



## Highlight the Diseases Generated by Food Pathogens: A Review

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**ABSTRACT:** Foods are exposing to infection with different types of pathogenic bacteria and fungi, and the emergence of many epidemics and cases of food poisoning in various regions of the world, particularly in developing countries.

The article includes, causes of food disease, which is happening as a result of eating toxic substances with food that may be of microbial origin (bacteria, fungi, parasites, viruses), animal, plant or chemical origin, which generates food poisoning. Microbial poisoning may result either from ingestion of microorganism toxins like *Staphylococcus aureus* or as a result of infection like *Campylobacter jejuni* also, some cases of food poisoning with some types of bacteria may recover without the need for medical intervention like *S. aureus*, and others may be fatal even in low concentrations with a high mortality rate, such as *Cl.botulinum*. The article also, reviewed the dangers of mycotoxins as a global concern and more dangerous than bacterial toxins, as they have a cumulative toxic effect that does not appear until years later, and responsible for many different cancers. It is also impossible to avoid food contamination with mycotoxins even with the use of high technologies in food processing, and the best solution lies in preventing the growth of toxic molds that secrete these toxins on food, by using Good Agricultural Practices (GAP) and Good Manufacturing Practices (GMP).

**KEYWORDS:** bacteria, food borne diseases, food poisoning, toxins, mycotoxins.

### 1- INTRODUCTION

#### Causes of food disease

The causes of nutritional disease are vary, in which a person may suffer, depending on many factors, which may include (Food allergies, Nutrition deficiencies ,Over eating, Eating toxic plants and animals, Chemical toxins in foods, Food bacteria intoxications, Food bacteria intoxication, Food mycotoxins, Food parasites, Food viruses, Prions and Unknown reasons [1].

Food poisoning is defined as a group of diseases resulting from human consumption of food contaminated with bacteria, fungi, parasites, viruses or toxins resulting from.

As a result of the different source of food contamination, the symptoms will vary, which may appear within hours, days, or weeks, represented by (fever, watery or bloody diarrhea, vomiting, nausea, abdominal pain and cramps [2]

Bacteria uses several ways to be present in human food, by:

- 1- Food contamination by human as carriers of germs through the nose, mouth and excreta.
- 2- Transmission of bacteria to humans food through the animals.
- 3- Transmission of bacteria to food by disease vectors (rodents and insects).
- 4- Dust and dirt stuck in vegetables, especially those that are eaten raw.
- 5- Left the cooked food at a high temperature out of the refrigerator.
- 6- Not exposing food during heating and preparation to sufficient heat to eliminate microorganisms.
- 7- Use unclean tools and surfaces which loaded with microorganisms.

Availability of, temperature, humidity, appropriate pH concentration and oxygen, are the most substantial determinants influential the growth and activity of microorganisms in food [3,4]

#### Types of bacterial toxins

- Endotoxins, which are toxins found in the outer layer of gram-negative bacteria that are degraded by lytic enzymes. These toxins are characterized by their fatty and sugary nature (lipopolysaccharide) and their resistance to high heat. Figure 1.

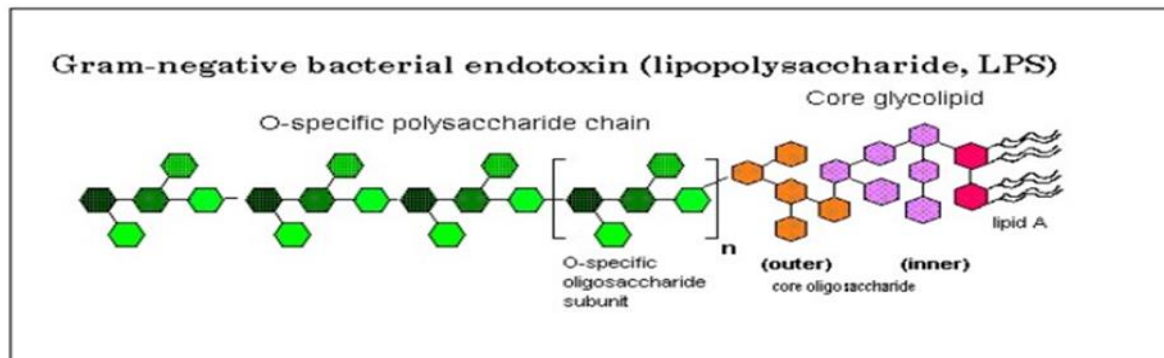


Fig 1: composition of endotoxin (5)

- Exotoxins, compounds of a protein nature, which are synthesized in the cytoplasm of the living cell only and secreted to the outside, mainly by Gram-positive bacteria. They are characterized by their lethal toxicity in small amounts ( $1.5 - 4 \times 10^4$  micrograms [6].

#### Classification of bacterial toxins according to the tissue target

- 1- Neurotoxins: Affect the functioning of the nervous system, for example (*Cl. botulinum*).
- 2- Protein-inhibiting toxins (cytotoxic): Works to inhibit cells and disrupt the action of enzymes, and thus cell death, such as *Streptococcus pyogenes*.
- 3- Enterotoxins: It works through two mechanisms:
  - A-Stimulating the cells of the gastrointestinal tract in unusual ways to increase the pumping of fluids outward, which causes diarrhea, such as *Vibrio cholera* and *Escherichia coli*.
  - B- Stopping protein synthesis in the cells lining of the small intestine, which causes an increase in fluid pumping into the small intestine and causes diarrhea, as in *Shigella dysentery* and *E.coli* [7]

#### Food borne diseases types

- **Food borne infection:** A group of pathological symptoms that occur as a result of the entry sufficient numbers of live bacteria and reproduction within the host cells, thus secreting endotoxins after lysis process causing the emergence of disease's symptoms, such as *Salmonella spp*, *Shigella spp*, *E.coli*.
- **Food born intoxication:** A group of pathological symptoms that appear on humans as a result of the presence of toxins secreted by bacteria after growing on food in sufficient quantities. In this type of poisoning, the presence of the toxin is required, but it may not be necessary for the bacteria to be present in the food such *S. aureus*, *Cl. botulinum*, *Bacillus cereus* [8,9].
- **Food born mediated:** A group of pathological symptoms that appear on a person as a result of eating large numbers of bacteria while they are alive in the food and multiplying within his tissues and cells and excreting external toxins, which causes appearance the symptoms of poisoning, such as *S.aureus* and *Cl.perfringens*, at the same time it has the ability to cause poisoning as a result of secretion external toxins in food. In this type of poisoning, it is required that the bacteria be alive.

#### Disease caused by staphylococcal poisoning

It is one of the most famous food poisonings that occur through food. Annually, in United States, about 241,000 cases of food poisoning resulting by staphylococcus [10].

The disease results from toxins or living cells present in contaminated food that human eats. This type of poisoning was known for the first time in 1914 in the Philippines after isolating the bacteria from a cow infected with mastitis. Despite the rapid occurrence of poisoning with this type of bacteria, the patient's recovery period is fast in most cases.

Staphylococcal poisoning results from the presence of the toxin previously secreted by *S.aureus* bacteria in food, which is called enterotoxin, as it's responsible for irritation in the stomach and intestines. Depending on the degree of toxicity, these toxins are divided into several types (A, B, C, D, E, and F) [11].



Type A, is the most toxin in staphylococcal food poisoning – cases. It is sufficient to keep the food for 2-4 hours at a temperature of 10 - 44 celsius to produce the necessary toxins and cause intestinal disease (5 nanograms as a minimum). Symptoms of poisoning appear half an hour to less than 6 hours after eating food. The toxin resists decomposing enzymes such as trypsin, radiation and heat (100 celsius for half an hour). Therefore, it is not destroyed by the normal cooking temperature, while bacteria are killed under this temperature [12].

In general, the number of cells needed to cause disease varies according to the type of toxin produced, the health and physiological condition and the immunity of the infected person, but it is within the limits of  $10^5$ - $10^7$  cells / gm or ml of food [13,14].

These toxins are consider miraculous receptors, through their influence on the body's immune defense mechanisms and their production of interleukins and interferons such as IL2.

Symptoms of the disease begin suddenly and violently, including vomiting, nausea, abdominal pain and diarrhea within 1-6 hours, and the condition may worsen and reach fever and changes in blood pressure.

### Disease caused by *Listeria* food poisoning

*L. monocytogenes*, is the most pathogenic to human, it's found in sewage, soil, animal waste, raw milk, dairy products, meat, seafood and raw vegetables. It infects fish, humans, milkmaids and birds. The pathogenicity of this species is due to the production of Listeriolysin - hemolytic toxin [15].

Despite the lack of clarity of the mechanism pursued by this bacteria to cause disease , however, it is likely to settle in the intestinal tract , through the mouth by contaminated food and multiply within phagocytic cells, as follows:

- 1- Oral entry.
- 2- Settlement in the intestinal tract.
- 3- Reproduction within phagocytic cells through the cytoplasm of the phagocytic cell.
- 4- Entry into non-phagocytic cells through a type of proteins present on the surface of the bacterial cell, namely Ln1A and Ln1B, where the Listeriolysin toxin contributes to helping *L. monocytogenes* to enter the phagocytic cells of the host, from which the bacteria spread in the cells. So far, the pathogenic dose for humans has not been known, but it is close to  $10^3$  cell / gm or ml of food [16,17].

The entry of bacteria into the host can cause one the following symptoms:

- Intestinal infiltrating bacteria, the most common and dangerous, causing blood poisoning and meningitis.
- Non-infiltrating bacteria of the intestine, usually not dangerous.

### 2- Disease caused by *E.coli* food poisoning

The human gastrointestinal canal is the main repository for many types of bacteria, including *E.coli*, in general most of their strains are non-pathogenic and provide the body with many vitamins and help in metabolic processes, while attributed to a few category, the pathogenicity, which includes six groups namely : (EPEC), (EIEC), (ETEC), ( EHEC), ( EAEC), (DAEC) [18].

The toxins secreted by *E.coli* are divide into:

- 1- Enterotoxins (gastrointestinal effects)
  - Heat labile enterotoxins: A toxin produced by pathogenic strain ETEC and symbolized by (LT), is a protein with a molecular weight of 88 kDa, destroy at 60 celsius for a period of 30 minutes. It consists of two units A1 and B5, A1 unit is responsible for causing toxicity in the host, while the B5 unit is responsible for facilitating the entry of A1 part into the target cell. Analogous to *V. cholera* toxin, as they have the same determinants, effectiveness and the installation. The infection occurs after the entry of the bacteria through food and drink, with a number of ( $10^6$ - $10^7$ ) cells/gm or ml of food, and settlement in the small intestine [19,20].
  - Heat stable enterotoxins: symbolized by (ST), it is a protein with a molecular weight of 1500-4000 daltons, resistant to heat (100 celsius up to 15 minutes). These toxins are divide into two main parts:
    - STA : causes diarrhea and has a molecular weight of 1500-4000 daltons.
    - STB : with molecular weight more than 4000 daltons and the mechanism of its action still unknown [21].
- 2- Verotoxin, symbolized by (Vt), a protein consisting of two parts, B5 and 2A, works to prevent protein synthesis by affecting the elongation process in the target cell of the host (Vero cells, epithelial cells of the intestine) , followed cell death and emergence



of hemorrhagic colon, kidney failure and anemia symptoms. The Foods responsible for infection with the six strains of *E.coli*, represents in, (contaminated water, milk and dairy products, fruits and vegetables, soil, contaminated animals and meat) [22]. Infection with the strain *E.coli* O157, H7, which is responsible for the production of the VT toxin, requires the entry of bacteria in small numbers,  $10 - 2 \times 10^2$  live cell, and adheres to the cells lining of the colon to produce the toxin, which will move into the bloodstream after being absorbed by the cells lining of intestine [23].

### 3- Disease caused by botulism food poisoning

Botulinum toxin, which is known as flaccid paralysis, is caused by a toxin secret by the bacterium *Cl.botulinum*. This bacteria is present in the droppings, on the surfaces of (fruits, vegetables, plants, contaminated meat, water), in general, the soil is one of the most natural sources that contain the spores of this bacteria for years until provide appropriate conditions to germinate into vegetative form and release toxins when it is present on food [24].

Although, the poisoning with this bacteria is few, and almost to be rare, but it represents 5-30% of deaths. The bacteria secrete seven groups of toxins, A, B, C, D, E, F, and G [25].

They are protein substances with a molecular weight of 150 kDa. These toxins are the most biologically dangerous in the world, as an amount of 4 kg is sufficient to kill all the inhabitants of the globe. It is not resistant to heat and breaks down at a temperature of 80 celsius for half an hour, while the spores remain standing for 4 minutes at a temperature of 121 celsius [26].

This toxin prevents secretion of Acetylcholine, which is important for transmitting nerve orders and signals. This poisoning occurs after eating food that contains the toxins of this bacteria that it previously secreted, as it is not required that the bacteria be alive to cause this type of poisoning.

The first indications of poisoning, nausea, vomiting, diarrhea, appearance of fatigue and muscle weakness symptoms. Then dry mouth occurs with difficulty speaking and swallowing, followed, drooping of the eyelids, slow response to light, blurring, and double vision, and constipation is also one of the dominant symptoms, nerve paralysis, preventing respiratory contractions and then death. Figure 2

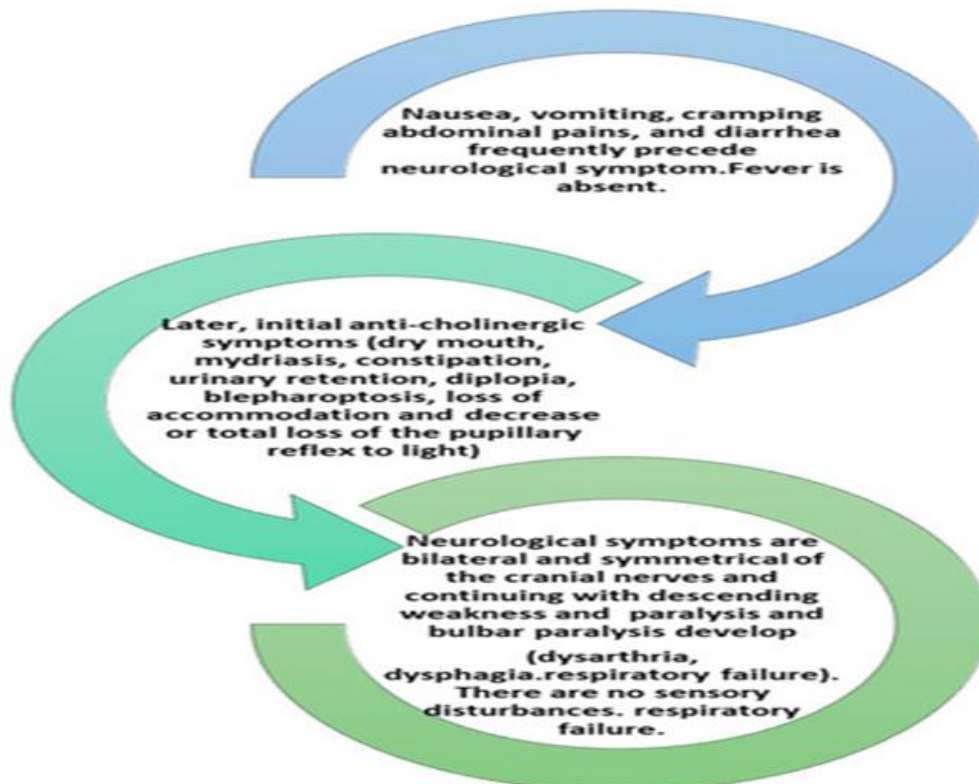


Fig 2: Clostridium botulinum symptoms (27)



**4- Disease caused by campylobacter food poisoning**

*C.jejuni*, is the most important species responsible for food poisoning. In many cases, humans are infected with this bacteria, usually through the meat and excrement of animals. The toxin is produced at a temperature of 43 celsius and is similar to the LT toxin secreted by *E.coli* and cholera toxin, it sensitive to heat. About  $5 \times 10^2 - 10^4$  cells capable of causing disease [28].

The patient with this type of poisoning suffers from symptoms that may last for more than 2 days, represented by headache, fever, vomiting, abdominal pain, and diarrhea [29].

In severe cases, it may develop into bloody diarrhea (watery, sticky and bloody) with symptoms continuing for more than 10 days [30].

**5- Disease caused by Yersinia enterocolitica**

The genus *Yersinia* includes many pathogenic species, where rodents, cats and dogs are the main hosts [31].

The enterocolitica species is responsible for many food poisonings that occur to humans. Infections caused by bacteria decrease in the spring, but they reach their peak in October and November. The bacteria secrete enterotoxin that is resistant to heat and lytic enzymes such as protease and lipase [32].

Symptoms appear after the incubation period and extend for several days, represented by intestinal pain and diarrhea. The poisoning results by eating contaminated food that contains bacteria, such as meat, seafood, milk, dairy products, and other sources [33].

**6- Disease caused by mycotoxins**

Mycotoxins, are among the most dangerous types of toxins, as they are characterized by their lack of rapid effect on the host, which makes them more dangerous than bacterial toxins in general. Various reports confirm that population of developing countries lost more than 40% of their life years as a result of these toxins [34].

While it was one of the multiple cancers causes in the United States, where it exceeded the impact of pesticides [35].

Mycotoxins, are known as secondary metabolism with a chemical composition produced by fungi when they are present in an appropriate environment. The diseases they cause, are called, mycotoxicosis. They are toxic to humans and animals, even to microorganisms.

Mycotoxins, are characterized by the inability of the human body to form antibodies. *Fusarium*, *Alternaria*, *Penicillium* are the most important fungal species responsible for toxicity, which secrete highly toxic compounds represented by aflatoxin, aflatoxins, zearalenone, ochratoxin A, fumonisins, patulin, etc. [36]. Figure 3

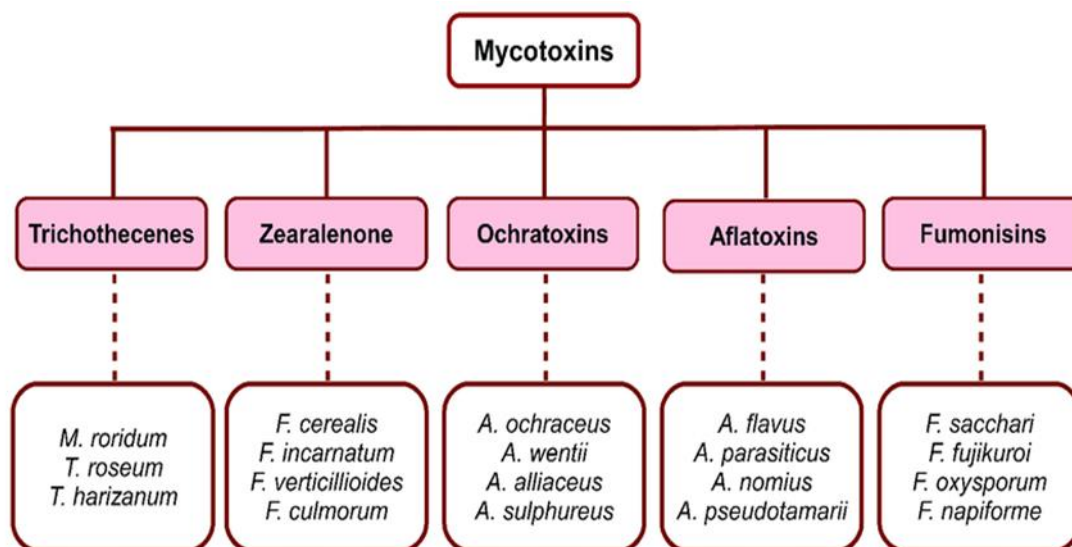


Fig 3: Mycotoxins - producing species (36)



Based on their areas of influence in mammals, mycotoxins were classified into: Genitoxins ,hepatotoxin , nephrotoxins , muscle toxins, Gardiotoxins , Gastrointestinal toxin , Neutrotoxins , Dermatotoxins [37].

Fruits and their juices, sesame, coconut, ground fenugreek, grains, herbs and spices, are among the most important foods that contribute to the delivery of mycotoxins to humans, as a result of eating directly after the fungus infects these foods [38].

The infected person with mycotoxins has symptoms of circulatory disorders, bleeding from (natural orifices, under the skin and with stool), loss of appetite, indigestion or diarrhea, emaciation, weight loss and dehydration. (Table 1)

**Table 1:** The most important issues that contribute in growing of toxic molds and how to avoid and reduce

	The type of problem	How to avoid and prevent it
1-	Mechanical harvesting of grain and crops in the field, which facilitates the growth of mold on them and production of toxin.	Protect the plant from fungal infection by using antifungals in the field.
2-	The availability of the appropriate temperature in grain stores, which encourages the growth of mold and secretion of mycotoxins.	Creating good storage conditions and continuous ventilation in stores to hinder the growth of toxic molds.
3-	Insect infestations of plants and crops in the field.	Periodic examination and analysis of mycotoxins to get rid of infected plants and crops.
4-	Animals eating fodder and diets made from raw materials infected with fungi and their toxins.	Taking care of animal feed and ensuring that it is free from mycotoxins and disposing of feed contaminated with toxic fungi.
5-	Food contamination with mycotoxins secreted from toxic fungi.	Emphasis on the destruction and disposal of food containing mycotoxins.

**CONCLUSIONS**

Food poisoning poses a risk and a potential threat to the lives of all age groups (young children, pregnant women, adults, the elderly, and people with low immunity), as some types of food poisoning have potentially dangerous complications for some and in the long run. Poisoning may occur at any stage of food production, so the necessary precautions must be taken by trying to prevent microbes from reaching food, preventing its growth and eliminating it by following the methods of preparing food until it reaches the consumer correctly and raising awareness of how to deal with and the procedures that must be followed to prevent food poisoning.

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