Chapter

Mycotoxins ... Silent Death

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Abstract

There are many types of fungi that produce secondary metabolites called mycotoxins. These compounds are very dangerous to humans and animals, as exposure to them causes acute or chronic toxicity. Temperature, humidity and pH are important environmental factors in the production of mycotoxins. There are about 500 types of mycotoxins that are found in many agricultural products such as peanut, cereals, wines, fruit juice, dried fruits, feed, and other foodstuffs. Among the most important genera of fungi that produce mycotoxins are *Aspergillus*, *Penicillium*, *Altenaria*, *Fusarium*, and others. Some of them infect plants in the field and produce mycotoxin, while others infect agricultural crops, foodstuffs, and feed in the store and produce mycotoxin during storage conditions. Mycotoxins are divided into various groups according to the degree of their impact and danger, into highly toxic, low toxic, carcinogenic, and mutagenic. This is depends on the chemical composition of the different types of mycotoxins, which are an open hydrocarbon chain with low molecular weights ranging between 100 and 697 Da. The biological effects of mycotoxins include damage to living tissues, suppression of immunity, and neurological disorders. Aflatoxins are one of the most dangerous mycotoxins as they are the main cause of hepatocellular carcinoma and the fifth most common carcinogen in the world.

Keywords: mycotoxins, characteristics, effects on health

1. Introduction

Mycotoxins are secondary metabolites produced by some fungi that are genetically capable of producing toxins when appropriate environmental and nutritional conditions exist for their production [1]. They are produced by fungi or filamentous molds belonging to the class Ascomycota, have low molecular weights, and are of great importance to human and animal health because they cause acute or chronic toxicity [2]. Directly or indirectly, living vertebrate organisms such as humans and animals are affected when exposed to very low concentrations of mycotoxins [3]. Many mycotoxins play a major role against plant defenses, some of which enable the fungi to compete with the environment in nature. There are hundreds of mycotoxins, some of which are used as the antibiotics we are familiar with, such as penicillin, and others are very dangerous such as aflatoxin, one of the most potent substances known to cause cancer. It is followed by diacetoxyserpineol in a small percentage [4]. The origin of the word mycotoxins is derived from the Greek mykes, meaning fungi, and toxicum, the Latin for poison [5]. Mycotoxins are considered one of the health and economic

problems in the world, as they constitute 25% of the problems of field crops. These toxins are found in many agricultural crops, foodstuffs, and feed, which may appear fit for consumption, but they contain many fungi and their secondary metabolites, according to FAO and WHO [6]. Mycotoxins are classified according to the fungi that produce them, their structural properties, and their toxic effects. There are about 400 types of them that vary in their toxicity [7]. Mycotoxins have been associated with diseases throughout history. In 1940s and 1950s of the last century, episodes appeared for humans in Russia and Japan, as intoxication by *Stachybotrys* appeared in the United States of America, and facial eczema appeared in sheep in New Zealand in 1961, In England, many animals died after eating feed polluted, all these events led to the discovery of mycotoxins [8]. Aflatoxins are one of the most important mycotoxins secreted by several genera of fungi such as *Aspergillus*, *Penicillium*, *Fusarium*, in addition to *Alternaria,* as these grow in the temperature range between 10 and 40°C, and these conditions may change according to the type of fungus [7] produced by many types of fungi, or one type of fungi can produce multiple types of mycotoxins, and among the most important and common toxins are Afatoxins of all kinds such as AFB1, AFB2, AFG1, AFG2, and Ochratoxin A (OTA) produced by *Aspergillus* and *Penicillium*, followed by fumonisin FBs such as fumonisinB1 (FB1), fumonisin B2 (FB2), are predominant zearalenone (ZEA) and trichothecenes, the most famous of which are deoxynivalenol (DON) and HT-2 and T-2 toxins. These fungi are associated with the climate and different stages of field crops in addition to geographical areas. Among the common fungi that infect crops in the field and during storage are *Fusarium*, *Alternaria*, *Penicillium*, and *Aspergillus* [9]. Consequently, mycotoxins OTA and AFs are produced in the pre- and postharvest periods, while FBs and DON are mainly produced in the preharvest period, in any type of agricultural crops and their harvesting stages, the presence of mycotoxins can be observed depending on the stage of production of mycotoxins by the fungi, the production of toxins can be reduced. The fungal infection is by following good agricultural practices and methods of controlling them, producing resistant cultivars, and using chemical protection, Despite the different factors suitable for the growth of different types of fungi and their production of mycotoxins, mycotoxins were found in many food and feed samples in the world, as they caused many problems. It travels through the food chain and is mainly found in grain samples and in dairy products, coffee, spices, vegetable oils, dried fruits, nuts, wine, as well as fruit juices [10, 11].

2. The fungi are responsible for producing most of the mycotoxins

If we look at the spread of fungi in foods around the world, which may be able to produce mycotoxins, these fungi contaminated with field crops are divided into two groups, which are:

1. **Field fungi** such as *Cladosporium spp*., *Fusarium spp*. and *Alternaria spp*., which infect the whole plant and reach seeds during plant growth and development.

2. **Storage fungi** such as *Aspergillus ssp*. and *Penicillium spp*., which grow and reproduce during the storage phase [12].

There are four types of toxic fungi that can be distinguished into:

1. Plant pathogens such as *Fusarium graminearum* and *Alternaria alternate.*

2. Fungi grow and produce mycotoxins on large and vulnerable plants such as *Aspergillus flavus* and *Fusarium moniliforme.*

3. Fungi infest the plant and increase its susceptibility to postharvest pollution such as *A. flavus.*

4. Fungi found in the soil, on decaying plants and the remains of field crops, which grow and multiply later during the storage phase, such as *P. verrucosum* and *A. ochraceus* [13].

3. Genus *Aspergillus*

Aspergillus spp. It is one of the plant pathogens that infect crops in the soil from time to time and produces aflatoxin, and the risk of producing aflatoxin increases during wrong agricultural practices, as it was found that *A. flavus* and *A. parasiticus* infect crops before harvest [2]. These species are considered the most important producers of aflatoxins, while Ochratoxins A are produced by *A. ochraceus*, *A. carbonarius*, and *A. niger.* The main species, such as *A. flavus* and *A. parasiticus*, are observed to produce aflatoxins with 10 other types of *Aspergillus* that are rarely found in food. It was found that there is a new species affecting peanuts, *A. minisclerotigenes*, similar to some strains of *A. flavus*, sometimes producing small sclerotia and similar to *A. parasiticus* by producing both Aflatoxins B and G. There is a species associated with insects, but it was found recently on the Brazilian nuts, which is *A. nomius*, as it is similar to *A. flavus* in terms of its production of types B and G and forms bullet-shaped sclerotia [14]. The minimum growth temperature for *A. flavus* ranges between 10 and 12°C and the maximum from 43 to 48°C. The optimum temperature is about 33°C [15]. The minimum aqueous activity (aw) that allows fungus growth is 0.82 at 25°C, 0.81 at 30°C, and 0.80 at 37°C [16]. Optimal growth of the fungus occurs in the pH range of 3.4–10, As for *A. parasiticus*, it grows in the same physical factors as *A. flavus* that were mentioned previously except that the minimum temperature is 42°C [17].

4. Genus *Penicillium*

Penicillium is one of the most common fungi as it is found in different environments such as different field crops, soil, and air. It is also found in food and has a great economic impact on human life. The main role of *Penicillium* is to spoil organic matter. *Penicillium* species are pre- and postharvest pathogens. With rotting of many foodstuffs, this genus is of great importance in many and varied fields such as food spoilage, biotechnology, plant pathology, and medicine [18, 19]. Currently, there are 438 accepted species, most of which are classified as pre- and postharvest pathogens and lead to significant losses in field crops [20]. *Penicillium spp.* are mesophilic fungi, growing between 5 and 37°C (optimal growth of 20–30°C) and at pH 3–4.5, maximum growth was obtained in vitro at 23°C and pH 3–4.5. *Penicillium*

genus includes many species, including *Penicillium atramentosum*, *Penicillium digitatum*, *Penicillium expansum*, *Penicillium notatum*, *Penicillium roquefortii*, *Penicillium oxalicum*, *Penicillium glaucum*, and others (https://www.inspq.qc.ca/en/moulds/fact-sheets/*penicillium-spp*). Some species of *Penicillium* produce different types of mycotoxins that cause acute or chronic toxicity to humans, such as Indole-diterpenes, Penitrems (PNT) A, C, F, Patulin (PTA), Citrinin (CTN), Cyclopiazonic acid (CPA), Ochratoxin A (OTA), Penicillic acid (PA), and other mycotoxins [21]. *Penicillium* can produce a variety of secondary metabolites and many antibacterial and antifungal compounds, immune suppressants, as well as cholesterol-lowering agents, the most famous example being penicillin, which was the first historically known antifungal antibiotic [22].

5. Genus *Fusarium*

Fusarium is among the most economically important genera of fungi in the world and is one of the most studied [23]. Most of the species of *Fusarium* live in the soil, *Fusarium conidia* can spread by rain spray or irrigation, but when dry it can spread by air, and this makes it perfectly suitable for long-distance atmospheric dispersal, and this contributes to its distribution all over the world [24]. The optimum temperature range for growth and reproduction of some species *of Fusarium* such as *F. oxysporum* was 24–28°C. The minimum growth is obtained at 45°C and 10°C. Also, the optimum pH for fungal growth was obtained at a pH of 5.5 [25]. *Fusarium spp*. has a very important role for humankind as plant pathogens, and this leads to its real role in creating toxicological risks to humans and our domestic animal species, A wide range of plant diseases are associated with *Fusarium*; most plant-pathogenic *Fusarium spp*. are grouped into four species complexes as defined by RNA polymerase II subunit gene sequence phylogeny such as *Fusarium fujikuroi*, *Fusarium graminearum*, *Fusarium oxysporum*, and *Fusarium solani* [26]. There are many hundreds of compounds (secondary metabolites) secreted by *Fusarium spp.* Described as toxic or potentially toxic, such as Trichothecenes and Fumonisins, these can contaminate agricultural products and make them unsuitable for food or feed. Trichothecenes can also act as virulence factors in plant diseases [27, 28]. There are other mycotoxins produced by some Fusarium spp. It is commonly found in corn and is called Zearalenone (Zea), Its name is a collection of letters from different origins (Zea) comes from *Gibberella zeae*, which is the name of a producing organism that was the first to be studied [29]. There are other species of *Fusarium* producing other types of mycotoxins such as *F. crookwellense* and *F. sambucinum* produce fusaric acid [30]. Moniliformin is produced from *F. moniliforme*, *F. acuminatum*, *F. culmorum*, *F. equiseti*, and *F. sporotrichioides* [31].

6. Characteristics of mycotoxins

Mycotoxins are toxic chemical compounds produced by molds, and molds cannot be used as building blocks for the body of fungi, but they are produced for other reasons that are not clearly understood so far. Fungi compete for their ecological position in nature. There are hundreds of mycotoxins, some of which are used as antibiotics, such as penicillin, others are very dangerous such as aflatoxin, which is one of the most potent carcinogens known, and others, such as diacetoxiscerinol, are much less a favor [32]. Mycotoxins are distinguished toxic chemical compounds produced by

fungi. Most mycotoxins are Aromatic hydrocarbon seldom Aliphatic hydrocarbon. With low molecular weights ranging between 100 and 697 Da [33], so they do not stimulate the immune system creating antibodies. Due to the different chemical composition, some may exhibit different biological effects. It causes tissue damage, immunosuppression, and nervous disorders [34]. It dissolves well in organic solvents and is resistant to freezing and high temperatures as boiling point and pasteurization [35]. They resist decomposition during the digestive processes that they occur in the human gastrointestinal system and animal [36]. Mycotoxins differ from each other in the degree of their toxicity. Depending on its chemical composition and molecular construction, as it enters the human body in several ways For example, orally through consuming it with food or inhalation of fungi produced. For toxins through the respiratory system or from by direct contact with fungi producing mycotoxins [37].

7. Some mycotoxins commonly found in food and feed

Mycotoxins exist in agricultural commodities such as peanuts, grapes, wines, grains, nuts, dried fruit, coffee, cocoa, spices, oil seeds, fruits, fruit juices, beer, and other foodstuffs and feed crops, both in the field and during transportation [38–40]. At any stage of the food production process (before harvesting, harvesting, drying, and storage), fungal production of mycotoxins can occur and can expose consumers to the risk of contamination directly through food consumption or indirectly through feed [41]. In general, under prolonged storage conditions and at extreme temperatures along with extreme humidity, all crops including cereals can be subjected to mold growth and mycotoxin contamination [42]. In fact, the occurrence of mycotoxins in foods and derivatives is not only a problem in countries, mycotoxins affect agribusiness in many countries, influencing or even impeding exportation, reducing livestock and crop farming production, and affecting human and animal health [43]. Most of the mycotoxins remain chemically and thermally stable, and this has been observed through various techniques in food processing such as cooking, boiling, baking, frying, and pasteurization, The presence of mycotoxins in animal products such as meat, eggs, and milk is the result of contaminated feed, and this leads to the contamination of the human plate [38]. The agricultural industry has to deal with the presence of mycotoxins in food, as it is of global importance and a major threat [44]. Huge agricultural and industrial losses in billions of dollars occur annually because 25% of the world's harvested crops are contaminated by mycotoxins [45]. The report stressed the WHO and IJRC that there is a need for a coordinated international response to the problem of mycotoxins and contamination of food and neglect of its health effect for a long time It causes human liver cancer, death, and stunting in young children, There are approximately 500 million poor people in sub-Saharan Africa, Latin America, and Asia daily exposed to natural toxins, aflatoxins and fumonisins, by following a diet based mainly on peanuts, corn, and other grains, and this exposure to toxins occurs throughout life as toxin levels far exceed internationally accepted standards, and this is in stark contrast to the situation in developed countries [46].

8. Aflatoxin

Aflatoxins are a type of mycotoxin produced by *Aspergillus* species of fungi, such as *A. flavus* and *A. parasiticus*, The most potent carcinogens found in nature,

aflatoxins are toxic not only to humans, but also to livestock, pets, and wildlife [47]. Dietary exposure to aflatoxins is one of the major causes of hepatocellular carcinoma, the fifth most common cancer in humans worldwide [48]. The term aflatoxin was created based on the name of its main agent producer *A. flavus*. The main known aflatoxins are called B1, B2, G1, and G2, based on their fluorescence under ultraviolet light and their mobility during thin layer chromatography (TLC). They are mainly produced by *A. flavus* and *A. parasiticus*. However, more recently, the species *A. nomius*, *A. bombycis*, and *A. tamarii* have also been shown to be aflatoxigenic [49]. More than 20 types of aflatoxins (AFs) and their derivatives occur in nature, but mainly four, B1, B2, G1, and G2, are proved to be dangerous for humans and livestock [50]. Aflatoxins are immunotoxic, carcinogen, and mutagen. The presence of the lactone and devoran ring is mainly due to the effects [51]. AFB1 is considered one of the most studied carcinogens, AFM1 is a 4-hydroxy derivative of AFB1, which is formed in the liver and secreted by the mammary glands in humans and lactating animals when fed a contaminated diet [52]. The chemical formula of the aflatoxin is C17H12O6, colorless to pale yellow crystals. Aflatoxins are soluble in organic solvents such as chloroform and methanol and slightly soluble in water, but insoluble in nonpolar solutions such as phenyl, cyclohexyl, ethyl, octyl, and octadecyl [53, 54] Aflatoxins (AFTs) are derivatives of difuranocoumarin, with a bifuran group attached to one side of the coumarin nucleus while a pentanone ring bound to the other side for AFTs and AFTs-B or six lacton rings attached to the AFTs-G series **Figure 1** [55, 56].

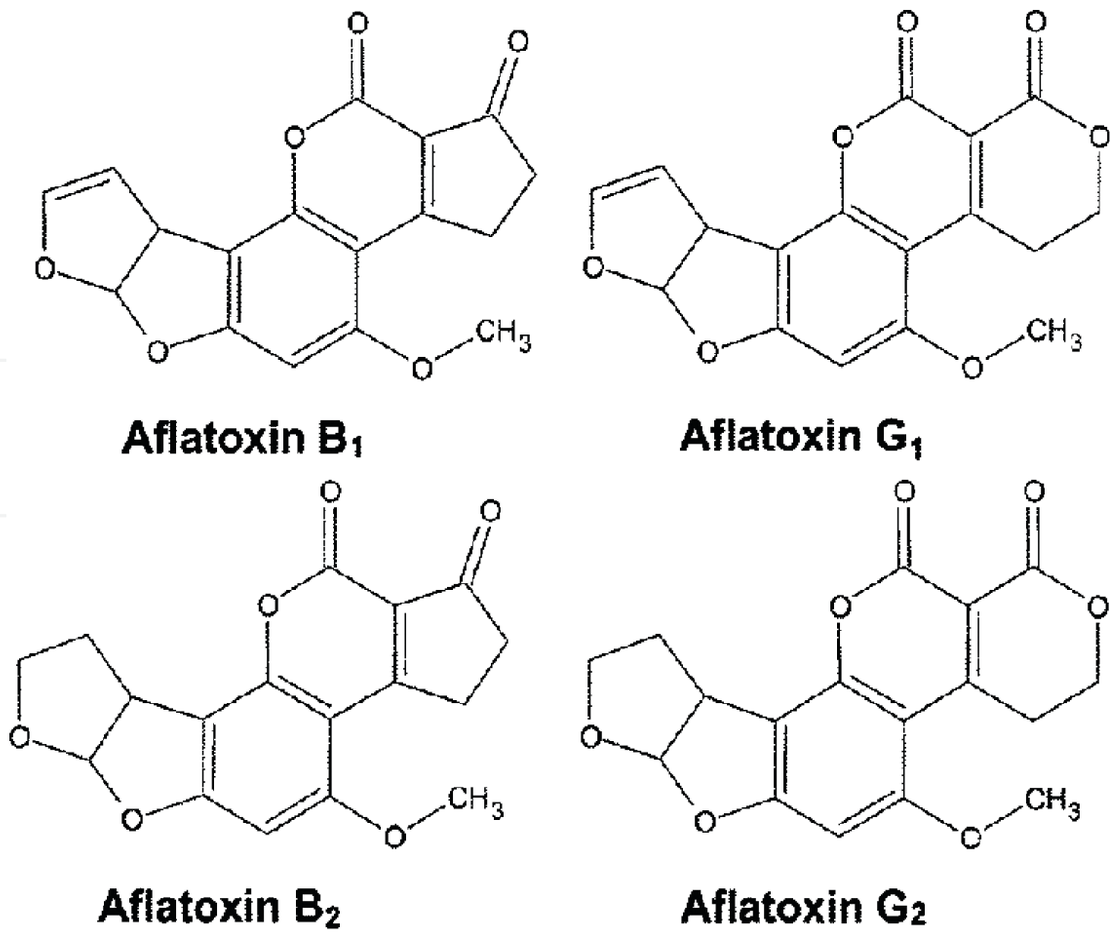


Figure 1.
Chemical structure of aflatoxins.

9. Trichothecenes

Fusarium toxins are produced by over 50 species of *Fusarium* and have a history of infecting the grain of developing cereals such as wheat and maize [57]. They include a range of mycotoxins, such as trichothecenes, which are most strongly associated with chronic and fatal toxic effects in animals and humans, the genera producing trichothecenes include *Fusarium*, *Myrothecium*, *Spicellum*, *Stachybotrys*, and *Cephalosporium*, *Trichoderma,* and *Trichostium*. Trichothecene (TCT) mycotoxin is agriculturally more important worldwide due to the potential health hazards they pose [58, 59]. It produces more than 20 metabolites mainly after the metabolism of trichothecene,

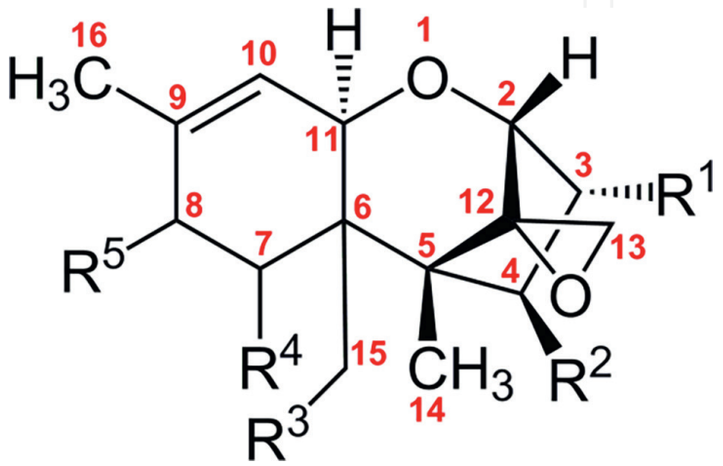


Figure 2.
Chemical structure of trichothecenes.

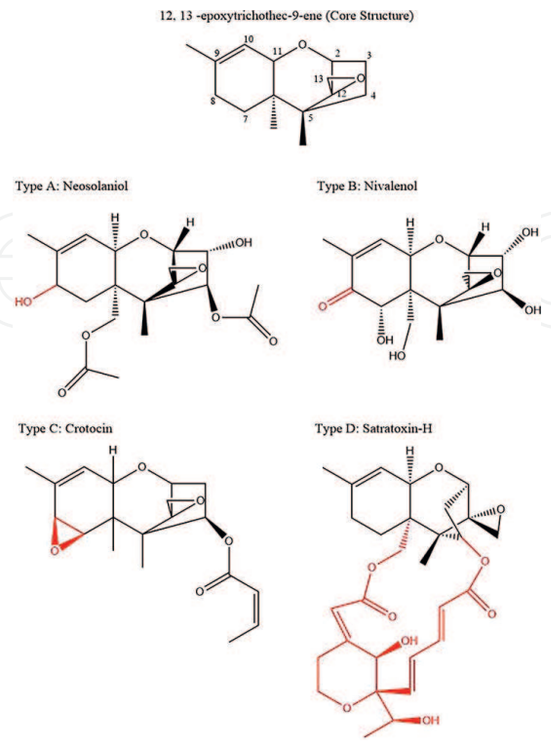
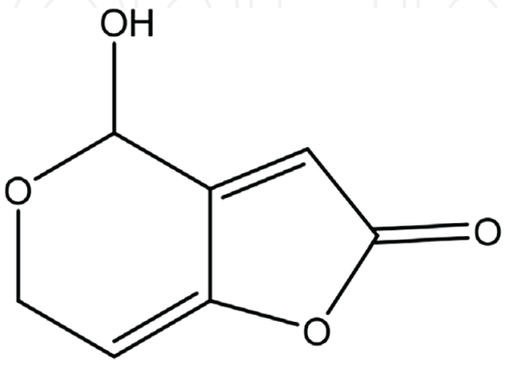


Figure 3.
Chemical structure of trichothecenes types A, B, C, D.

and this happens when ingested to get rid of it, and hydroxy trichothecene-2 is the main metabolite, this family is divided into four groups according to its composition, namely A, B, C, and D [60, 61]). Trichothecenes are groups of chemicals such as T-2 toxin (T-2), HT-2 toxin (HT-2), neosolaniol (NEO), diacetoxyscirpenol (DAS), monoacetoxyscirpenol (MAS), verrucarol (VER), scirpentriol (SCP), and their derivatives are reported as representative type A trichothecenes [62]. Types C and D of trichothecenes are chemical compounds of different structures. It is not produced by *Fusarium* species. Therefore, type A and type B are some of the most common types of trichothecenes found in nature and highly toxic, The most toxic group is type A (T-2 and HT-2) compared with type B DON, NIV, and FUS-X [63, 64]. Trichothcinate is a low-molecular-weight (MW 250–550) mycotoxin, nonvolatile, and slightly soluble in water, but highly soluble in acetone, ethyl acetate, chloroform, dimethyl sulfoxide (DMSO), ethanol, methanol, and propylene glycol Pure trichothcinates have a low vapor pressure but evaporate when heated in organic solvents (**Figures 2** and **3**) [65].

10. Patulin

Patulin (PAT) is produced by many different molds, predominantly by *Penicillium spp*., but, occasionally, by some *Byssochlamys* and *Aspergillus spp*. including *A. giganteus*, *A. longivesica*, and *A. clavatus* [66–68]. It is a low-molecular-weight mycotoxin. Compounds with low volatility, which are secondary metabolites found in crops, in the field or after harvest, are capable of causing disease and death to humans and animals by eating contaminated food products [67]. The contamination of patulin in fruits, vegetables, and fruit-derived products, especially in apple and derived products, is very common worldwide and occasionally in other fruits such as pears, oranges, grapes, and their products [69]. If rotten fruits, especially apples, are not removed during fruit juice processing, patulin is transferred to juices [70]. Patulin is a polycystic metabolite, like many other major mycotoxins, such as aflatoxins, fumonisins, and ochratoxins, but this latter toxin is a polycetoxin/amino acid hybrid compound, Structurally, PAT is a heterocyclic lactone (4-hidroxi-4H-furo [3,2-c] piran-2(6H)-ona) (**Figure 4**) [71].



$C_7H_6O_4$ - molecular weight = 154.12 g/mol

Figure 4.
Chemical structure of patulin.

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11. Mycotoxins and public health

There are approximately 500 mycotoxins, most of which have been discovered since the 1960s, it has been generally classified into groups based on structural similarities and its major toxic effects [56]. Mycotoxins are classified into polycetoacids, cyclopeptides, terpenes, and nitrogenous metabolites, depending on their biological origin and structure. From a health point of view, the important mycotoxins in food and feed include: aflatoxins, ochratoxin, trichothecenes, fumonisins, ZEN, and patulin. Aaflatoxins, fumonisins, and ergot alkaloids are associated with acute mycotoxicoses in both humans and livestock [72]. Mycotoxins can travel through the food chains of humans and animals through direct or indirect contamination, The indirect contamination of food and animal feed occurs when any component has been previously contaminated with toxic fungi, and mycotoxins remain in the final product despite the elimination of the fungi during processing, on the other hand, direct contamination occurs when the product, food, or feed is infected with a fungus toxic with the subsequent formation of mycotoxins. It is known that most food and feed products can allow toxin-causing fungi to grow and develop during production, processing, transport, and storage [7]. The term mycotoxicosis is given to the toxic effect of mycotoxins on human and animal health. Mostly exposure to mycotoxins is through ingestion but can also occur through inhalation and skin. The extent of harmful effects of mycotoxins on human and animal health depends mainly on exposure (dose and period). The physiological and nutritional status, the type of toxins, as well as the potential synergistic effects of other chemical substances to which humans or animals are exposed [73]. Aflatoxins are the best known among all mycotoxins, because of their serious impact on human and animal health, aflatoxin.

B1 is a carcinogenic substance (according to the classification by the IARC in 1987, while AFM1 is a potentially carcinogenic substance with a toxicity range of B1, G1, B2, and G2 [74, 75]. In addition to being a carcinogen, aflatoxin is mutagenic (DNA destruction), have teratogenic effects, and immunosuppressive effects. Symptoms of acute aflatoxicosis in humans include vomiting, abdominal pain, jaundice, pulmonary edema, coma, convulsions, and death while chronic aflatoxicosis occurs via cancer, immune system inhibition, and liver damage [76, 77]. Aflatoxicosis is the consumption of foods or feed contaminated with high levels of aflatoxins, which leads to acute Aflatoxicosis, while regular intake at low levels (ppb) is responsible for stunting and weight loss in children and in some cases led to the development of hepatocellular carcinoma. Aflatoxins have also been linked with kwashiorkor, a protein-energy malnutrition disease [78]. Those who are most exposed to Aflatoxicosis illness are residents of developing countries, because the security blankets on crops before and after harvest is not as strict as in other countries.

The same is happening with dairy products, as developing countries do not accept or assume amenities like developed countries, and it is estimated that there are more than 5 billion people in developing countries around the world at risk of chronic exposure to aflatoxins through contaminated foods [79]. The effects of aflatoxins are similar in all animals; however, susceptibility to infection varies by gender, age, and individual variation. Symptoms of acute poisoning consist of depression, loss of appetite, weight loss, disease, gastrointestinal bleeding, and pulmonary edema

Liver damage. Signs of acute liver injury are thrombosis and capillary enlargement feeling, bleeding, and prolonged clotting. Pigments of blood may appear in urine and mucous membranes are rhythmic. Symptoms of prolonged exposure to moderate to

aflatoxins may be reflected in a decline in feed consumption and production (growth and production of eggs and milk) [80]. The US Food and Drug Administration (FDA) has recommended acceptable levels of aflatoxins in foods and feeds in order to protect human and animal health from the toxicity of high doses of aflatoxins, The permissible levels range from 20 to 300 ppm, depending on the product and host (children, adults, animals) **Table 1** [81]. Trichothecenes are toxic to humans, other mammals, birds, fish, plants, and plants Eukaryotic cells in general, TCT is dangerously toxic due to its added ability to be locally absorbed. Its metabolites affect the gastrointestinal tract, kidneys, liver, skin, cellular immune system, and blood. The most sensitive end points are in neuroimmune effects, hematological and reproductive diseases, and there is variation in the sensitivity of some animals. This type of poison ranges from dairy cows to pigs [82]. The mechanism of action mainly consists of the inhibition of protein synthesis and oxidative damage to cells followed by the disruption of nucleic acid synthesis and ensuing apoptosis [59]). Trichothecenes have a spectrum of adverse effects including emesis, anorexia, growth retardation, neuroendocrine changes, immunotoxicity, and a reduction in food consumption in various animal species (mink, mice, and pigs) [83]. TCT is easily absorbed in the membranes of the gastrointestinal tract and is rapidly distributed to various organs and tissues of the

Aflatoxin		
Commodity	**Action level (ppb)**	**Reference**
Animal feeds		
Brazil nuts	20	CPG 570.200
Foods	20	CPG 555.400
Milk	0.5 (aflatoxin M1)	CPG 527.400
Peanuts and peanut products	20	CPG 570.375
Pistachio nuts	20	CPG 570.500
Corn, peanut products, and other animal feeds and feed ingredients but excluding cottonseed meal, intended for immature animals	20	CPG 683.100
Corn, peanut products, cottonseed meal, and other animal feed ingredients intended for dairy animals, for animal species or uses not specified above, or when the intended use is not known	20	CPG 683.100
Corn and peanut products intended for breeding beef cattle, breeding swine, or mature poultry	100	CPG 683.100
Corn and peanut products intended for finishing swine of 100 pounds or greater	200	CPG 683.100
Corn and peanut products intended for finishing (i.e., feedlot) beef cattle	300	CPG 683.100
Cottonseed meal intended for beef, cattle, swine, or poultry (regardless of age or breeding status	300	CPG 683.100

Table 1.
FDA action levels for aflatoxins present in animal feeds and food.

body due to its low molecular weight and amphipathic nature. The toxic activity of trichothecenes is due to the fact that they all contain epoxide at the C12,13 position [84]. Modulation of emesis and anorexia occur as a result of the direct action of trichothecenes in the brain or the indirect action in the gastrointestinal tract. The direct action of trichothecenes is in specific areas of the brain such as nucleate tractus solitarius in the brainstem and the arcuate nuclei in the hypothalamus. Activation of these areas in the brain leads to the activation of specific neuronal populations containing anorexigenic factors [85]. Since trichothecenes induce emesis and growth retardation, mycotoxin contamination is becoming a major issue for child and young animal health [86]. The trichothecene mycotoxins are readily absorbed by various modes, including the topical, oral, and inhalational routes [87]. Intestinal epithelial cells newly identified as an important target for trichothecenes, which affect the network of tight junctions and thus lead to impaired intestinal barrier function, impairing nutrient transport, the immune system, and increased risk of transmission of pathogens and antigens from the intestinal lumen to surrounding tissues, increased the possibility of allergic reactions in humans [88].

12. Conclusion

This review showed the main dangerous effect of mycotoxins on public health and the occurrence of dangerous diseases such as cancer and mutations by some of them such as aflatoxins. In addition to its transmission through the food chains, it was also found that there is the ability of different species of fungi to secrete mycotoxins at a wide range of different environmental factors, in addition to their occurrence in the pre- and postharvest stages and during poor storage conditions and marketing to the consumer (human and animal). In view of the seriousness and importance of this topic, more light should be shed on mycotoxins and their occurrence in many agricultural, food, and feed products, especially in developing countries, should be shed light on the lack of accurate systems and programs that reveal this. And since the effect on the public health of mycotoxins does not appear quickly until after long periods, they really represent the silent or slow death of humans and animals, modern strategies, means and methods must be followed to prevent the occurrence of mycotoxins, especially in the pre- and postharvest stages and in the store, represented by genetic, agricultural, biological, chemical, and physical methods.

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