

FE 305 FOOD MICROBIOLOGY
Foodborne Parasites and
Natural Food Toxins

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Foodborne Parasites

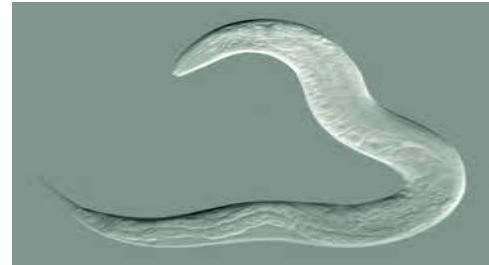
- Parasites are organisms that provide the nutrients and energy required for their life cycle through other living things.
- It is known that there are over 300 Helminth (Cestode, Nematode, Trematode) and over 70 Protozoan species that threaten human health.
- Complex life cycles, diversity in transfer routes, and the length of time for symptoms of infection make parasites a critical issue for public health.
- Parasites are transmitted to humans in various ways.
 - Contamination by food and water is the most important known route.
 - Parasitic infections; consumption of muscles or internal organs of edible animals
 - By the water sources where contaminated water is mixed and the consumption of vegetables and fruits grown in the fields irrigated with these waters.
 - Foodstuffs grown on soils fertilized with human or animal feces carry this risk at a high rate.

Foodborne Parasites

- Although parasites are common throughout the world, some species are known to be distributed in a limited geography.
- However, while parasites can use a specific group of organisms as hosts, there are also examples that can switch between many species.
- While most of the parasitic cases are asymptomatic, typical symptoms can also be seen in some acute or chronic conditions.
- In addition, a parasite that is well adapted to its host can live here for a long time and feed, even without adversely affecting the health of its host in this process.
- In these cases, the picture progresses to the point where the host's body resistance decreases, and then symptoms appear.

Helminths

- Helminths are classified under three main headings among themselves:
 - Cestodes (Tapeworm)
 - *Taenia* spp.
 - *Diphylobothrium latum*
 - *Echinococcus* spp.
 - Nematodes (Worm)
 - *Trichinella* spp.
 - *Ascaris* spp.
 - *Anisakis* spp.
 - Trematodes (Flat Worm)



Cestodes (Tapeworm)-*Taenia* spp.

- It is a group of the most common species of cestodes.
- These parasites, which have anaerobic metabolism, obtain all their nutritional needs from their host.
- Larvae, infective forms of *Taenia* species, are found in the intermediate host, while adult and reproductive parasites are found in humans.
- Contamination with these parasites is more often through the consumption of insufficiently cooked infected meat, and vegetables and fruits washed with contaminated water.
- In the inactivation of cysticercosis, which can be destroyed by cooking the tapeworm-infected meat at a minimum temperature of 60°C, freezing below -10°C and keeping it in a brine solution for up to 3 weeks are also effective.
- Infection by *Taenia* spp. in humans is known as Taeniasis, and the most common species of this family are also known as bovine and pork tapeworm, respectively.
 - *Taenia saginata* and
 - *Taenia solium*.

Cestodes (Tapeworm)-*Taenia* spp.

- ***Taenia saginata***: It is frequently seen in countries such as the Middle East, Africa, Thailand, Ethiopia, India and Korea. The infective, larval form of this species is *Cysticercus bovis*, and it is found in movable muscles (tongue, pharynx, diaphragm, etc.), especially in beef.
- Larvae taken with contaminated meat first settle in the small intestine and multiply there. It takes 8-10 weeks for the larvae to gain infective power.
- The larvae developing in the intestine spread first to the brain region and then to the mobile muscles of the body. It is known that tapeworms that settle in the human intestine reach an average length of 3-5 m and can live up to 20 years without showing any symptoms in their host.

Cestodes (Tapeworm)-*Taenia* spp.

- *T. saginata* infections are mostly asymptomatic.
 - However, one-third of patients may experience nausea or an abdominal hunger pain relieved by frequent eating.
 - In the later stages, constipation, diarrhea, weight loss, ligament pain and dizziness are added to these epigastric symptoms.
 - In addition, it has been reported that there is an increase in the cases of neurocysticercosis caused by *T. saginata* all over the world.
 - Patients with taeniasis are usually aware of the infection when proglottidine (tapeworm ring) enters the perianal area, stool or underwear.
- The use of niclosamide and praziquantel as drugs in the fight against taeniasis is the most effective method known.
- On the other hand, successful results are obtained in eradication thanks to the detailed meat examination to be carried out in slaughterhouses and the detection of infected animals.

Cestodes (Tapeworm)-*Taenia* spp.

Taenia solium: While *T. solium* infections are not very common in Muslim countries due to the infrequent consumption of pork, they are frequently seen in Mexico, South and Central America-Africa, the non-Islamic southeast region of Asia and Asia, Slavic countries and southern and eastern Europe.

- In this species, where pigs are intermediate hosts, humans are the final hosts.
- However, in some cases, humans can be both intermediate and final hosts. This is called **autoinfection**. Since this is seen only in *T. solium*, infections caused by this parasite are considered to be more dangerous than those caused by *T. saginata*.
- Infection occurs with the consumption of raw or insufficiently cooked pork meat containing the larval form of this parasite, ***Cysticercus cellulosae***. It then reaches the myocardium and skeletal muscles through the blood and lymph channels. After a period of approximately 8-10 weeks, the larvae transform into their main form, *C. cellulosa*.
- Infections originating from *T. solium* like *T. saginata* infections, show an asymptomatic course in most individuals.
- However, in cases where the individual immunity is low, symptoms such as nausea, cramps, loss of appetite, weakness and fatigue can be seen.

Diphyllobothrium latum

- This parasite is common in countries such as Finland, Scandinavia, Alaska, Canada, Japan and Peru, where raw or undercooked fish are commonly consumed.
- The definitive hosts of the parasite are humans and fish-eating mammals. The spread of *D. latum* eggs to the environment is through human feces. As a result of the mixing of sewage waters with seas and lakes, parasite larvae are taken by the fish living in this area and re-infected with the consumption of these fish.
- *D. latum* cases usually show a symptomless course. However, ingestion of a large number of parasites and their growth and condensation in the ileum cause abdominal pain, diarrhea and macrocytic anemia, which is shaped by the lack of vitamin B12 in the following 2-3 years. It is known that an adult *D. latum* can reach up to 10 m in the human intestine.
- In order to prevent infection with *D. latum*, consumption of raw or undercooked fish should be avoided. In addition, cooking at 55-60°C or freezing below -18°C is sufficient to inactivate the parasite.

Echinococcus spp.

- This parasite family is endemic in Asia, Middle East, Africa and Mediterranean countries.
- Two important members of
 - *Echinococcus granulosus* cystic echinococcosis,
 - *Echinococcus multilocularis* causes alveolar echinococcosis.
- Although *E. multilocularis* is a less common species compared to the other species, it is also known that its mortality is higher.
- The definitive hosts for both parasites are carnivores such as dogs, foxes, and wolves. These creatures have the adult form of the parasite.
- Young parasites use sheep, goats, cattle, pigs and horses as intermediate hosts. Humans participate in the life cycle of this parasite as an accidental intermediate host as a result of feeding on contaminated water and food.

Echinococcus granulosus

- It is the smallest member of the tapeworm family (3-5 mm), and in contrast to its size, it causes significant infections in humans. It is among the important zoonotic diseases in Türkiye.
- Adult forms of *E. granulosus* are found in the intestines of carnivores, and their eggs are shed in the feces of the host animals.
- Parasite eggs that reach the main organs such as liver, lung, kidney and spleen in the human body turn into fluid-filled vesicles. This larval form is called **Hydatid Cyst**, and the disease caused by these cysts in humans is called **Hydatidosis**.
- The size of the cysts formed in the body varies from a pinhead to a goose egg.
- If there are too many cysts in organs such as the lungs and liver, severe coughing and related ruptures in the lungs can be seen. Subsequently, secondary infections and death are observed with the decrease of immunity of individuals.
- The most effective methods of struggle with hydatidosis are to prevent the delivery of infected internal organs to animals in the vicinity of slaughtering areas and to vaccinate stray animals in terms of this parasite.
- In addition, it is important to inform the personnel and the public working in the slaughterhouses on this issue.

Nematodes (Worm)

- In this group, there are important parasites that can be taken with foods such as *Trichinella*, *Ascaris* and *Anisakis*.
- Some nematodes are transmitted by fecal routes without using any intermediate hosts. Species such as *Trichinella*, on the other hand, can be found in cystic form in foods such as meat or fish and settle in the muscle groups of the people who consume them.

***Trichinella* spp.**

- This species is a parasite group that can be seen in almost all carnivores and omnivores. This family has species such as *Trichinella spiralis*, *T. nativa*, *T. britovi*, *T. pseudospiralis*, *T. nelsoni*, *T. murrelli* and *T. Papuae*. However, the most dangerous member of this nematode family is *T. spiralis*.
- Consumption of raw or insufficiently cooked pork causes Trichinellosis, a zoonotic infection in humans. Trichinellosis is one of the oldest known parasitic infections affecting all warm-blooded animals, especially carnivores.
- *T. spiralis* spends one cycle of its life cycle in the host animal. This parasite, which generally settles in the diaphragm and tongue muscles of butchery pigs, reaches the skeletal muscles by lymphatic routes.

Trichinella spp

- The course of infection and the symptoms seen in Trichinellosis cases vary according to the number of active parasites and their location in the body. General symptoms appear between 1-4 weeks.
- The main symptoms are myalgia, fever, difficulty in using mobile muscles (swallowing, chewing, etc.), conjunctivitis, and death due to encephalitis and myocarditis in very intense infestations. In these cases, mortality reaches a high rate of 1.5%-15%.
- Classical cooking, long-term freezing (-15-25°C, 3-4 weeks) and irradiation in small doses are also effective in inactivating the parasite and its larvae.
- One of the measures that can be taken for Trichinellosis cases is keeping the herd free.
- Necessary precautions should be taken in adding animals to the herd, transporting animals and slaughtering in slaughterhouses. Entry of infected animals into the herd or illegal slaughter are the main factors in the spread of this factor and deterioration of herd purity.

Ascaris spp.

- The most important member of this family, which affects approximately $\frac{1}{4}$ of the entire world population, is *Ascaris lumbricoides*.
- Humans are the only known hosts of these roundworms. This factor, which causes mortality due to diarrheal infections in early childhood (5-15 years) and especially in infants, continues its life cycle by absorbing fat and protein from food in the intestinal tract without showing symptoms in most adults.
- Infection; contaminated water, vegetables and fruits washed with these waters, especially food prepared by parasite carriers who do not pay attention to hygiene rules.
- These eggs, taken with water or foodstuffs, mature in the intestinal tract.
- Adult *Ascaris*, which can survive for 1-2 years in the intestinal tract, can also adhere to the lungs and liver in some cases.
- Persons working in the food field should pay great attention to hand hygiene, vegetables and fruits should be washed with clean water, and foods should be consumed after being subjected to sufficient heat treatment.

Anisakis spp.

- This parasite species from the Anisakidae family first caused an infection in humans in the 1960s, which was defined as **Anisakiasis**. This case was shaped by the consumption of salted herring in the Netherlands and was referred to as "**Worm Herring Disease**" in the literature.
- *Anisakis simplex* is the most active member of this family. Especially in Far East countries such as Japan, there are often health problems related to this parasite due to the consumption of raw and smoked fish.
- Fish are the principal and only known vector of *A. simplex*.
- Humans are only accidental hosts of this agent.
- This factor, whose main hosts are dolphins and whales, cannot develop in the human body.
- Gastric disorders and allergic reactions may occur in infected individuals as a result of the circulation of parasites in the lungs, liver and other tissues. The development of allergy is actually due to the reaction of the immune system of the individuals against the fish.

Trematodes (Flat Worm)

- Trematodes are an important group of parasites that threaten the health of the entire world population.
- The most common types of trematodes are as follows.
 - ***Fasciola hepatica***: It is the first trematode species whose life cycle has been fully elucidated. This parasite, which was described at the beginning of the 14th century, both harms health and causes economic losses in domestic ruminant livestock.
 - *F. hepatica* from the Fasciolidae family causes a disease known as Fascioliasis in humans, characterized by liver flushing (biliary cirrhosis).

Trematodes (Flat Worm)

- This parasite is commonly seen in geographical regions such as Africa and the Middle East where water hygiene is inadequate. The spread of the parasite to the environment is through the droppings of animals raised in these regions, especially sheep.
- Fasciolosis is seen in two forms as acute and chronic.
 - Acute Fasciolosis, which manifests itself with liver pain approximately 2-4 months after the ingestion of eggs, continues with liver enlargement, fever, fatigue, urticaria, respiratory disorders, loss of appetite and weight loss.
 - The chronic phase may occur months or even years later. In this period, also known as the obstructive phase, adult parasites settle in the bile ducts and cause hyperplasia in the epithelial tissue, thinning and enlargement of the gallbladder, as well as cholangitis, cholecystitis and obstruction in the gallbladder.
- In order to combat fasciolosis, especially in herd-breeding areas, drinking and utility water hygiene should be given due importance. Praziquantel is the most suitable drug that can be used for the treatment of animals infected with this parasite.

Protozoans

- Protozoan parasites are generally characterized by causing mild or moderate diarrhea in humans.
- On the other hand, there are also life-threatening effects in malnourished children, the elderly and people with compromised immune systems.
- Some infections show an asymptomatic course. Protozoans can live and reproduce in more than one animal species, but they cannot develop in nature or in food.
- The most common types of protozoa in foods are:

Giardia lamblia

- It is a flagellated protozoan capable of reproducing asexually. Also known as *Giardia intestinalis* or *Lamblia intestinalis*, this protozoan infects in both epidemic and sporadic forms.

Protozoans-*Giardia lamblia*

- Transmission with giardia occurs through contaminated food, the fecal-oral route, or direct person-to-person contact.
- *G. lamblia* cysts, which are transmitted to vegetables and fruits from contaminated water sources, can also be transmitted to humans through foods prepared by infected people.
- The infective dose of *G. lamblia* is quite low (approximately 10 cysts).
- Infected individuals experience foul-smelling, oily and mucous diarrhea, malabsorption and associated rapid weight loss, abdominal cramping and nausea. This can last for months unless the patient is treated.
- Giardia infections are detected by examining the stool of sick people.
- Cystic Giardia agents are excreted at a high level, such as 10^7 .
- While eradication of Giardia cysts from contaminated water is possible with chlorination, irradiation and ozonation methods, cooking food at appropriate temperatures is sufficient for inhibition.

Protozoans- *Cryptosporidium* spp.

- **Cryptosporidiosis** has been recognized as one of the main causes of foodborne diarrhea in recent years.
- Epidemiological studies show that raw meat and fish products and water are important tools in the spread of **cryptosporidiosis**.
- The two most important **Cryptosporidium** species that cause disease in humans are *Cryptosporidium parvum* and *Cryptosporidium meleagridis*.
- In amoebic dysentery, transmission is by the fecal-oral route.
- Foods manipulated by infected people or contaminated water play an important role in foodborne contamination.
- In addition, flies, cockroaches and similar insects can also carry parasitic cysts from feces to food.
- After being taken into the body, the oocysts of *C. parvum*, an obligate intracellular coccidian, reach the target region, the small intestine, and are separated into sporozoites.
- Although the incubation period of the disease lasts 6-16 days, typical symptoms appear within 9-23 days.
 - Diarrhea (sometimes with mucus, sometimes blood), abdominal pain, nausea, vomiting and fever are common symptoms.
- In the fight against parasites, the hygiene of food, drinking and utility water is very important. Cooking at at least 70°C, UV irradiation and ozonation are frequently preferred eradication methods.

Protozoans- *Cyclospora* spp.

- Cyclospora is a protozoan belonging to the family Eimeriidae.
- The only member known to cause disease through food is *Cyclospora cayetanensis*.
- Cyclospora infection is an endemic condition generally seen in developing countries due to the lack of clean water and hygiene. This infection, which is transmitted by the fecal-oral route, is caused by the contamination of the water used in the spraying or irrigation of the crops or the fertilization process.
- Humans are the sole and final host of *C. cayetensis*.
- *C. cayetensis* oocysts show affinity for the epithelial layer of the small and large intestines and initiate the disease here.
- Direct diagnostic methods such as epifluorescence microscopy and phase-contrast microscopy are used in the diagnosis of *C. cayetensis*. In addition, advanced molecular analyzes have been useful in species discrimination in recent years.
- It is reported that the most successful antimicrobial agent in treatment is trimethoprim-sulfamethoxazole.

Protozoans-*Toxoplasma gondii*

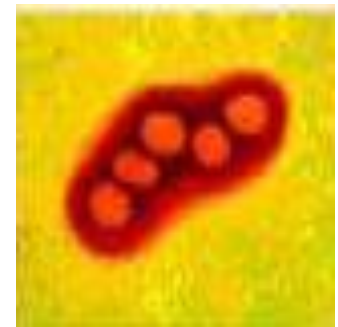
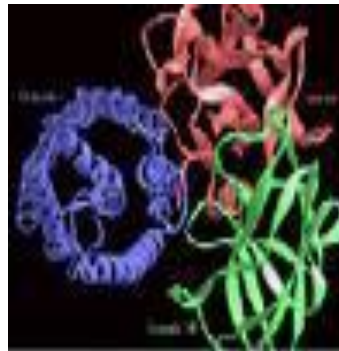
- ***T. gondii***, the only member of the Toxoplasmatidae family, is one of the most common parasitic infections in humans and other warm-blooded creatures.
 - Cats carry and spread the only form of the parasite that can tolerate natural conditions.
 - In principle, *Toxoplasma* infections occur by the consumption of animal tissues containing the parasite (bradyzoite) in cystic form or by the consumption of infected food and water, as well as by the transplacental route (from mother to fetus).
 - In addition, oocysts in the soil can be carried into human food and animal feed by insects such as flies, cockroaches, dung beetles and earthworms.
- Today, it is seen that many factors are effective in the increase of food-borne *T. gondii* infections.
 - These include meat and meat products consumed raw or undercooked, raw or unwashed vegetables, foods eaten outside the home, lack of hygiene and sanitation of tools and equipment used in kitchens, and the importance not given to personal (hand) hygiene.
- *Toxoplasma* infections are mostly asymptomatic, but this situation causes quite different, quite devastating results in children of women who are infected during pregnancy and in people with suppressed immune system.
- Cooking, freezing or gamma irradiation techniques kill *Toxoplasma* cysts and oocysts. Cooking at 61°C and above temperatures for a minimum of 3.6 minutes and freezing at -13°C results in the inactivation of the cysts. Combination of folinic acid with pyrimethamine or trisulfapyrimidine are the most commonly used drugs for treatment. Especially in acute Toxoplasmosis, the most effective treatment is done with these drugs.

Protozoans- *Sarcosporodidium* spp.

- Although its systematic location is not certain, *Sarcosporodidium* spp. It is a species that spends its life cycle on two different types of hosts.
- Sarcosporids, which perform sexual reproduction in the last hosts such as humans, cats and dogs, are present in the form of asexual cysts in species such as cattle, sheep and pigs, which are their main hosts.
- Although there are more than 13 known species of sarcosporidium, two species cause extraintestinal disease in humans. These are *Sarcocystis hominis* and *Sarcocystis suihominis*. The reservoir of *S. hominis* is cattle, and *S. suihominis* is pig.
- After sarcocysts are ingested through contaminated food, sporocysts are released in the small intestine and penetrate the lamina propria where sexual reproduction will take place.
- In cases caused by *S. hominis*, the incubation period is 3-6 hours and the symptoms are mild gastrointestinal symptoms such as nausea and diarrhea, while the incubation period takes much longer in infections caused by *S. suihominis*.
- The detection of these parasitic cysts in the muscles of the animals offered for consumption is made by seeing the cysts in the sections thrown into the striated muscles after cold storage. It can also be detected by serological methods such as ELISA or by DNA-based molecular methods.
- In the inactivation of the agent, the food must be cooked sufficiently or have undergone an effective freezing process.
- Raw consumption of beef and pork, which has a reservoir, should also be avoided.

Food Toxins

- Foods may encounter factors that impair their safety at every stage of the production-consumption chain (from farm to fork).
- What is **Toxin**?
- They are substances that harm biological systems in a certain dose and/or a certain period of time when taken by mouth, inhalation or skin.



Foodborne toxins

| Toxins | Sources |
|-------------------------|----------------------|
| Fungal Toxins | |
| Aflatoxins | peanuts, grains |
| Ochratoxins | grains |
| Ergotamines | grains, grass seeds |
| Zearlenones | grains |
| Plant Toxins | |
| Pyrrolizidine alkaloids | herbal teas |
| Solanine | tomato family |
| Gossypol | cottonseed oil |
| Oxalates | spinach, beets, poke |
| Ricin | castor oil |
| Cyclopeptides | mushrooms |
| Hydrazines | mushrooms |
| Cyanotoxins | stone fruits |
| L-concavalin | alfalfa |
| Seafood Toxins | |
| Ciguatoxins | seafood |
| Tetrodotoxin | seafood |
| Scombrototoxin | seafood |

Food Toxins

- Natural plant toxins are poisonings caused by chemical compounds naturally found in the structure of plants. These are;
 - plant-derived toxins,
 - mushroom toxins,
 - animal origin.

Plant Derived Toxins

They are

- cyanogenic glycosides,
- Phytohemagglutinins or lectins,
- protease inhibitors,
- Lathyragens,
- Favism-influenced items,
- gouvatrogens,
- glycyrrhizin,
- saponins,
- solanine,
- Gosypol,
- You are myristic,
- biogenic amines,
- Caffeine and theophylline
- erucic acid,
- Nitrate,
- Safrole and its derivatives,
- carotoxin,
- Pyrolizidine alkaloids,
- metal connectors,
- antivitamin factors.

Mushroom Toxins

1. Protoplasmic Poisonings
2. Neurotoxins
3. Irritants of the Gastrointestinal System
4. Disulfiram-Like Toxins
5. Mixed Poisonings

Animal Origin Toxins

- Saxitoxin
- Tetrodotoxin
- Scombrototoxin
- Toxic Honey (Mad Honey)
- Avidin
- Biogenic Amines

Mushroom Poisonings

a) Amatoxins and phallatoxins

- responsible for most fatalities in mushroom poisonings.
- produced in *Amanita bisporigera*, *A. phalloides*, *A. virosa*, *A. verna*
- *A. phalloides* is responsible for 95% of fatal cases of mushroom poisoning throughout the world.
- Lethal dose of amatoxins is about 0.1 µg per kg body weight and 1-2 mg per kg body weight for phalloidin.
- Poisoning characterized by
 - Long incubation period (range 6-48 h, average 6-15 h). In this period the patient shows no symptoms.
 - Symptoms: abdominal pain, vomiting, watery diarrhea, thirst and lack of urine production.
 - loss of strength, prostration and pain.
 - death may occur with 5 to 10 days in 50-90 % of cases;
 - irreversible liver, kidney, cardiac and skeletal muscle damage.

Mushroom Poisonings

b) Ibotenic acid/muscimol poisoning

- Fly agaric (*Amanita muscaria*) and panthercap (*Amanita pantherina*) mushrooms: ibotenic acid and muscimol toxins.
- They grow under pine trees.
- One gram of mushroom causes symptoms within 1-2 h.
- Symptoms: abdominal pain, dizziness, lower blood pressure, increase sweat and saliva, visual distortions, hallucinations, hyperactivity, excitability and delirium.
- Last after 10 h.
- Fatalities rarely occur in adults,
 - but in children, accidental consumption of large quantities of these mushrooms may cause convulsions, coma and death.

Microbial Toxins

- **Mycotoxins**
 - Aflatoxins,
 - Ochratoxins,
 - Patulin,
 - Trichothenes,
 - Fumonisin

Mycotoxins

- The most harmful natural food toxins are mycotoxins produced by some molds as a result of metabolism.
- Molds are formed during the growing or storage of food. Some, but not all, produce toxic substances that cause disease when consumed by humans and/or animals. These substances are called “**mycotoxins**”.
- It is difficult to prevent the growth of molds in foods. However, their amounts can be reduced by maintaining hygienic conditions during processing and storage of foods.
- The occurrence of toxin-producing molds is a particular problem in developing countries. Because such countries do not have controlled storage conditions as in developed countries. In addition, the risk of mold growth in foods increases in tropical regions with warm and humid climates.
- Mycotoxins vary widely in their toxicity and effects on human health.
- The effect of mycotoxin varies according to the amount and type of toxin consumed. Mycotoxins are produced by many kinds of molds, especially *Aspergillus*, *Penicillium* and *Fusarium*. Not all of these molds produce mycotoxins, and a mold can produce a different kind of toxin and generalization about the effect on human health can be difficult.

Aflatoxins

- Aflatoxin is a mycotoxin synthesized by *Aspergillus flavus* and *Aspergillus parasiticus*.
- Aflatoxins are derivatives of difuranocoumarin. So far, 8 different types of substances have been identified (B1, B2, B2a, G1, G2, G2a, M1, M2), of which B1 is the most toxic. These toxins are sensitive to light.
 - Especially during storage, aflatoxins are formed as a result of keeping many food and animal feed products in inappropriate humidity and temperatures. They do not deteriorate at cooking temperature, but it is stated that they deteriorate at 270 °C.
- In 1960, it was determined that the cause of death of 100,000 turkeys in England was a toxic substance called “aflatoxin” created by *Aspergillus flavus*.
- The target organ of aflatoxins is the liver, but they can also cause damage or tumors in other tissues. Aflatoxin is not only an acute hepatotoxin active agent, but also has a carcinogenic effect.
- Aflatoxin can be found in moldy plant foods, as well as in organs such as liver and kidneys, muscle, milk and eggs of animals fed moldy feeds.

Ochratoxins

- Ochratoxin is one of the mycotoxins found in moldy rice and barley.
- It has been stated that this toxin is the cause of significant animal losses in New Zealand, Australia and Denmark with the use of moldy barley as feed. This toxin, which is produced by *Aspergillus ochraceus*, *Penicillium viridicatum*, *P. cyclopium*, *P. frequentans*, *P. nidulans* and *P. expansum*, has three derivatives as A, B and C.
- Especially ochratoxin A has a strong toxic effect.
- **Ochratoxin A**; It is formed as a result of the proliferation of these molds in foods such as corn, dried beans, cocoa beans, coffee beans, soybeans, barley, oats, citrus fruits and peanuts. The toxin inhibits the growth of animals, causes kidney enlargement and other disorders, causing death. It has been reported that ochratoxin may be related to kidney diseases in humans.
- The most effective way to prevent mycotoxins in moldy grains;
 - harvesting the grains as fully ripe and
 - humidity level is below 15%. As the humidity of the place where the grains are stored increases, molds multiply and produce mycotoxins as a result of their metabolism.
 - Like peanuts, grains must be well stored and protected from mold.

Patulin

- Patulin is a mycotoxin produced by some *Penicillium*, *Aspergillus* and *Byssochlamys* species.
- Patulin is the most; It occurs as a result of the proliferation of these molds in apple juices, moldy bread and other fruit juices (grape, peach, etc.).
- In addition to its antibiotic properties, patulin has also been found to have carcinogenic, mutagenic and teratogenic properties. Patulin is reported to be a possible carcinogen, as well as causing symptoms such as edema, hemorrhage, nausea and vomiting in tissues.
- SO₂ and vitamin C break down patulin. In addition, patulin is broken down as a result of fermentation of grape must. Patulin is stable in acidic environments (up to pH 6). It is resistant to heat at this pH value and does not deteriorate up to 125 °C. For this reason, patulin is especially important in foods such as fruit juice.