Chapter 3
Food Poisoning and Foodborne Diseases

Microorganisms that Causes Food Poisoning

Food poisoning actually is caused by microorganisms that are in the food that we eat and may not be destroyed by cooking. There are actually three different categories of these microorganisms that could cause food poisoning if proper food safety precautions are not followed.

The three types are bacteria, virus and parasite.

Bacteria

This is the most common type of food poisoning. This type of problem usually comes along when food has gone bad because it was not stored properly. The most common types of bacteria that cause food poisoning includes *Staphylococcus aureus, E. coli, Listeria monocytogenes, Salmonella*, *Campylobacter jejuni*. If foods are kept properly refrigerated, then these types of bacteria can usually be avoided unless there is a problem of contamination.

Virus

Virus are not as common as bacteria when it comes to food poisoning, but it is still a possibility. The main two types of foodborne viruses are Hepatitis A and Norovirus. Generally, these contaminate foods that have been grown in or near sewage. Food poisoning of this type usually results in a recall of the contaminated foods for the protection of the consumers.

Parasite

Generally, parasites are not as big of a problem for food poisoning, but they could happen. If an animal is contaminated when it is butchered for food, then the result could be contaminated meats. The two main types of parasite food poisoning would be *Cryptosporidium parvum* and *Giardia lamblia*. If meats are cooked properly, then there should be no issue of food poisoning from parasites.

Microbial toxins

Microbial toxins are toxins produced by microorganisms including bacteria and fungi. Microbial toxins promote infection and disease by directly damaging host

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tissues and by disabling the immune system. Bacterial toxins are classified as exotoxins and endotoxins.

Endotoxins

Endotoxins are cell-associated substances that are structural components of bacteria. Most endotoxins are located in the cell envelope. Endotoxin refers specifically to the lipopolysaccharide (LPS) or lipooligosaccharide (LOS) located in the outer membrane of gram-negative bacteria. Although structural components of cells, soluble endotoxins may be released from growing bacteria or from cells that are lysed as a result of effective host defense mechanisms or by the activities of certain antibiotics. Endotoxins generally act in the vicinity of bacterial growth or presence.

Exotoxins

Exotoxins are usually secreted by bacteria and act at a site removed from bacterial growth. However, in some cases, exotoxins are only released by lysis of the bacterial cell. Exotoxins are usually proteins, minimally polypeptides that act enzymatically or through direct action with host cells and stimulate a variety of host responses. Most exotoxins act at tissue sites remote from the original point of bacterial invasion or growth. However some bacterial exotoxins act at the site of pathogen colonization and may play a role in invasion.

Bacterial protein toxins

Exotoxins are usually secreted by living bacteria during exponential growth. The production of the toxin is generally specific to a particular bacterial species that produces the disease associated with the toxin. (eg:- only *Clostridium tetani* produces tetanus toxin, only *Corynebacterium diphtheriae* produces disphtheria toxin). Usually virulent strains of the bacterium produce the toxin while non virulent strains do not, and the toxin is the major determinant of virulence (eg:- tetanus and disphtheria). At one time, it was thought that exotoxin production was limited mainly to gram-positive bacteria, but clearly both gram-positive and gram-negative bacteria produce soluble protein toxins. Bacterial protein toxins are the most powerful human poison known and retain high activity at very high dilutions.

Usually the site of damage caused by an exotoxin indicates the location for activity of that toxin. Terms such as enterotoxin, neurotoxin, leukocidin or hemolysin are descriptive terms that indicate the target site of some well-defined protein toxins. A few bacterial toxins that obviously bring about the death of an animal are known simply as lethal toxins. Some bacterial toxins are utilized as invasins because they act locally to promote bacterial invasion. Examples are extracellular enzymes that degrade tissue matrices of fibrin, allowing the bacteria to spread. This includes collagenase, hyaluronidase and streptokinase.

Some protein toxins have very specific cytotoxic activity. (ie, they attack specific types of cells). For examples, tetanus and botulinum toxins attack only neurons. But some toxins (as produced by *Staphylococcus*, *Streptococcus*, *Clostridia* etc) have fairly, broad cytotoxic activity and causes non specific death of various types

of cells or damage to tissues, eventually resulting in necrosis.

Protein exotoxins are inherently unstable. In time they lose their toxic properties but retain their antigenic one. This was first discovered by Ehrlich who coined the term "toxoid" for this product. Toxoids are detoxified toxins which retain their antigenicity and their immunizing capacity. The formation of toxoids can be accelerated by treating toxins with a variety of reagents including formaline, iodine, pepsin, ascorbic acid, ketones etc. The mixture is maintained at 37^0C at pH range of 6-9 for several weeks. The resulting toxoids can be used for artificial immunization against disease caused by pathogens. Toxoids are effective immunizing agents against diphtheria and tetanus that are part of the DPT (DTP). Bacterial protein toxins are strongly antigenic.

Foodborne intoxications or food poisoning is caused by ingestion of toxicants found as toxins of certain plants or animals, toxin formed by microbes while they multiply in the foods or after entering the intestine and poisonous substances that may be intentionally or incidentally added to foods during production, processing and transportation or storage. Toxicants or toxic substances in food are substances that are found in food that can produce harmful effects on ingestion by human and animals.

Bacterial intoxications

Staphylococcal poisoning

- Most common infection caused by *Staphylococcus aureus*
- Enterotoxins produced are heat stable
- Toxin causes gastroenteritis, symptoms appear within 1-6 hours of consuming contaminated food.
- The symptoms of Staphylococcal food poisoning includes nausea, vomiting and moderate diarrhoea. But usually no fever occurs.
- The disease usually lasts for less than 12 hours and never fatal
- The foods likely to be involved are Milk products, Custards, Processed meat, Creampuff, Sandwich, Poultry stuffing, Potato salad etc.
- The best preventive measures are to use sanitary precautions when preparing all perishable foods and refrigerate the food at temperature below 6-7^0C and food should not be allowed to stand for several hours at room temperature before serving.

Botulism

- Produced by the bacterium *Clostridium botulinum*
- It produces neurotoxin which is heat sensitive

- It is a food intoxication caused by the toxin secreted by the bacteria and not by the bacteria themselves.
- *C. botulinum* grows only in anaerobic condition, it grows in canned, smoked or cured food. It doesn't grow in fresh food.
- The food is easily contaminated by the spores of *Clostridium*. In improperly canned or preserved food, the spores grow and produce neurotoxin.
- While multiplying, it releases a powerful exotoxin called botulinum. It affects the nervous system. Hence it is called a neurotoxin.
- This toxin is a protein and is easily destroyed by heat (70^0C)
- Common foods implicated are fermented or smoked marine products, home cured ham, meat products etc.
- Disease starts within 2 hours to 14 days after ingestion of contaminated food
- The first sign of the disease is the paralysis of muscles of eye lid. This symptom appears in a few hours of eating the food.
- Next the paralysis affects the muscles of speech, swallowing becomes difficult. It is a neuroparalytic disease. Other symptom are blurred vision or double vision, dilated pupils, nausea, vomiting, headache, persistent constipation etc.
- Botulism can be prevented by killing *C. botulium* spores in the foods
    - During processing
    - Eliminating recontamination of processed food
    - Destroying the toxin by proper heating of processed food
    - By proper storage
    - By discarding the product that has developed signs of spoilage such as off odor, bulging of cans and gas bubbles on opening the can.

Bacillus cereus Poisoning

- Caused by *Bacillus cereus* infection
- Symptoms may appear within 15 minutes to 11 hours
- May cause nausea, abdominal pain or diarrhoea
- Common foods attributed are cereal dishes like rice, pudding, mashed potatoes, sauces, vegetable soups etc.
- Most of the out breaks are due to contamination of cooked rice

Preventive measures

- Proper hygiene before and after cooking
- Proper storage of food till usage. Rice and other hot foods have to be maintained at 65^0C and above till consumption. Other foods like milk and its products are to be stored below 7^0C.
- Avoid holding rice and other cooked preparation at room temperature for long periods
- Avoid frequent handling

Infantile gastroenteritis and Traveller's diarrhoea

These are caused by the enterotoxin produced by *E. coli* and *B. cereus*.

Mycotoxicosis

Food poisoning caused by the ingestion of fungal toxin. The fungal toxin is called mycotoxin.

- It is produced in the food in which the fungus lives
- The fungus *Aspergillus flavus* produces a toxin called aflatoxin. It causes hepatoma and carcinoma (cancer).
- *Penicillium rubrum* produced rubratoxin which affects the liver
- The mushroom *Amanita phalloides* produce amatoxin which causes liver damage and hypoglycemia.

Food infections

It is caused by ingestion of pathogenic microbes that penetrate the intestinal mucosa and multiply or migrate into other tissues where they multiply.

Salmonellosis (Typhoid)

- Disease caused by *Salmonella* food injection
- *Salmonella* is a gram-negative rod-shaped bacterium
- Infection occurs through contaminated food or domestic animals
- Salmonellosis is of two types namely enteritis and typhoid fever
- Enteritis is due to the existence of *Salmonella enteritidis* in the intestine. It produces a toxin called enterotoxin.
- The symptoms of enteritis include chills, head ache, nausea, vomiting, abdominal pain and several diarrhoea. Symptoms persists for 2-3 days. Mortality is low.

- Typhoid fever is also a kind of salmonellosis caused by *S. typhi* and *S. paratyphi*
- The symptoms of typhoid fever include fever, headache, abdominal tenderness, constipation and appearance of rose red spots on the body.
- In later stages, diarrhoea with 'pea soup' stools appear. In severe cases, there is haemorrhage in the intestine and perforation of the intestine leading to peritonitis.
- Salmonellosis can be prevented by avoiding consumption of contaminated food, destruction of *Salmonella* by heat, prevention of *Salmonella* growth by refrigeration etc.
- Salmonellosis can be treated by antibiotics like chloramphenicol, ampicillin, amoxycillin etc.

Shigellosis (Bacillary Dysentery)

- Caused by bacteria of genus *Shigella*
- It can be destroyed by heating
- Mostly caused by human to human to human transmission, contaminated water, milk and salad preparation.
- Incubation period ranges from 1-7 days
- Symptoms are bloody diarrhoea, fever, nausea and cramps
- *Shigella* infection in an intestinal disease caused by a family of bacteria known as *shigella*
- Children under age 5 are most likely to get *shigella* infection, but it can occur at any age

Vibrio parahaemoliticus Gastroenteritis

- Curved, rod-shaped, gram-negative bacterium found in brackish, salt water, which when ingested causes gastro intestinal illness in humans.
- Incubation period is 12-24 hrs
- Major symptoms are severe abdominal pain, vomiting and diarrhoea
- Sources of contamination are fish, shellfish, crab and shrimp
- Organisms is easily destroyed by heat

Enteropathogeic *E. coli* diarrhoea

- Enteropathogeic *E. coli* (EPEC) is a special kind of *E. coli* that lets it

attach to intestinal cells. Some types of EPEC may cause diarrhoea.

- Presence of *E. coli* in foods indicates faecal contamination
- It is a heat sensitive organism
- Pasteurization and normal cooking temperature are effective in destroying the organism
- Symptoms appear within 12-72 hrs
- Abdominal pain, diarrhoea, vomiting and fever are common
- Foods implicated are poultry, meat and dairy products
- It can be prevented by adopting strict personal hygiene and good sanitary practices

Hepatitis A

- It is a viral liver disease that can cause mild to severe illness
- It is caused by faecal contamination and spreads from an to man
- The hepatitis A virus (HAV) is transmitted through ingestion of contaminated food or water or through direct contact with an infected person.
- It has long incubation period 15-50 days
- Symptoms are fever, abdominal pain, headache and jaundice
- Prevention includes ensuring good personal hygiene of food handlers and avoiding eating foods if hygiene practised is doubtful.

Shellfish Poisoning

- Shellfish like Oysters, Mussels and Clams are generally bred in sewage polluted beds or brackish water.
- Poisoning occurs due to accumulated toxins produced by a dino-flagellate algae *Gonyaulax catenella* in the shellfish.
- Shellfish is also usually consumed under cooked or uncooked hence may have other pathogenic organisms. Poisoning is usually an emergency and needs medical advice at the earliest.

Other toxic infection

Some foodborne toxic infections are caused by ingestion of large number of enterotoxigenic bacteria which while multiplying in the intestine produce and release enterotoxins in the intestine which are responsible for the symptoms.

Clostridium perfringens Gastroenteritis

- Common in places where large number of people eat like in restaurants, institutional canteens, hospitals etc.
- *C. perfrigens* is a gram-positive, spore forming, anaerobic bacteria that is normally found in the intestine of human and animals.
- It is also a common cause of food poisoning when ingested in sufficient numbers
- *C. perfringens* is also known to cause other diseases, such as infections of the skin and deeper tissues. This is known as "Clostridial myonecrosis or gas gangrene" and also results from toxins produced by *C. perfringens*. Gas gangrene can occur when deep wounds are contaminated with foreign objects containing the bacteria.

Enterotoxigenic *E. coli* Gastroenteritis

- It is one of the chief causes of traveller's diarrhoea
- Occurs due to contaminated water and improper food handling

Cholera

- It is an infectious disease that causes severe watery diarrhoea; which can lead to dehydration and even death if untreated.
- It is caused by eating food or drinking water contaminated with *Vibrio cholerae*
- It is characterized by watery diarrhoea, extreme loss of fluid and electrolytes and severe dehydration. It can be fatal. Incubation period for cholera is few hours to 5 days.
- Symptoms include abrupt onset of vomiting and watery diarrhoea and dehydration. It may turn fatal if not promptly rehydrated.
- Cholera can be prevented by proper and safe disposal of sewage and supply of protected water.

Listeriosis

- Listeriosis is a serious infection usually caused by eating food contaminated with the bacterium *L. monocytogenes*.
- *L. monocytogenes* is commonly found in soil, stream water, sewage, plants and food
- It mostly occur in pregnant women, newborn children and in people whose immune system is compromised. The disease could be fatal.
- Milk and dairy products, contaminated sea foods, vegetables and salads

are implicated

- Proper cooking and hygienic food handling can prevent the infection

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