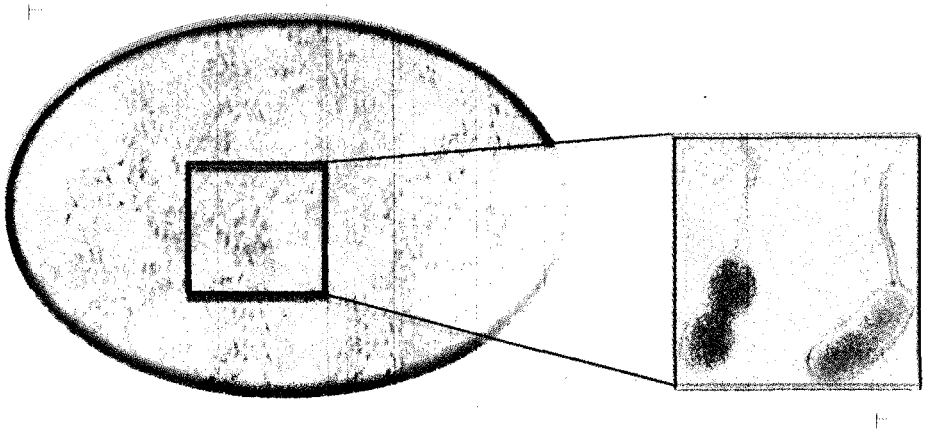

Figure 5.6: Vibrio parahaemolyticus

In the *V. parahaemolyticus* gastroenteritis, the symptoms are severe abdominal pain, vomiting and diarrhoea, leading to dehydration and fever. The incubation period is usually from 12 to 24 hours and the illness may last from 1 to 7 days.

V. parahaemolyticus is found in marine environment. The organism is found abundant during the warm months and it colonizes the water and marine life. Fish and shellfish are the two major sources of contamination and are generally implicated in the outbreaks. The important cause of the outbreaks in Japan is the habit of consuming raw fish, as such, hence there is a high prevalence of the disease in the country. In India, the disease has been reported from Kolkata. The major reservoirs of the pathogenic bacteria are crabs, shrimps and certain fresh water fish commonly consumed in West Bengal. Normally, the recovery after illness takes place anywhere between a few hours to 10 days. The organism is easily destroyed by heat.

The best way to, however, prevent the illness due to *V. parahaemolyticus* is by:

i) thorough cooking of the sea foods,

ii) avoiding cross-contamination of cooked food from raw foods, and

iii) proper refrigeration of raw sea foods.

5.4.4 Enteropathogenic *Escherichia Coli* Diarrhoea

Escherichia coli (*E. coli*) is an important organism, as it is, regarded as a part of normal intestinal flora of humans and animals. Its presence in food has been used as an indicator for faecal contamination. The *E. coli* is a short, non-spore forming, facultative anaerobe, motile and gram negative rod. Refer to Figure 5.7 to see how it actually looks like. Some strains of *E. coli* can cause acute gastroenteritis affecting children. Such strains are designated as enteropathogenic *E. coli* (EPEC).

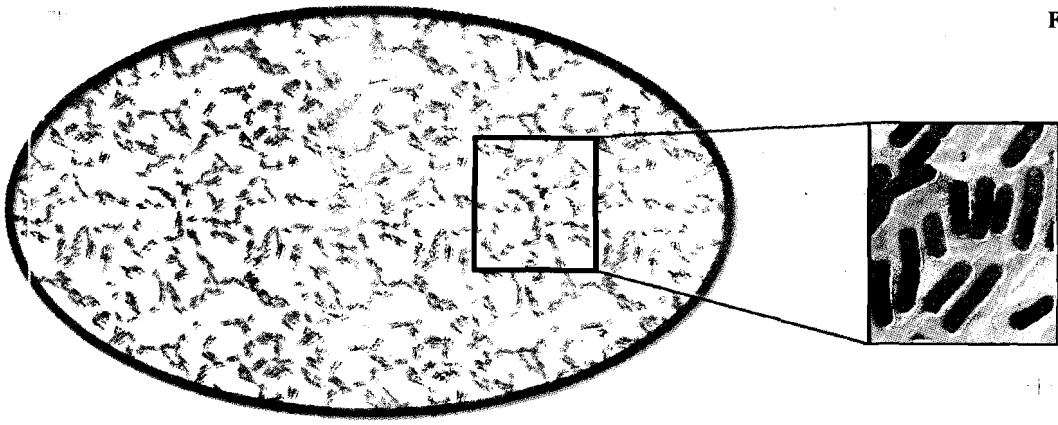

Figure 5.7: Escherichia coli

Diarrhoeal disease due to EPEC is age-related, usually occuring in infants. Outbreaks involving babies, even foetuses have been reported from hospitals and nurseries. There are certain serotypes of *E. coli*, known as *Vero Toxigenic E. coli* (VTEC), which may cause diarrhoeal disease or more serious forms of illness, such as acute renal failure or long-term kidney problems. VTEC produces toxins referred to as *verotoxins* because they affect vero cells (a tissue culture line of monkey's kidney cells). The main serotype of verotoxin producing *E. coli* is *E. coli 0157*. This strain of *E. Coli* produces a powerful toxin and can cause severe illness.The optimal temperature for the growth of E. Coli is 37°C but it can grow between 7 to 43°C. The organism is heat-sensitive. The pasteurization and normal cooking temperatures are effective in destroying the organism. The organism survives well at low temperatures with the incubation period between 12-72 hours. The symptoms include abdominal pain, diarrhoea, vomiting and fever. Blood and mucus in stools may also be observed.

EPEC may be present in poultry, beef products, pork, lamb, apple cider, meat and dairy products, like cheese, which has been implicated in some outbreaks reported from USA and UK. It is spread through faecal contamination of food, water and from person-to-person transmission. Diagnosis of its outbreak is only possible through culture and identification of the germ using biochemistry and serology. The prevention of EPEC-induced gastroenteritis is to adopt strict personal hygiene and good sanitary practices.

Next, let us get to know about infectious hepatitis.

5.4.5 Hepatitis A

Infective hepatitis, which is caused by hepatitis A, is a viral disease which spreads through food. How does the hepatitis A virus look like? Well, have a look at the Figure 5.8. Hepatitis A virus is presumed to replicate initially in the gastrointestinal tract and then it spreads primarily to liver, where it infects hepatocytes (liver cells) and kupffer cells.

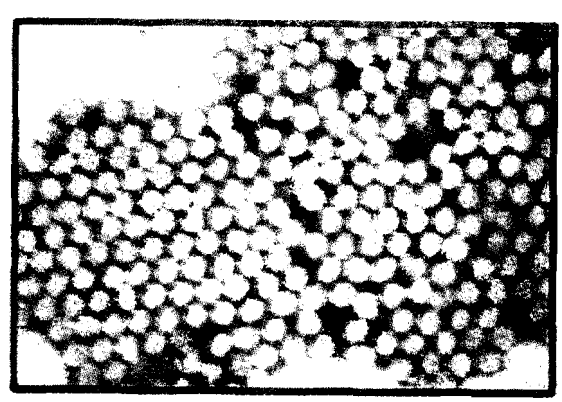

Figure 5.8: Hepatitis A virus

Infective hepatitis is a major public health problem all over the world. The major source of the virus has been *man*. The disease is transmitted through the oral-faecal route. The sources of outbreaks involving food have been reported but the long incubation period of 15-50 days (normally between 28-30 days) makes it difficult to investigate. However, foods such as ice, water, ice cream, milk, pastries, salads, sandwiches, shellfish, raw foods or foods subjected to additional handling after cooking are the major food vehicles for virus transmission.

The typical symptom of the disease is jaundice accompanied by abdominal pain, headache, fatigue, fever etc. Jaundice, as you may already know, is the symptom characterized by yellowish discolouration of the whites of the eyes, skin and mucous membranes caused by the deposition of bile salts in these tissues. Shellfish from polluted waters, fruits and vegetables contaminated by faeces and various salads prepared under unhygienic conditions were responsible for several outbreaks. The best way for the prevention of infective hepatitis is to ensure good personal hygiene of food handlers, like proper hand washing etc. The other approach is to avoid foods known to have been procured from polluted water sources.

Finally, let us get to know about shell fish poisoning.

5.4.6 Shellfish Poisoning

Shellfish like oysters, mussels and clams are generally bred in the sewage polluted beds or brackish water. The shellfish poisoning in humans is caused due to the consumption of oysters, mussels and clams etc. which accumulate the toxins produced by dinoflagellate algae *Gonyaulax catenella*. Have a look at the Figure 5.9, which illustrates the dinoflagellate algae.

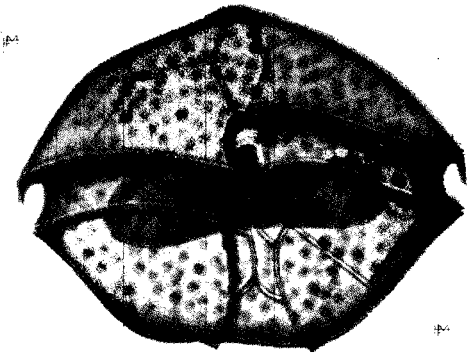

Figure 5.9: Gonyaulax catenella

The mussels and clams concentrate the dinoflagellates by filtering them as food from the surrounding water. If the concentration exceeds 200 cells per ml in the surrounding water during a "bloom", they will contain sufficient toxin to cause illness to those consuming the shellfish. The shell fish poisoning assumes importance due to the fact that they are consumed undercooked or uncooked. They also harbor other pathogenic microorganisms. In India, shellfish poisoning has been reported from the coastal areas of Tamil Nadu and Karnataka.

Check Your Progress Exercise 2

1) Match the following:

A		B	
a)	*Salmonella* sp.	i)	non-motile, non-spore forming gram negative rods.
b)	*V. parahemolyticus*	ii)	motile, non-spore forming gram negative rods.
c)	*Shigella*	iii)	motile, gram negative flagellated rods.

2) Fill in the blanks:

a) *Salmonella tyhimuruim* causes ..... .

b) Primary source of salmonellosis is .....while ..... are the carriers.

c) The main mode of transmission of Shigellosis is ..... to .....

d) Two major sources of contamination leading to *V. parahemolyticus enteritis* are .....and .....:.....

e) Shellfish poisoning is caused due to the consumption of ....., which accumulate the toxin produced by the algae .....

3) Give the symptoms, foods involved and preventive measures of the following diseases:

a) Salmonellosis

.....

.....

b) Shigellosis

.....

.....

c) *V. parahemolyticus* gastroenteritis

.....

.....

d) *E. coli* diarrhoea

.....

.....

e) Hepatitis A

.....

.....

Our discussion so far focussed on food intoxications and food infections, which you learnt earlier are the types of food borne disorders. The third category of food borne disorders are toxic infections. Let us get to know about these disorders next.

5.5 FOOD BORNE TOXIC INFECTIONS

The food borne toxic infections, you may recall reading earlier, are caused by the ingestion of a large numbers of enterotoxigenic strains of bacteria which, while multiplying in the intestine produce and release enterotoxins in the intestines. Few of the foodborne toxic infections include *Clostridium perfringens* gastroenteritis, enterotoxigenic *Escherichia coli* gastroenteritis, cholera, listeriosis etc. Now we will focus on these major food borne infections and study about the characteristic features of the organism responsible for these infections.

5.5.1 *Clostridium Perfringens* Gastroenteritis

Clostridium perfringens-associated gastroenteritis is a food borne disease which is frequently reported and is a common cause of illness. The organism *Clostridium perfringens* is a large (2-8 μm long; 1 μm wide), non-motile, gram positive, obligate anaerobe and spore-forming rod as can be seen in Figure 5.10. The organism does not produce spores while growing in the food but it forms spores when it reaches the intestinal tract.

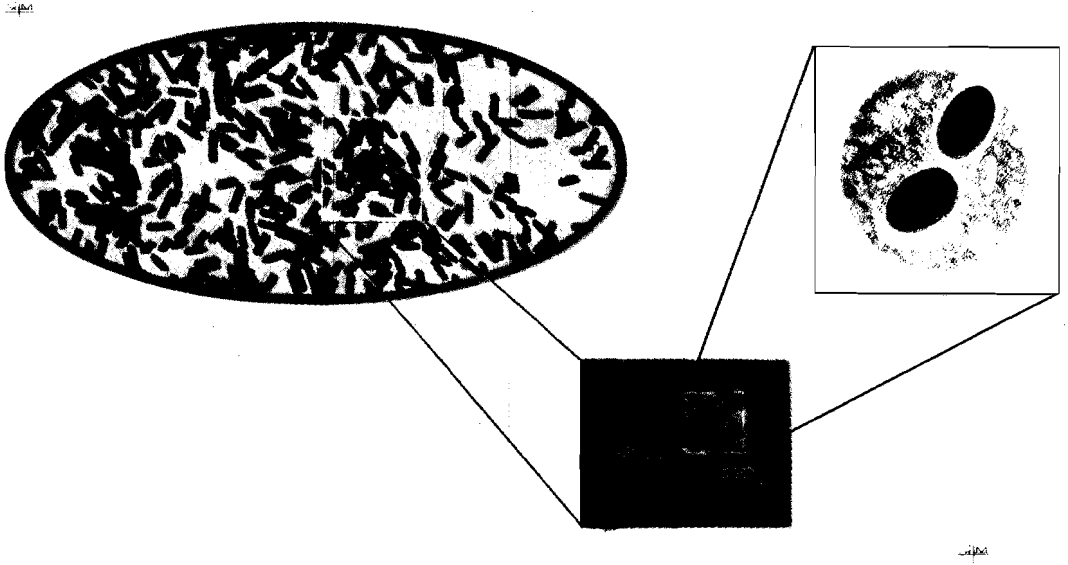

Figure 5.10: Clostridium perfringens

The spores of *C. perfringens* can withstand boiling temperatures for up to 6 hours. The optimum temperature for growth is between 43°C to 45°C, whereas, the maximal temperature at which it can grow is 55°C. Its growth gets restricted at the temperatures of about 15-20°C. The vegetative cells of the organism are usually destroyed at the temperatures of 60°C and above.

The strains of *C. perfringens* are classified into 5 types–A to E, depending on the type of toxin produced. The strains of *C. perfringens* type A, the spores of which are heat resistant survive at temperatures from 95-100°C for periods of upto one hour. These are responsible for several outbreaks in the United Kingdom. The incubation period for the disease ranges between 8 to 22 hours, but normally the symptoms occur between 8 to 12 hours after the ingestion of contaminated food. The important symptoms are severe abdominal cramps and watery diarrhoea, vomiting is rare. The recovery is usually within 1 or 2 days.

The *C. perfringens* is the most common of all pathogenic bacteria, as it is widely distributed and usually can be isolated from soil, dust, marine sediments, human faeces and animal manure. They are also found in raw meat and poultry. The usual vehicles of infection are the dishes prepared from meat and poultry. The outbreaks have been reported from places where a large number of people eat, like the restaurants, institutional canteens, hospitals etc. The major reason for the cause of outbreaks is the time temperature abuse after the preparation of the dishes. The slow cooling process which sets in while the cooked food is held at room temperature, aids in the growth of spore germination and a large number of vegetative cells may develop within a few hours.

C. perfringens causes a mild but common type of food poisoning. Its spores are heat resistant, surviving normal cooking. The organism usually forms the toxin, once it is in the human intestine and has started to sporulate. The toxin formed in food is not very heat resistant (destroyed by heating at 60°C for 10 minutes). *C. perfringens* food poisoning causes severe abdominal pain and prolific diarrhoea. Sometimes fever,

nausea and even vomiting may occur. Normally, a large number of cells need to be ingested to cause illness and the recovery is usually rapid (24-48 hours).

The *C. perfringens* being widely distributed in nature and due to the danger of the presence of spores in raw and cooked foods due to contamination, the preventive approach should aim to restrict the germination of spores and inhibiting the multiplication of the vegetative cells. To achieve this, the cooled foods have to be: (i) consumed as early as possible (ii) held at temperature above 56°C or higher, if there is a delay in consuming (iii) cooled rapidly (within 1 hour) and held below 7°C, and (iv) if the food is prepared far in advance, heating thoroughly above 74°C before serving.

Next, let us look at enterotoxigenic *E. Coli* gastroenteritis.

5.5.2 Enterotoxigenic *Escherichia Coli* Gastroenteritis

You may recall reading earlier in sub-section 5.4.4 about *Escherichia coli. E.coli*, you learnt, is a bacterium that normally lives in the intestines of humans and other animals. Most types of *E. coli* are harmless, but some can cause disease. Disease-causing *E. coli* are grouped according to the different ways by which they cause illness. Enterotoxigenic *Escherichia coli*, or ETEC, is the name given to a group of *E. coli* that produce special toxins which stimulate the lining of the intestines causing them to secrete excessive fluid, thus producing diarrhoea. You must make a note of the fact that the toxins and the diseases that ETEC causes are not related to Enteropathogenic *Escherichia coli* (EPEC) i.e. *E. coli* 0157, about which you learnt earlier in sub-section 5.4.4.

Enterotoxigenic *Escherichia coli* gastroenteritis is one of the most common forms of food borne illness. Gastroenteritis is the common name of the illness caused by ETEC, although it is also referred to as *traveler's diarrhoea*. Infants and people travelling in developing countries are most at-risk of infection. ETEC produces two toxins, a heat-stable toxin (known as ST) and a heat-labile toxin (LT). The *E. coli* causes illness between 8 to 44 hours but generally around 26 hours. Large number of cells (10^{10}) have to be ingested for the infection to set in.

What illness does the ETEC cause? Infection with ETEC can cause profuse watery diarrhea and abdominal cramping. Symptoms such as fever, nausea with or without vomiting, chills, loss of appetite, headache, muscle ache and bloating can also occur but are less common. Illness develops 1-3 days after exposure and usually lasts 3-4 days.

How does one get infected by ETEC? Infection occurs when a person eats food or drinks water or ice contaminated with ETEC bacteria. Human or animal wastes i.e. faeces are the ultimate source of ETEC contamination. Contamination may occur through the hands of food handlers to the cooked foods.

What can be done to prevent infection of ETEC? Well, the preventive approach in this form of illness is to adopt proper personal habits, like washing hands frequently. The foods must be thoroughly cooked and held before consumption at elevated temperatures or low temperatures. It is essential that potable water supply is ensured to reduce the illness due to contamination of foods by *E. coli.*

The next toxic infection, cholera needs no introduction. But certainly we need to know about the organism that causes this disease. Let us get to learn about *Vibrio cholerae.*

5.5.3 Cholera

Cholera is one of the diseases which had caused epidemics all over the world. The organism which causes the disease is *Vibrio cholerae.* It is an aerobic, facultatively anaerobic, straight or slightly curved, short, gram-negative, oxidose-positive rod with a single flagellum as can be seen in Figure 5.11.

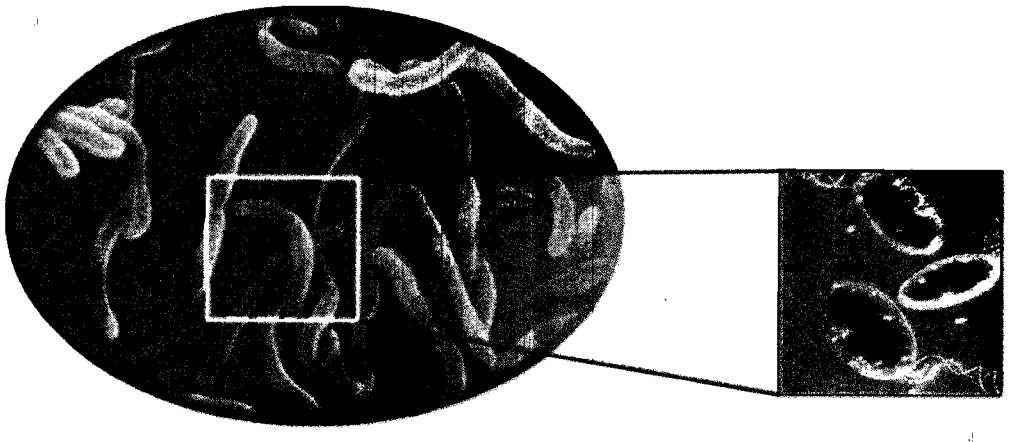

Figure 5.11: Vibrio cholerae

The *V. cholerae* produces a heat-sensitive enterotoxin while growing in the human intestine. It causes the characteristic cholera symptoms including *'rice water stool'*. The toxin is heat labile. The incubation period of cholera ranges from a few hours to 5 days but usually between 2-3 days. The symptoms include abrupt onset of vomiting and watery diarrhoea. Diarrhoea has a rice water appearance, where the stools look like water with flecks of rice in it hence the name 'rice water stool'. Dehydration may be followed, causing death in some cases, if prompt electrolyte supplementation is not provided. Antibiotic treatment helps in reducing the duration of the disease by killing the organisms before they become bound to mucosa.

What is the etiology of cholera? The most common cause of cholera is consumption of food or drinking water that has been contaminated with the bacteria. It is important to note that after a disaster such as earthquake, flood etc. this is a very real danger, since regular and clean water and food supplies are often unavailable. The disease can be spread even further by infected people using already dirty water sources to clean themselves or dispose off the waste.

Man is the main reservoir of *V. cholerae,* who is the carrier. The organisms are transmitted through contamination of food and water by faecal matter. Cholera can be prevented if there is safe disposal of sewage and also through supply of protected water. The good personal hygiene of food handlers also helps in reducing the spread of the disease.

5.5.4 Listeriosis

Listeriosis is a food borne illness caused by a pathogenic bacterium called *Listeria monocytogenes*, which is food borne. *Listeria monocytogenes* is a gram-positive, motile, non-sporing and short rod organism as highlighted in Figure 5.12. It is aerobic and facultatively anaerobic in nature. This is a psychrotrophic organism i.e., potentially capable of growing at refrigeration temperatures as low as 0°C. It is the most heat-resistant organism among all the non-spore forming, vegetative food pathogens.

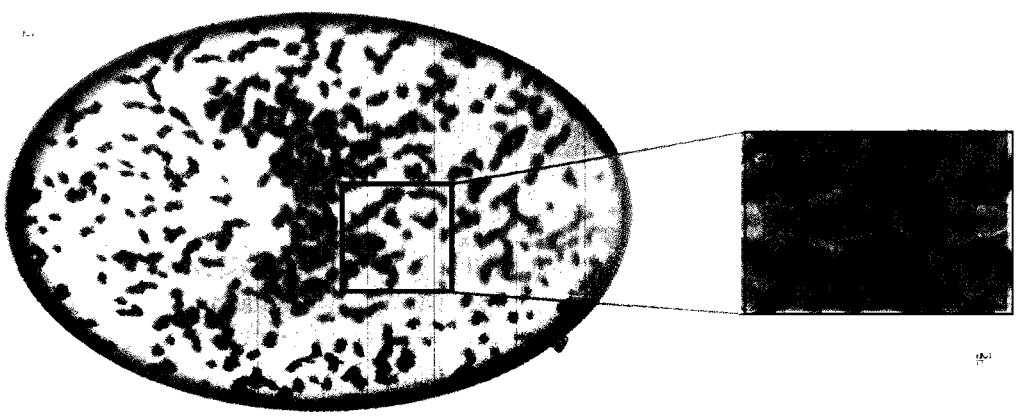

Figure 5.12: Listeria monocytogenes

The comparatively rare disease, which is known as 'listeriosis', is spread through contamination of a variety of foodstuffs. Several major food commodities including milk and dairy products have been implicated in the transmission of disease. The disease spreads through milk from the infected cattle. Other food products include the raw meat and poultry products, fermented sausage, raw and pre-cooked chicken. It also spreads through the consumption of vegetables, salads and sea foods.

The human listeriosis occurs in pregnant women, foetuses and new born children. In people whose immune system is compromised, the disease could be fatal. It is ubiquitous in the environment and so can be transferred to foods from a wide variety of sources. Its incubation period is between one and several weeks. The organism persists in soil and the faeces of affected animals could be a major route when used as a manure in growing vegetables or fruits, as they are normally used as salad or eaten raw. Foods can become contaminated with *Listeria* at any stage in the food chain, from the farm, through the processing and distribution, to the consumer's kitchen.

What are the symptoms of the illness? Its symptoms are typically meningitis or septicemia and in pregnant women, it can cause a flu-like illness, which can result in miscarriage, still birth or birth of a severely-ill infant. Unlike other bacteria, due to its psychrotropic nature, the microorganism, *L. monocytogenes* is able to grow even at the refrigeration temperatures of 4-6°C. It can be prevented by treatment with pasteurization, proper cooking and also by adopting hygienic practices.

The next toxic infections disease we shall cover is Yersinia associated gastroenteritis.

5.5.5 Yersinia *Enterocolitica* Gastroenteritis

Yersiniosis is an infectious disease caused by a bacterium of the genus *Yersinia*. Most human illness is caused by one species, *Y. enterocolitica*. It is a gram-negative, rod-shaped bacterium as you can see from the Figure 5.13. Although normally its optimum growth temperature is about 32°C, it can grow even at temperatures below 4°C.

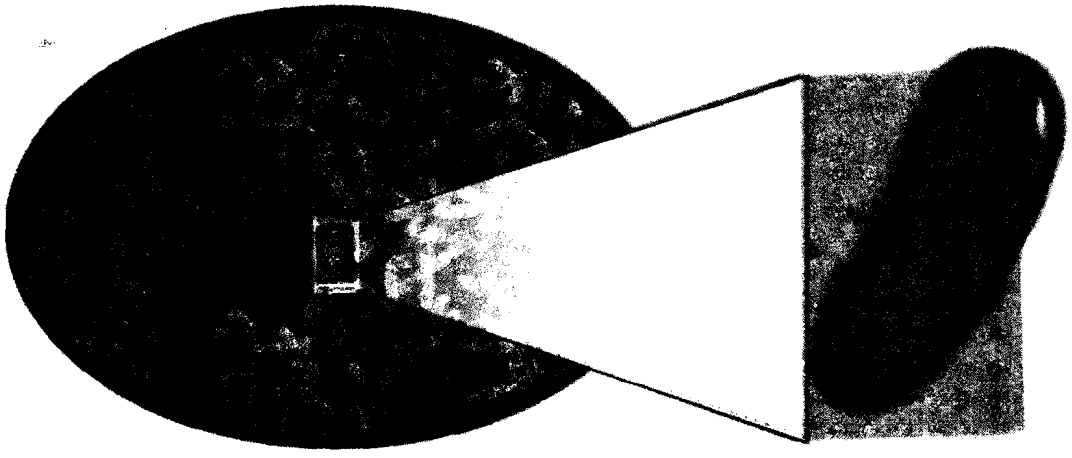

Figure 5.13: Yersinia enterocolitica

The organism produces an enterotoxin that survives at 100°C for 20 minutes. The symptoms of the disease include severe abdominal pain, fever and diarrhoea which occur after 24 hours due to the consumption of the incriminated food. The abdominal pain in this case resembles that of 'appendicitis'. The organism is found in the intestinal tract of several animals including pigs, cattle and dogs. *Y. enterocolitica* has been isolated from dairy products, egg products, raw meats, poultry and vegetables.

Finally, in this group of toxic infections we shall get to know about Campylobacter jejuni diarrhoea.

5.5.6 *Campylobacter Jejuni* Diarrhoea

Campylobacter jejuni is responsible for 80-90% of *Campylobacter* infections in most parts of the world. *Campylobacter jejuni* is a small, spiral or curved, motile, gram-negative, rod-shaped bacteria, as you can observe in Fiugre 5.14. They grow under reduced oxygen levels, being 'micro-aerophiles'. The organism grows well at 42°C and is inactivated above 45 to 50°C. They do not grow below 25°C and are sensitive to drying.

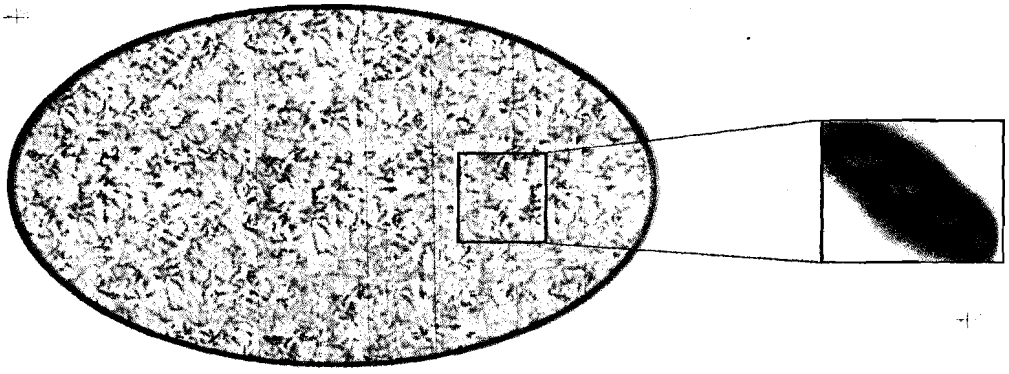

Figure 5.14: Campylobacter jejuni

Campylobacter occurs widely as a part of the normal intestinal flora of many warm-blooded animals including chickens and turkeys. In addition, the organism occurs in raw water and raw milk. It enters the human food chain at the time of slaughter of the animals and this is believed to be the main source of infection for man.

C. jejuni has gained importance in recent years as several outbreaks are reported. The incubation period ranges from 1 to 10 days but is usually between 3 to 5 days. The onset of symptoms may be sudden, with abdominal cramps and diarrhoea. The diarrhoea may persist for 1-4 days and preceded by a period of fever of a few hours to several days. The major source of infection is the dressed chicken, raw milk and raw seafood. The food handler is another source of infection. The prevention of *C. jejuni* contamination can be achieved by proper cooking and pasteurization of milk.

Check Your Progress Exercise 3

1) Fill in the blanks:

   a) ..... strain of *C. perfringens* is responsible for several outbreaks.

   b) Enterotoxigenic *E. Coli* causes .....

   c) The main reservoir of *V. cholerae* is .....

   d) Listeriosis is caused by a pathogenic bacterium called .....

   e) *Y. enterocolitica*, produces .....that survives at 100°C for 20 minutes.

2) Briefly explain the major reason behind the outbreak of *C. perfringens* infection.

   .....

   .....

   .....

3) List the causes of ETEC gastroenteritis and preventive measures.

.....

.....

.....

We studied about food intoxications, food infections and toxic infections in the text above which you now know are the common food borne diseases mainly of bacterial origin. Next, let us get to know about few diseases caused by toxins produced by fungus.

5.6 MYCOTOXINS

What are mycotoxins? How are these produced and where are these found? Are these naturally-occurring or produced? What is their significance? Here, in this section, we shall focus on these aspects.

First what are mycotoxins? The term mycotoxin comes from a Greek word, "*Mykes*", meaning fungus and the Latin word, "*Toxicum*", meaning poison or toxin i.e. fungus toxin or poison. Mycotoxins are the *substances (metabolites by-products) produced by moulds like Aspergillus flavus etc. produced in agricultural commodities either during pre or post-harvest stages, which may be toxic or produce adverse effects in living organisms, especially animals and/or humans.* They are found in agricultural commodities like cereals (e.g., maize, wheat), oilseeds (e.g. groundnuts) and spices (e.g., chillies) etc. They are both important from the domestic, as well as, export market considerations. Poisoning caused by ingestion of a food or feed that contains a mycotoxin is called *'mycotoxicosis'*.

Let us learn about a few important mycotoxins that affect both humans and animals. We shall begin with aflatoxicosis.

5.6.1 Aflatoxicosis

During 1974, an unknown disease resulting in over 100 deaths among tribals in Western India occurred. Epidemiological and laboratory investigations carried out revealed it to be the first authentic outbreak of aflatoxicosis in the world, caused by the consumption of maize contaminated with aflatoxins produced by the fungus *Aspergillus flavus.*

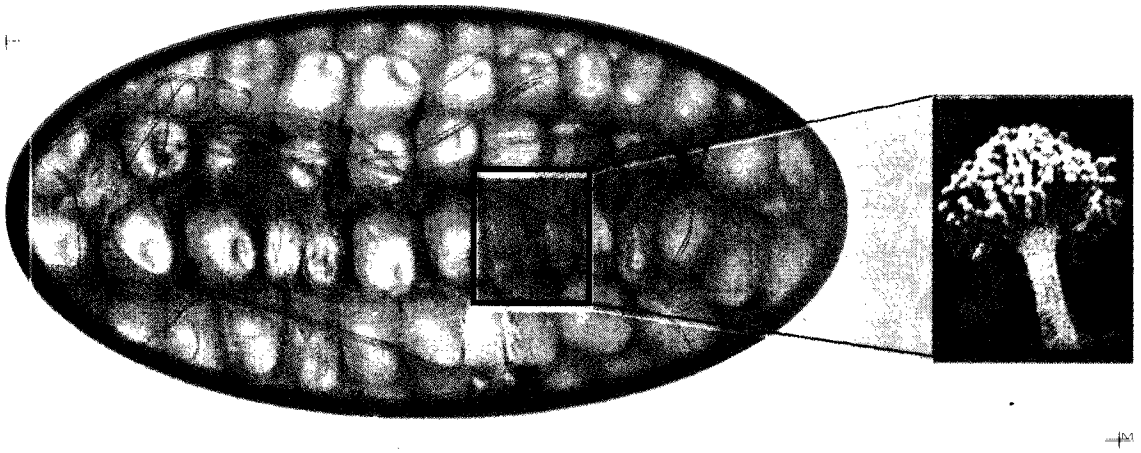

Figure 5.15: Aspergillus flavus

What does this fungus looks like? Well, have a look at the Figure 5.15. It illustrates Aspergillus flavus. The important characteristic features of aflatoxicosis are jaundice, cirrhosis. Long term exposure to aflatoxins could lead to chronic hepatitis and primary liver cancer. Besides maize, other foods in which this toxin or its metabolite can occur, are the raw food commodities including cereals, nuts, spices, figs, dried fruits, dairy products such as milk and cheese and also animal feed ingredients like groundnut and cottonseed cake. Aflatoxins are quite stable in many foods and are fairly resistant to degradation. Prevention measures include drying the agriculture commodities well, keeping commodities dry and decontamination. Detoxification using ammonia is also useful in case of animal feed ingredients like groundnut cake. The complete elimination of aflatoxins in human and animal food, while desirable, is extremely unlikely as the climatic conditions determine the occurrence of aflatoxins during preharvest, harvest and post-harvest stages.

Aflatoxins, you should know, are both acutely and chronically toxic. Aflatoxins are quite stable in many foods and are fairly resistant to degradation. The complete elimination of aflatoxins in human and animal food, while desirable, is extremely unlikely as they have the potential to arise in a wide range of agricultural products.

Besides maize, other foods in which this toxin can occur, are the raw food commodities including cereals, nuts, spices, figs, dried fruits, dairy products such as cheese and yogurt. The important characteristic features of aflatoxicosis are jaundice, primary liver cancer, chronic hepatitis, cirrhosis, rapidly developing ascites (accumulation of fluids in the abdominal cavity) and portal hypertension.

Recognizing the debilitating effects of the illness, various regulations, as well as, the maximum permissible limits for aflatoxins have been established for a range of commodities by the government.

Next of the mycotoxins highlighted in this section is deoxynivalenol. Let us get to know about this toxin.

5.6.2 Deoxynivalenol Mycotoxicosis

During 1987, an outbreak estimated to have affected over 50,000 people in the State of Jammu and Kashmir, was traced to the consumption of preparations made out of wheat products like wheat flour and refined wheat flour, barley, oats, rye, maize, sorghum and rice. The disease symptoms included pain in the stomach 10-15 minutes after consuming food and vomiting. The problem was diagnosed as *deoxynivalenol mycotoxicosis*. What caused the illness? It was found that unseasonal rains at the time of harvest of wheat had resulted in the damage to wheat by fungi like *Fusarium,* as shown in the Figure 5.16, and the production of deoxynivalenol and other mycotoxins, known as 'tricothecenes' caused the outbreak.

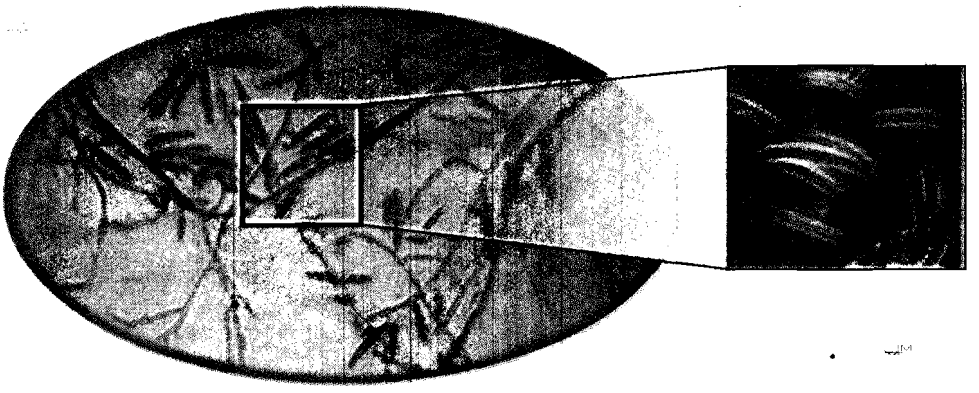

Figure 5.16: Fusarium

The mycotoxins can have effects on the immune system as well. It is thermally stable partially, so once formed, it is likely to persist through storage and food chain. The only good thing is that as the toxin is water-soluble, a significant proportion can be removed by washing grain. Hence, preventive measures rest on advocating washing of grains before use.

5.6.3 Ergotism

Ergot is a disease of cereal crops like rye, wheat, millet, sorghum and grasses. Ergot of rye is a plant disease caused by the fungus *Claviceps purpurea* as highlighted in Figure 5.17. The infected flower, instead of developing into a normal grain, develops to a dark black mass, as shown in Figure 5.17, often referred to as 'ergot'. The ergot grain gets harvested along with good grains and contaminate the rye crop. Poisoning attributed to ergot of rye is, therefore, referred to as *ergotism.*

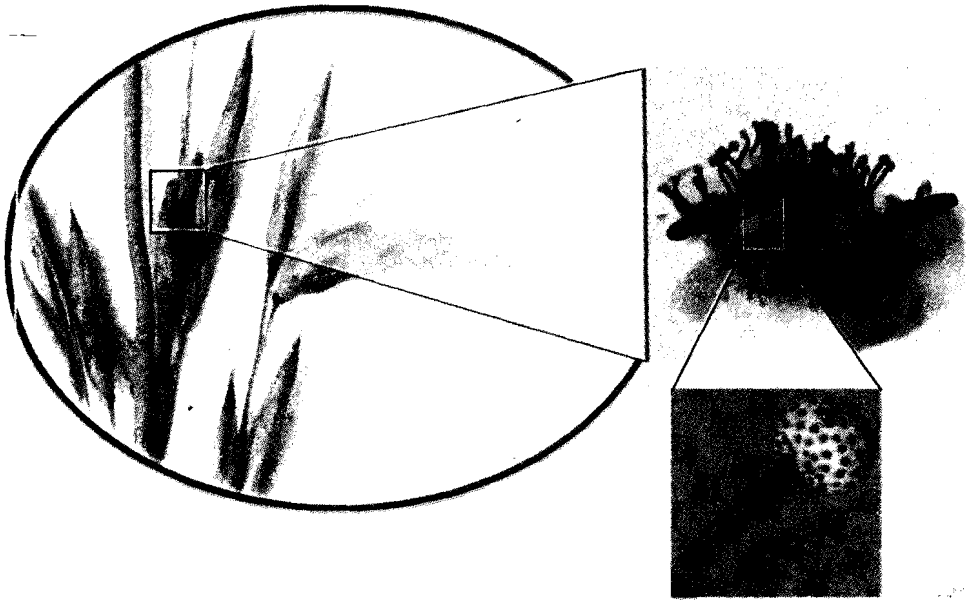

Figure 5.17: Claviceps purpurea

This disease was common in Europe in middle ages. In India, ergotism is caused by the consumption of bajra. Contaminated ergot was caused by the fungus *Claviceps fusiformis*. The ergotism found in India was manifested as nausea, vomiting, giddiness and prolonged sleepiness and is termed as *enteroergotism* while the European classical ergotism was characterized by convulsions and gangrene. In India, several outbreaks due to the consumption of ergoty bajra were reported from Maharashtra, Gujarat and Rajasthan.

With our discussion on ergotism, we come to an end of our study on mycotoxins. So far we have studied about food borne hazards of microbial origin. We learnt that microorganisms – bacteria, fungus – themselves or the toxins produced by them in the food or in the human body can lead to food borne diseases. You would be interested to know that other than microorganisms and their toxins, certain naturally occurring toxins in foods, can also cause food poisoning. We shall learn about these naturally occurring toxins and the diseases caused by them in the next section.

5.7 FOOD BORNE DISEASES DUE TO NATURALLY OCCURRING TOXICANTS

A variety of naturally occurring food toxins have been linked to human ill-health and death. Among them, the principal toxicants that have been responsible to cause disease outbreaks in humans in India include the following:

i) Lathyrism

ii) Veno-occlusive disease

iii) Epidemic dropsy

Let us discuss each of these.

5.7.1 Lathyrism

Human lathyrism is endemic in some parts of the country specially certain areas of Madhya Pradesh. Cases of lathyrism have also been known to occur in Uttar Pradesh, Karnataka, Maharashtra and Andhra Pradesh. Several reports of human lathyrism have been recorded in the past. The disease has been attributed to the consumption of *Lathyrus sativus,* popularly known as 'Kesari Dal', as a staple diet. The plant and seeds of Lathyrus sativus is shown in the Figure 5.18. Why should consumption of kesari dal lead to lathyrism? A neurotoxic amino acid, *β-oxalyl amino alanine (BOAA)* has been identified as the constituent of the kesari dal responsible for the disease.

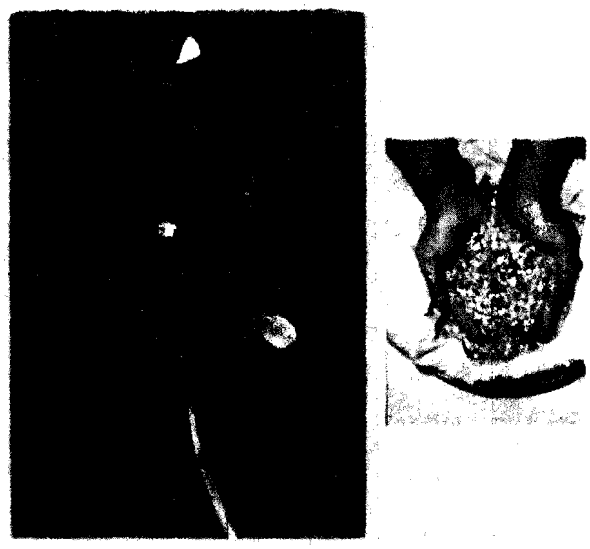

Figure 5.18: Lathyrus sativus

Kesari dal or *Lathyrus sativus* is a drought tolerant legume. It actually flourishes in conditions of the most devastating flood and drought, when no other food crop survives. The grains contain 20 to 32 per cent protein, but they also contain a number of antinutritional compounds known as *lathyrogens*. Lathyrogens are *the neurotoxic amino acids that act as metabolic antagonists of glutamic acid, a neurotransmitter in brain.* BOAA, found in kesari dal, is a neurotoxic amino acid. Consumed in large amounts during times of drought, a toxic syndrome – lathyrism – develops resulting in a crippling paralysis of the lower limbs is highlighted in Figure 5.19 and may result in death. The symptoms at the time of the onset include heaviness and stiffness of the limbs, muscle cramps, tremors and involuntary movement of the upper extremity.

Figure 5.19: Lathyrism – Crippling paralysis of lower limbs

However, it is encouraging to note that a declining trend of lathyrism has been observed in our country. This trend is attributed to the fact that the consumption of *L. sativus* in the endemic areas has come down during recent years mainly because of availability of alternative grains like wheat. Further, increased cost of *L. sativus* and the ban on sale of *L. sativus* under the PFA Act has contributed to the declining trend of lathyrism.

5.7.2 Veno-occlusive Disease (VOD)

Veno-occlusive disease (VOD) of the liver is a well-recognized form of toxic liver injury produced by pyrrolizidine group of alkaloids. The VOD outbreak was observed in the tribal areas of Sarguja district of Madhya Pradesh and was characterized by ascites, pain in the epigastrium and death. This incident occurred due to the consumption of minor millet, gondhli – *Panicum milliare* – contaminated with toxic weed seeds of *Crotalaria nanaburn*. The seeds of *Crotalaria* contain monocrotaline and other toxic alkaloids belonging to the pyrrolizidine group.

5.7.3 Epidemic Dropsy

There are several reports about outbreaks of epidemic dropsy in the last three decades in the country. Epidemic dropsy was first reported from Kolkata in 1877 and the most recent outbreak in Shivapuri district in Madhya Pradesh. The disease results from the ingestion of mustard oil or other vegetable oils contaminated with *Argemone mexicana* seed oil, whose seeds closely resemble the mustard seeds. Figure 5.20 illustrates the picture of *Argemone mexicana*. The disease is characterized by oedema over ankles, gastrointestinal disturbances, vascular changes, ocular changes and cardiac insufficiency. Argemone toxicity presumably is due to the toxic alkaloid, *sanguinarine* which interferes with the oxidation of pyruvic acid, accumulates in blood resulting in signs and symptoms. Mortality is variable but it disables the victim for a long time. Epidemic dropsy has been a recurrent problem in those areas where mustard oil is used as a cooking medium. In other parts of the country, the disease is confined to the communities using mustard oil or deliberate adulteration of other vegetable oils with argemone seed oil by traders.

Figure 5.20: Argemone mexicana

With our discussion on naturally occurring toxins, we come to an end on our study of food borne diseases. You would agree it was an exhaustive reading. Before you relax, we suggest you look up the exercises given herewith under check your progress exercise 4. Answering these questions will help you review your understanding on the topic.

Check Your Progress Exercise 4

1) Explain the following terms:

a) Mycotoxins

.....

.....

b) Ergotism

.....

.....

c) VOD

.....

.....

d) Lathyrism

.....

.....

e) Enteroergotism

.....

.....

2) List a few characteristic features of :

a) Aflatoxicosis

.....

.....

b) Deoxynivalenol mycotoxicosis

.....

.....

3) Write short notes on:

a) Epidemic Dropsy

.....

.....

b) Symptoms of Lathyrism

.....

.....

The information above provided you the basic knowledge on food borne diseases. With this knowledge, we hope you would be able to identify the food borne diseases in the field setting. Reporting and investigation of food borne diseases, you would

realize, is very crucial for its prevention. In the next section, we have focused on this aspect and you will find a detailed discussion on the basic elements of outbreak investigation.

5.8 REPORTING AND INVESTIGATIONS OF FOOD BORNE DISEASES

We have already seen earlier in this unit that the reporting of food borne diseases is very little due to various lapses. You would now realize how crucial it is to record such instances for further investigations. Reporting an outbreak incidence could help in identifying the mode of transmission, the causative organism and in facilitating necessary action to be undertaken. Further, it helps in formulating preventive strategies for the future so as to avoid or minimize the chances of occurrence of an outbreak. Hence, it can be said that the epidemiological surveillance of food borne disease is fundamental to the planning and management of food safety programme in a country.

One of the important components of the surveillance is the reporting of a disease as it occurs which would enable the public health personnel to take the necessary actions. It is very difficult to have information on every food borne disease that occurs in a country. In the Indian context, the information on the occurrence of a food borne disease is mostly through the newspaper reports and especially in vernacular press. Inspite of the best communication and networking facilities, the ratio between actual to reported cases is 25:1 in developed countries, whereas, it may be as low as 100:1 in developing countries like India.

We have seen earlier also that in India, the food borne diseases are rarely recorded and when recorded, most often they are categorized under gastroenteritis. Under Indian Food Regulations, all the physicians working in an area have to inform the occurrence of a food borne disease to the Medical Officer designated by the Government. However, this rule is rarely implemented and the food borne diseases are not recorded systematically.

What is the process of recording or investigation of an outbreak? Are you aware of the process? Let us learn about the procedure in the next section.

Investigation of an outbreak

Once a suspected outbreak of a food borne disease has been reported, the basic elements of an outbreak investigation include:

1) Receipt of an initial data
2) Determination of whether an outbreak has occurred
3) Description of cases in terms of time, place and person
4) Epidemiological investigation
5) Formulation of hypothesis
6) Laboratory studies, and
7) Synthesis of findings with conclusions and recommendations.

You would realize that these elements are a part of an exercise of outbreak investigation and these steps are discussed herewith.

A) *Receipt of initial data and assessment*

How does an outbreak gets noticed? Food borne diseases are often brought to the attention by admission of patients with symptoms of vomiting and diarrhoea. The

initial step, therefore, in any investigation is to verify the diagnosis or to confirm that illness has occurred. This is followed by an assessment of whether there is an outbreak and if so, its potential magnitude and importance. The major factor to be considered in food borne disease is that a true cluster of cases of the same illness is present. Certain additional factors which need to be considered include:

1) the number of people possibly affected
2) the severity of the suspected disease
3) time for which illness occurred, and
4) the potential for continued disease transmission.

The clinical symptoms will suggest the type of agent involved and initial laboratory specifications may have already identified the agent. Initial cases also may provide important clues to identify a common source, groups or cohorts of people exposed and the areas to target.

In the early stages of an outbreak investigation, it may be useful to survey the major providers of acute or emergency medical care serving the likely where the ill persons are located.

Geared with this knowledge, we are ready for planning the investigation.

B) *Planning the investigation*

Now, how to go about planning the investigation procedure? First of all, the method of investigation needs to be decided early in the investigation. The cohort method is often used in food borne outbreak investigation in which the whole group of exposed individuals is known, for example, all persons attending a wedding party at which a food borne outbreak occurs constitute the cohort of persons at risk of illness. The investigation will be carried out by questioning all cohort members about illness and food consumption. In case a cohort is too large, a random sample can be interviewed. We have talked about one of the methods of investigation i.e., Questionnarie. Let us have a look at what this method is and how it is used.

As you may already know, *questionnaire is a set of questions, both open-ended and close-ended, used to elicit information about any topic.* It can be administered over a large sample which should be literate or semi-literate. What kind of information can be collected through the questionnaire? Can you suggest? Well, the information that needs to be collected can be listed as:

1) *Demographic information:* This includes name, address, age, sex of the both affected and normal individuals.
2) *Symptoms:* These include diarrhoea, fever, abdominal pain, nausea, vomiting, time of onset and sequence of onset of symptoms.
3) *Food history:* The standard practice in food borne outbreaks is to take a detailed history of foods consumed by affected persons over the 72 hours prior to the onset of symptoms. It is important to include water or other liquids consumed, as they also can be the vehicles for infection. It is also important to quantitate the intake i.e., number of servings, glasses etc.
4) *Data screening:* Filled up questionnaires need to be verified for the discrepancies, if any, while filling up of the information.

As can be seen, depending on the information required, the type of questionnaire will vary. Also the type of questionnaire used will depend on the population and the method of administration. Once the data has been collected, the next step is 'analysis'.

C) *Epidemiological Analysis*

Once the questionnaire has been checked, data needs to be analyzed, to describe the outbreak in terms of time, place, persons, symptoms and the likely causative agent. This is how it is to be done.

- *Time*

The typical way the time course of an outbreak is to be known, is to use date/time of onset of symptoms and draw a histogram of number of cases by time of onset of the symptoms. The pattern displayed by the histogram will indicate whether an outbreak occurred from a single point or is it a propagation. A sharp peak in the histogram suggests that the incubation period is very short.

- *Place*

Examining the attack rates i.e., number of persons affected/total group in various geographical sub-groups of the outbreak can help to concentrate on a particular area where the investigations need to be done.

- *Persons*

The personal characteristics of cases like age and sex will help in identifying the source of an outbreak. For example, if the affected persons are children, it may provide a clue to suspect a certain food.

- *Other important information*

Additional information such as place, time, group of people involved, involvement of animals which might have consumed the incriminating food etc. will also need to be collected.

After the simple analysis, it is time to determine association between different factors investigated in the outbreak. Let us see how this is done.

D) *Analytical Epidemiological Analysis*

Analytical epidemiological studies seek to determine associations between certain food items and illness. The selection of a control group is a vital step in the analytical epidemiological studies. In an investigation of a food borne disease among a cohort, the food consumption histories of all persons in attendance are collected and examined for association of eating certain food items with illness. Let us see how this is done. We will briefly go through one of the methods used to identify implicated food items by analytical epidemiological analysis. This method is traditional approach.

Traditional approach

Questionnaire responses from the affected and unaffected persons are used to generate a food-specific attack rate table. For example, if 100 people attended a marriage party and 55 became ill after 4 hours, *Staphylococus aureus* was detected in the stool samples of several people who attended the marriage party. The food specific attack rate for 2 food items is shown in Table 5.1.

Table 5.1: Food-specific attack rate – marriage party

Food item	Number of persons eating food items				Number of persons who did not eat the food items				Chi-square
	Affected	Not affected	Total	% affected	Affected	Not affected	Total	% affected	
Kheer	55	45	100	55%	2	98	100	2%	68.92
Ice-cream	30	70	100	30%	10	90	100	10%	5.32

As seen in Table 5.1, the per cent of illness among persons eating and not eating each food item is calculated and compared. The kheer has the highest attack rate among consumers and lowest among non-consumers. Highly significant correlation ($P < 0.001$) is found with kheer.

Same data can be analyzed by another method called "Relative risk". Relative risk is calculated by dividing the rate of illness in food consumers by the rate of illness in persons not consuming the food. Similarly, there are many methods to analyze the data like case-control analysis and stratified analysis.

After the epidemiological analysis, it is imperative to carry out the laboratory analysis to identify the etiological agent causing the disease. We will learn about this aspect next under the heading 'collection of samples'.

E) *Collection of Samples*

Most important aspect of food borne disease would be to collect the right sample. Now, what procedure to follow while collecting the specimen? Let us try to understand a few steps involved in the collection of the food specimen. Collect the specimens of all left-over foods. It is often observed that once a food borne disease occurs, all the suspected food is discarded deliberately or in the natural course. Efforts should be made to trace the sample. Normally, in the Indian context, in case of food borne disease outbreaks, the first to investigate are Police under section IPC 304A. Often, the incriminating sample is destroyed to erase any trace of evidence. If foods from commercial sources are suspect, carefully record the label information. If the food handler's role is suspected, the hand washings or swabs of infected wounds should be collected. All the samples should be collected in sterile containers (sterile jar, beakers or plastic jug) and should be transported to the laboratory in an ice-bucket and analyzed at the earliest. Collection of biological samples of affected persons such as urine/blood is also necessary.

After sample collection, the next step is analysis.

F) *Laboratory Analysis*

Laboratory analysis is the next crucial step in determining the agent which led to the outbreak of a disease. The most important consideration here is that the laboratory should be informed in advance, so that all the necessary arrangements are made for analysis as soon as the samples are brought to the laboratory. Appropriate analysis should be carried out to find out the etiological agent. Whenever positive results are found, the cultures and specimens should be preserved for further confirmation.

After analysis, it is time for preparing the report, as highlighted in the next step.

G) *Preparation of the Final Report*

Synthesis of epidemiological and laboratory analysis data leads to identification of the causative agent, vehicle of transmission and circumstances under which a food borne disease occurred. A final report has to be written meticulously, documenting all the compartments of epidemiological and laboratory analysis data, with conclusions and recommendations.

So you see, this is how we report and investigate a food borne outbreak. We hope, you would use this information too while reporting and investigating an outbreak in your region.

Check Your Progress Exercise 5

1) Why should the food borne diseases be systematically reported?

.....

.....

2) List the basic elements of an outbreak investigation.

.....

.....

.....

3) Fill in the blanks:

a) The method most often used in food borne outbreak investigation is ..... method.

b) The type of questionnaire to be used for food borne outbreak investigations depends on ..... and method of ..... .

c) The information to be collected through questionnaire includes ....., information, ... and data ..... .

d) Determination of attack rates help to ..... on a particular area.

e) The ratio of the rate of illness in food consumers to the rate of illness in persons not consuming food is calculated as ..... .

5.9 LET US SUM UP

In this unit, we studied about food borne diseases, categorized as food infections, intoxications and toxic infections. We learnt in details about important food diseases caused by bacteria, viruses, parasites, mycotoxins and naturally occurring toxins in food. The main focus here was on the characteristics of the disease, its occurrence, etiology, incubation symptoms, mode of transmission and preventive measures.

Finally, methods of reporting and field investigation of food borne disease outbreaks were also dealt with.

5.10 GLOSSARY

Aflatoxicosis : a major food borne disease outbreak involving aflatoxins, a metabolite of the fungus *Aspergillus* belonging to a variety of species.

Ascites : an abnormal accumulation of fluid within the abdominal cavity. It develops most frequently as a result of liver disease.

Botulism : an extremely serious neurological illness caused by the ingestion of improperly preserved canned foods, containing a neurotoxin produced by *C. botulinum.*

Carcass : the dead body of an animal, especially one slaughtered for food.

Diarrhoea : the passage of an increased amount of stool. This is frequently considered to be 3 or more stools per day, or excessively watery and unformed stool. Chronic diarrhea occurs when loose or more frequent stools persist for longer than two weeks.

Emetic Toxin : an agent/toxin that causes emesis i.e. nausea, vomiting, upchucking, regurgitation.

Enteric	:	relating to or inside the intestines.
Enterotoxigenic	:	an organism that produces toxins in the gastrointestinal tract that causes such things as vomiting, diarrhoea and other symptoms of food poisoning.
Enterotoxin	:	a toxin produced by bacteria that is specific for intestinal cells and causes the vomiting and diarrhoea associated with food poisoning. It is the toxin which causes gastroenteritis i.e. inflammation of the lining of gastro-intestinal tract.
Food borne disease outbreak	:	an incident in which two or more persons experience a similar illness, usually gastroenteritis, after ingestion of a common food which is identified as the source of food borne illness.
Food hazard	:	consumption of a contaminated food likely to cause adverse health effects to the consumers.
Food poisoning	:	the diseases transmitted by the ingestion of foods containing toxic or infectious agents; or the harmful effects of consuming foods contaminated by micro-organisms.
Gastroenteritis	:	inflammation of the stomach and small and large intestines.
Halophile	:	an organism that requires a salty environment.
Jaundice	:	yellowish discolouration of the whites of the eyes, skin, and mucous membranes caused by deposition of bile salts in these tissues. It occurs as a symptom of various diseases affecting the liver, such as hepatitis, that affect the processing of bile.
Neurotoxin	:	the toxin which acts upon the peripheral nerves of the involuntary muscles of the body.
Oral-fecal route	:	the route of transmission of diseases wherein many diseases occur when the stool (or remnants thereof) of one host ends up in someone else's mouth; can occur through contaminated water, food etc.
Psychrotrophic organism:		an organism that is potentially capable of growing at refrigeration temperatures as low as 0°C.
Relative risk	:	rate of illness in food consumers divided by the rate of illness in persons not consuming the food.
Serology	:	the science that deals with the properties and reactions of serums, especially blood serum.
Sporulate	:	to produce or release spores.
Toxin	:	a poison; usually refers to protein poisons produced by bacteria, animals, and some plants.
Ubiquitous	:	being or seeming to be everywhere at the same time; omnipresent.

5.10 ANSWERS TO CHECK YOUR PROGRESS EXERCISES

Check Your Progress Exercise 1

1) a) mycotoxins

b) intoxication, infection, toxic

c) Staphylococcal

d) diarrhoeagenic, emetic

e) *Clostridium botulinum*

2) a) The diseases transmitted by the ingestion of foods containing toxic or infectious agents are referred to as food poisoning.

b) Food borne disease is an incident in which two or more persons experience a similar illness, usually gastrointestinal, after ingestion of a common food which is identified as the source of food borne illness.

c) The toxins which act upon peripheral nerves of the involuntary muscles of the body are referred to as neurotoxins.

3) Raw milk, meat, poultry, ham, bakery foods, egg foods are implicated in the outbreak of staphylococcal poisoning.

4) a)
- minimum handling of cooked foods
- holding prepared foods above 56°C
- rapid cooling and storing chilled foods below 7°C
- processing foods within 1-2 hrs.
- minimizing cross contamination
- adoption of hygienic practices by food handlers.

b)
- reduction in the holding period of cooked rice
- holding portions of cooked rice at less than 7°C
- avoid holding of cooked rice at room temperature
- *C. botulinum* spores can be killed during processing
- eliminating recontamination
- proper heating of processed food
- proper storage

c)
- discard spoiled product
- avoiding suspected food

Check Your Progress Exercise 2

1) a) – ii)

a) – iii)

b) – i)

2) a) typhoid

b) animal, human beings

c) human, human

d) fish, oysters, mussels, clams (any two of the following)

e) shellfish, *Gonyaulax catenella*

3) a) The symptoms of Salmonellosis are nausea, diarrhoea, abdominal pain, fever, chills and headache. Chicken, eggs, turkey, egg and egg products, meat and meat products, milk and milk products are the foods involved. The preventive measures include avoiding cross contamination, proper cooking, disease-free animal, cooling to below 7°C and holding at 60°C or above, removing carriers, improving general sanitary conditions.

b) Diarrhoea, fever, nausea, vomiting, cramps, stools containing pus, blood and mucus are the symptoms of shigellosis. The foods involved are contaminated water, milk, shellfish, raw vegetables, salad preparation. The preventive measures include strict personal hygiene, holding cooked foods at temperature 40°C above and cooking and reheating to a safe temperature.

c) The symptoms of *V. parahemolyticus* gastroenteritis are severe abdominal pain, vomiting, diarrhoea, dehydration and fever. Fish, shellfish are the foods involved. The preventive measures include thorough cooking, avoiding cross contamination and proper refrigeration of raw sea foods.

d) The symptoms of *E. coli* diarrhoea are abdominal pain, diarrhoea, vomiting, fever, blood and mucus in stools. The food involved in it are poultry, beef, meat and dairy products, pork, lamb, apple cider, strict personal hygiene and god sanitary practices are some of its preventing measures.

e) Jaundice, abdominal pain, headache, fatigue, fever are the symptoms of Hepatitis A. The foods involved are shellfish, fruits, and vegetables. Its preventive measures include good personal hygiene and avoid foods from polluted water sources.

Check Your Progress Exercise 3

1) a) Type A

b) gastroenteritis

c) man

d) *Listeria monocytogenes*

e) enterotoxin

2) The major reason for the cause of outbreak of *C. perfringens* infection is the time temperature abuse after the preparation of the dishes. The slow cooling process aids in the growth of spore germination, leading to the development of a large number of vegetative cells.

3) Transfer of organisms from sources to the meat and contamination through food handlers are the causes of ETEC gastroenteritis. The preventive measures include:

- proper personal habits
- thorough cooking and holding of foods, and
- ensuring potable water supply.

Check Your Progress Exercise 4

1) a) Mycotoxins are the toxic secondary metabolites of moulds produced in the agricultural commodities either during pre-or post-harvest stages.

b) Ergotism is a disease caused by the consumption of contaminated ergot cereal grains like rye, pearl millet, wheat and sorghum.

c) A well recognized form of toxic liver injury produced by pyrrolizidine group of alkaloid is VOD.

d) Lathyrism is an endemic disease caused due to the consumption of *Lathyrus sativus* (Kesari Dal) as a staple diet.

e) Enterorgotism is Indian ergotism, manifested by nausea, vomiting, giddiness and prolonged sleepiness.

2) a) Jaundice, primary liver cancer, chronic hepatitis, cirrhosis, ascites and portal hypertension are the characteristic features of aflatoxicosis.

b) The characteristic features of deoxynivalenol mycotoxicosis are pain in the stomach 10-15 minutes after food consumption, vomiting and effects on the immune system.

3) a) Epidemic dropsy results from the ingestion of mustard oil or other vegetable oils contaminated with *Argemone mexicana* seed oil. It is characterized by edema over ankles, gastrointestinal disturbances, ascular and occular changes and cardiac insufficiency. The toxicity is due to the presence of alkaloid 'sanguinarine', which interferes with the oxidation of pyruvic acid, which accumulates in blood.

b) The symptoms at the time of the onset include heaviness and stiffness of the limbs, muscle cramps, tremors and involuntary movements of upper extremity. Lathyrism causes a crippling paralysis of the lower limbs and may result in death.

Check Your Progress Exercise 5

1) Food borne disease should be systematically reported as:

- these are often categorized under gastroenteritis.
- their occurrence is not usually informed to the Medical Officer.

2) The basic elements of an outbreak investigation are:

- Receipt of initial data
- Determination of whether on outbreak has occurred
- Description of cases in terms of time, place and person
- Epidemological investigation
- Formulation of hypothesis
- Laboratory studies, and
- Synthesis of findings with conclusions and recommendations.

3) a) cohort

b) population, administration.

c) demographic symptoms, food history, screening.

d) concentrate

e) relative risk