Unit -3

Food borne diseases and intoxication

Food borne diseases caused by microorganisms are subdivided into 2 types—

A) Food poisonings
B) Food infections

A) Food poisonings: -

Food poisonings can be the result of either chemical poisoning or the ingestion of a toxicant (intoxication). The toxicant might be found naturally in certain plants or animals or be a toxic metabolic product excreted by microorganisms. Bacterial food intoxication therefore refers to food borne illness caused by the presence of a bacterial toxin formed in the food.

There are two main kinds of food intoxications / poisonings caused by bacteria—

1. **Botulism caused (by toxin in food by *Clostridium botulinum)***
2. **Staphylococcal intoxication (by *Staphylococcus aureus)***

1. Botulism: -

Botulism is a disease caused by the ingestion of food containing the neurotoxin produced by *Clostridium botulinum.*

The organism: -

This rod shaped soil bacterium is saprophytic, spore forming, gas forming, and anaerobic. Seven types are distinguished on the basis of the serological specificity of their toxins. The predominant toxin from these types is designated by the same capital letter.

Type A: - It is the one commonly causing human botulism in the western part of the United States. It is more toxic than type B.

Type B: - It is found more often than type A in most soils of the world and is less toxic to human beings.

Type C: - It causes botulism of fowls, cattle, and other animals but not of human beings.

Type D: - It is associated with forage poisoning of cattle in the Union of South Africa.

Type E: - It is toxic for humans, and is obtained from fish and fish products.

Type F: - It is similar to types A and B, has been isolated in Denmark and produces human botulism.
Type G: - It is isolated from the soil in Argentina but has not been implicated in human botulism.

Not all types produce a single toxin, but produce mixture of toxins. The *Cl. Botulinum* ferments carbohydrates with gas production. The strains are divided into 3 general groups, based on cultural and physiological characters.

Group I: - It includes all types A, B and F strains (proteolytic).

Group II: - It includes all types of B, E and F strains (non-proteolytic).

Group III: - It includes types of C and D (non-proteolytic) and share a common metabolic pattern.

- **Growth and Toxin production: -**

Toxin production by *C. botulinum* depends on the ability of the cells to grow in a food and to autolyze there, therefore, factors that influence spore germination, growth, and hence toxin production are of special interest. These factors include the composition of the food, moisture content, pH, O-R potential, salt content, temperature and time of storage of the food.

Meats, fish, and low or medium acid canned foods have been shown to support toxin production. The media containing milk or casein, glucose or maltose, and corn steep liquor yield more potent type A toxin than other media. More NaCl is needed at higher temperature, such as 37 C, than at a lower one, at 15 C. A PH near neutrality favours the growth. A pH 4.5 or lower prevents toxin production. The optimum temperature for toxin production and the growth of the proteolytic strains is about 35 C. Low O-R potential (anaerobic condition) is required for the growth and toxin production.

- **The toxin: -**

The toxin of *C. botulinum* is protein in nature and is powerful in minute amount to cause death. It is absorbed in the small intestine and paralyses the involuntary muscles of the body. It is thermo labile i.e. can be destroyed by

heat. In the laboratory, heat treatments of 5 to 6 minutes at 80^0 C will inactivate type A toxin, while 15 min at 90^0 C will inactivate type B toxin. The toxin can be destroyed in cheese by 7.3 Mrad of gamma rays and in broth by 4.9 Mrad. The toxin has been known to persist in foods for long periods, especially when storage has been at low temperature. It is unstable at pH values above 6.8.

The seven toxins (A to G) are antigenic, causing the production of antitoxin specific for a given toxin type injected. Toxoids have been prepared for the active immunization.

Toxicity and Bacteriophages: -

Recent studies on the relationship between toxigenecity and bacteriophages have suggested that the bacterial genome may not be responsible for the production of the toxin but is coded for by the genome of an incorporated temperate bacteriophage. This would explain the occasional loss of toxigenecity by some strains.

Heat resistance of spores: -

The resistance of spores of *C. botulinum* is more than that of spores of other species of clostridium. The heat treatment necessary to destroy all the spores in the food depends on the kind of food, type of strain, medium, temperature, number of spores and the age of the spores. In general, spores of type C, D, and E are less heat resistant than type A and B. Type E spores are inactivated in 15 min at 80^0 C.

Distribution of spores: -

Spores are found in both cultivated and virgin soils all over the world. Type A spores are found more in western soils in this country and type B spores elsewhere. Type E spores are found in sea, lake mud, and in fish.

Incidence of Botulism: -

Fortunately, botulism occurs only rarely, but it always receives much attention because of the high mortality. The fatality rate in between 1970 to 1973 was 23 %, but in between 1899 to 1949 it was above 60 % in United States.

Foods involved: -

In the United States, inadequately processed home-canned foods are most often the cause of botulism. In Europe causes are preserved meats and fish. Of the home canned foods, those most often responsible for botulism have been string beans, sweet corn, beets, asparagus, and spinach. The spores of *Cl. Botulinum* survive long storage periods in raw and precooked frozen foods and can grow and produce toxin.

The disease: -

People are so susceptible to botulism that if low amounts of toxin are present, everyone who eats the food becomes ill and consumption of very small pieces of food can cause illness and death.

Symptoms: -

→ The typical symptoms usually appear within 12 to 36 hours, although longer or shorter time may be required.

→ The earliest symptoms usually are acute digestive disturbances followed by nausea and vomiting and possibly diarrhoea.

→ Fatigue, dizziness and headache.

→ Constipation, double vision, difficulty in swallowing and speaking.

→ Dryness of the mouth and constriction of the throat, swollen and coated tongue.

→ Temperature normal, involuntary muscles become paralysed, paralysis spreads to the respiratory system and heart

→ Death results from respiratory failure.

Treatment: -

The only known method for the successful treatment of botulism is the administration of antitoxin. Unfortunately, this injection usually is not successful if made after the symptoms have appeared, but it should always be used at the earliest possible moment. Other treatments include artificial

respiration, keeping the patient quiet, maintaining the fluid balance in the body, removal of food from the digestive system.

Prevention: -

The methods for the prevention include—

→ Use of approved heat processes for canned foods

→ Rejection of all gassy (swollen) or spoiled canned foods

→ Refusal even to taste a doubtful food

→ Avoidance of foods that have been cooked, held, and not well reheated

→ Boiling of suspected food for at least 15 minutes.

==========

2. Staphylococcal intoxication

One of the most commonly occurring food poisonings is caused by the ingestion of the enterotoxin formed in food during growth of certain strains of *Staphylococcus aureus.*

The organism: -

The organism is a typical staphylococcus, occurring in masses like clusters of grapes or in pairs and short chains. Growth on solid media usually is golden or yellow but may be unpigmented in some strains. Most enterotoxin producing *S. aureus* cultures are coagulase positive, facultative anaerobic, salt tolerant (10 to 20 % NaCl), nitrite tolerant, sugar tolerant, fermentative and proteolytic, produce 6 serologically distinct enterotoxins (A, B, C_1, C_2, D and E), most food poisoning is from type A.

The range of conditions permitting growth of the staphylococci, and hence toxin production, varies with the food involved. In general, the better medium the food is for the cocci, the wider the range of temperature, pH, or a_w over which growth can take place.

The temperature range for growth and toxin production is about 4 to 46 ^{0} C, depending on the food. The million staphylococci per ml or gram of

perishable foods will be inactivated by 66 ^{0} C maintained for at least 12 min or by 60 ^{0} C at 78 to 83 min.

The sources from which the food poisoning staphylococci enter foods are for the most part human or animal. The nasal passages of many persons are a common cause of infection. Staphylococci are becoming increasingly important in causing mastitis in cows. Ordinarily, air is a relatively important source of the cocci.

The enterotoxin: -

The staphylococcal enterotoxins are simple proteins with molecular weights between 26,000 to 30, 000. The single polypeptide chains are cross-linked by a disulfide bridge to form a characteristic **cystine loop.** Six types of serologically distinct enterotoxins (A, B, C_1, C_2, D and E) are produced by staphylococci. A and D types are more often associated with food poisoning outbreaks. Appreciable levels of enterotoxin are produced only after considerable growth of the staphylococci.

This enterotoxin is stable to heat. The normal cooking of foods will not destroy the toxin; such foods might cause poisoning, although no live staphylococci could be demonstrated.

Incidence of the disease: -

There are no reliable figures on the numbers of cases in the United States or any of the states for any given period. The poisoning usually is not reported or publicised unless the outbreak is fairly large.

Foods involved: -

Custard and cream filled bakery goods, ham, and poultry have caused the most outbreaks. About 75 % of all staphylococcal food poisoning outbreaks occur because of inadequate cooling of foods. Other foods include meat and meat products, fish and fish products, milk and milk products, cream sauces, salads, puddings, custards, and salad dressings. Growth and toxin production may take place in the steam tables in cafeterias and restaurants and in food vending machines that keep foods heated for extended periods if temperatures and times are not properly controlled.

The disease: -

Individuals differ in their susceptibility to staphylococcal poisoning, some may become very ill and few may be affected little or not at all. The incubation period is brief, 2 or 4 hours.

Symptoms: -

→ Salivation, then nausea, vomiting, abdominal cramping, diarrhoea.

→ Blood and mucous may be found in stools in severe cases.

→ Headache, muscular cramping, sweating, chills, weak pulse, shock, and shallow respiration may occur.

→ Subnormal body temperature rather than fever.

→ The duration is brief, usually 1 or 2 day, and recovery ordinarily.

→ The mortality is extremely low.

Conditions necessary for an outbreak: -

→ The food must contain enterotoxin-producing staphylococci

→ The food must be a good culture medium for growth and toxin

→ The temperature must be favourable for the growth of staphylococci, and enough time must be allowed for production of enterotoxin

→ The enterotoxin-bearing food must be ingested.

Prevention: -

1. Prevention of the contamination of the food with the staphylococci
2. Prevention of the growth of the staphylococci
3. Killing staphylococci in the foods.

- **Food infections**

A bacterial food infection refers to food-borne illness caused by the entrance of bacteria into the body through the ingestion of contaminated foods and the reaction of the body to their presence or to their metabolites.

Examples are—

1. Salmonellosis
2. *Clostridium perfringens* gastroenteritis
3. *Bacillus cereus* gastroenteritis
4. *Escherichia coli* illness
5. Shigellosis
6. Cholera

Sr. No.	Disease & Causative organism	Morphology	Incubation period, symptoms
1	**Salmonellosis** *Salmonella enteritidis*, *S. typhimurium*, *S. derby*, *S. java*, *S. infantis*,	Gram negative, non-spore forming rods, ferment glucose with gas, do not ferment lactose or sucrose	5-72 hrs, diarrhoea, abdominal pains, chills, fever, vomiting, dehydration, anorexia, headache, malaise (depression).
	Typhoid fever *Salmonella typhi*	-- Do --	7-28 days, Septicemia and lymphoid tissue involved, malaise, headache, high continued fever, cough, nausea, vomiting, constipation, slow pulse rate, enlarged spleen, chills.
	Paratyphoid fever *Salmonella paratyphi A*, *S. paratyphi B*, *S. paratyphi C*	-- Do --	1-15 days, bloodstream infection, headache, continued fever, profuse perspiration, nausea, vomiting, abdominal pain, enlarged spleen, diarrhoea.
2	***Clostridium perfringens*** **Gastroenteritis** *Clostridium perfringens (welchii)*	Gram positive, rods, nonmotile, anaerobic, spore forming	8-24 hrs, Acute abdominal pains, diarrhoea, gas, fever.

3	***Bacillus cereus*** **gastroenteritis**	Gram positive, rods, spore forming, aerobic,	8-16 hrs, nausea, abdominal cramps, watery diarrhoea, vomiting.
4	***Escherichia coli*** **infection** Enteropathogenic *Escherichia coli* (EEC)	Gram negative, motile, lactose fermenting, enterotoxin producing	8-24 hrs, fever, chills, headache, abdominal cramps, watery diarrhoea, (rice-water stools), vomiting, dehydration, shock, similar to cholera.
5	**Shigellosis** *Shigella sonnei, S. flexneri, S. dysentrae, S. boydii*	Gram negative, rods, nonmotile, non-spore forming	1-7 days, abdominal cramps, fever, chills, watery stools containing blood, mucous or pus, headache, prostration, nausea, dehydration.
6	**Cholera** *Vibrio cholerae,* V. *parahaemolyticus*	Gram negative, comma shaped. Motile, non-spore forming	2-48 hrs, abdominal pains, fever, chills, watery stools containing blood, mucous or pus, headache, prostration, nausea, dehydration. More vomiting, fishy odour to stool & vomit.

*** Foods involved and control measures of food infection**

Sr. No.	**Disease**	**Foods involved**	**Control measures**
1	**Salmonellosis**	Moist, mixed foods, milk, beans, potato, fruits,	Cook foods thoroughly, chill foods rapidly in small quantities, prevent cross contamination, protect foods from contamination.
2	***Clostridium perfringens*** **Gastroenteritis**	Meat and meat products, Fish and fish products,	-- Do --

3	***Bacillus cereus* gastroenteritis**	Custards, cereal products, puddings, sauce.	-- Do --
4	***Escherichia coli* infection**	Milk & milk products, Beverages.	Proper pasteurization and heating
5	**Shigellosis**	Moist, mixed foods, milk, beans, potato, fruits,	Cook foods thoroughly, chill foods rapidly in small quantities, prevent cross contamination, protect foods from contamination.
6	**Cholera**	Raw foods of marine origin, fish and fish products.	-- Do --

==========

- **Mycotoxins**

Some food borne diseases are caused by the consumption of the foods containing **mycotoxins**, which are produced by fungi. Some are highly toxic to animals and human beings.

1. Aflatoxin
2. Patulin
3. Ochratoxin
4. Luteoskyrin
5. Sterigmatocystin
6. Penicillic acid
7. Alimentary toxic Aleukia (ATA)
8. Roquefortine

Sr. No.	Name of Mycotoxin	Producing Fungus	Foods or feeds isolated from
1	Aflatoxin	*Aspergillu flavus, A. parasiticus, some penicillium spps*	Barley, corn, cottonseed, oats, peanuts, rice, soyabean, wheat, sorghum, peas, sweet potatoes, soyabean meal.
2	Patulin	*Penicillium expansum, P. claviforme, P. patulum, P. melinii, P. cyclopium, Aspergillus clavatus, A. terreus*	Apple sap, apple cider, apple juice
3	Ochratoxin A	*Aspergillus ostianus, A. ochraceus, A. petrakii, A. alliaceus, A. sulphurous, Penicillium cyclopium, P. commune.*	Corn, wheat, barley, white beans, peanuts, bread, eggs
4	Luteoskyrin	*Penicillium islandicum*	Rice flour
5	Sterigmatocystin	*Aspergillus regulosus, A. nidulans, A. versicolor, Penicillium luteum*	Wheat, oats
6	Penicillic acid	*Penicillium puberulum, P. cyclopium, P. thomii, P. madriti, A. sulphurous, A. mellens*	Dried beans, tobacco
7	Alimentary toxic aleukia (ATA)	*Species of Cladosporium, Penicillium, Fusarium, Mucor, Alternaria*	Grain
8	Roquefortine	*Penicillium roqueforti*	Cheese,

Sr. No.	Name of mycotoxin	Toxic to	Carcinogenic to
1	Aflatoxin	B_1 quail, cats, chickens, rabbits, monkeys, dogs, hamsters, cattle, guinea pigs	B_1 trout, rats, sheep, mice, ducklings
2	Patulin	Mice, rats, cats, rabitts, quail,	Mice,
3	Ochratoxin A	Rats, chicks, ducklings	Rats, trout, chicks
4	Luteoskyrin	Mice	Mice
5	Sterigmatocystin	Mice, monkeys, rats	Rats
6	Penicillic acid	Rats	Rats
7	Alimentary toxic aleukia (ATA)	Human beings	--
8	Roquefortine	Mice	--

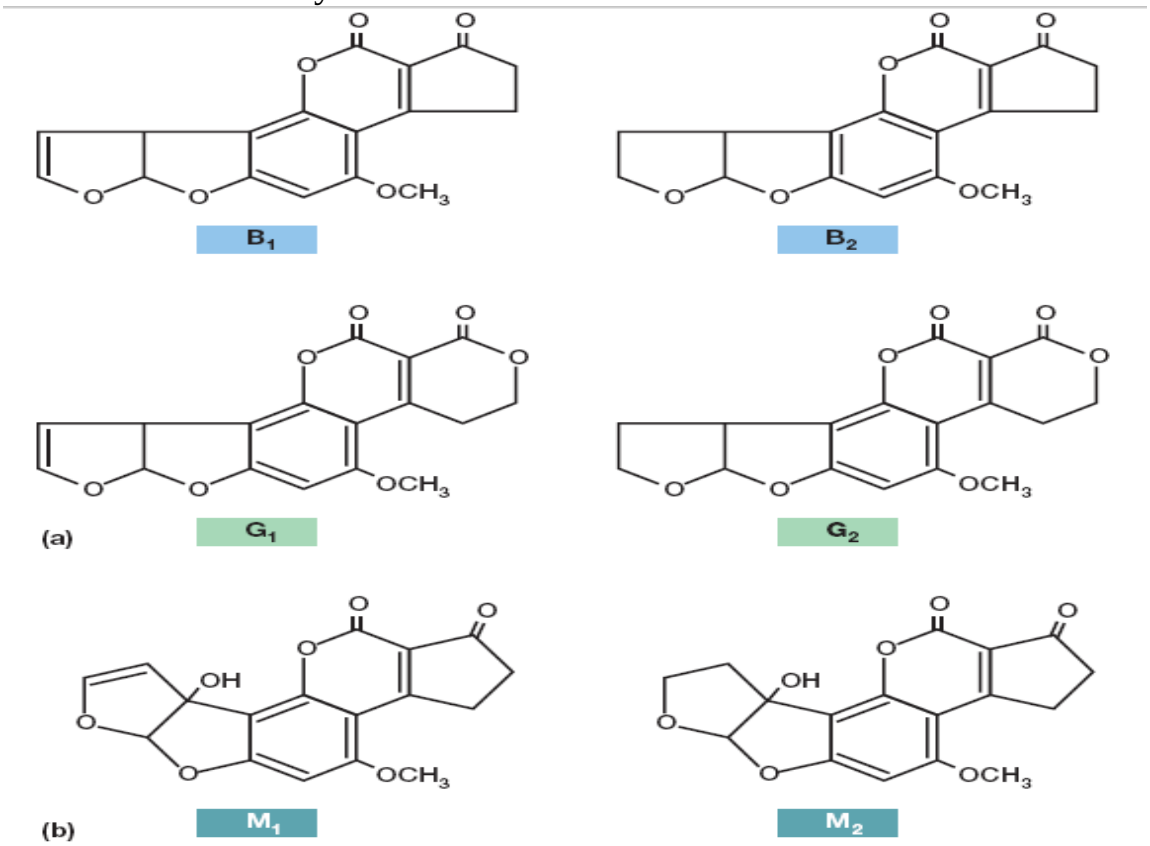
1. Aflatoxins: -

Oxygenated heterocyclic compounds, 2 main aflatoxins B_1 and G_1 because they fluoresce blue & green under U.V. B_2 and G_2 are dihydroderivatives of B_1 and G_1. M_1, M_2 & P_1 are hydroxylated derivatives of B_1 and G_1.

Fungus-derived carcinogens include the aflatoxins and fumonisins. **Aflatoxins** are produced most commonly in moist grains and nut products. Aflatoxins were discovered in 1960, when 100,000 turkey poultry died from eating fungus-infected peanut meal. *Aspergillus flavus* was found in the infected peanut meal, together with alcohol-extractable toxins termed aflatoxins.

These flat-ringed planar compounds intercalate with the cells' nucleic acids and act as frameshift mutagens and carcinogens. This occurs primarily in the liver, where they are converted to unstable derivatives.

Aflatoxins B1 and B2, after ingestion by lactating animals, will be modified in the animal body to yield the aflatoxins M1 and M2**.** If cattle consume aflatoxin-contaminated feeds, these also can appear in milk and dairy products. With the ability to screen grains and corns rapidly for these compounds, it is possible to limit shipments of potentially contaminated grains and feedstuffs. The aflatoxins are potent hepatocarcinogens, which have been linked to effect on immunocompetence, growth, and disease resistance in livestock and laboratory animals.



2. Patulin: -

Unsaturated lactone, 4-hydroxy-4H-furo[3, 2c]pyran-2(6H)-one. White crystal, melting point 110.5C, M.W. 154, sensitive to SO_2 , unstable in alkali but stable in acid.

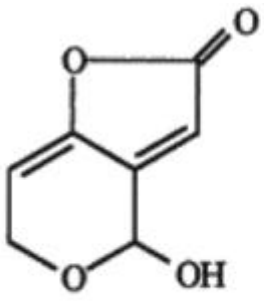
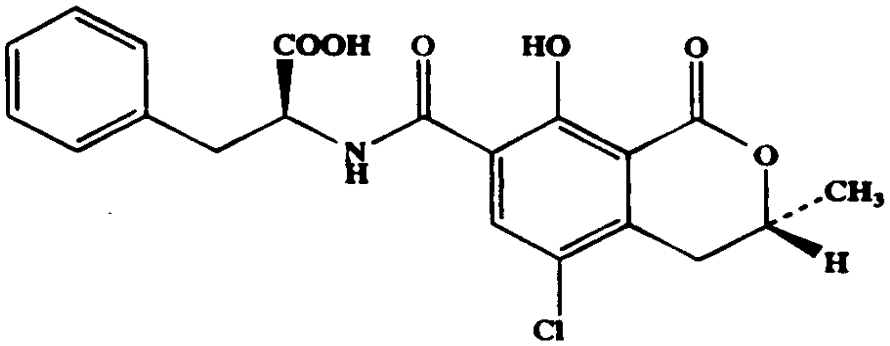


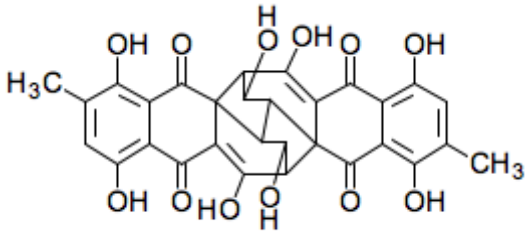
FIGURE 1 - Structure of Patulin (4-Hydroxy-4H-furol [3,2-c] pyran-2(6H)-one).

3. Ochratoxin: -

Chlorinated isocoumarin derivative with an amide bond to phenylalanine. It fluoresces green under U.V.



4. **Luteoskyrin**



C16763

5. **Sterigmatocystin**