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Mycotoxins: Effects and Management

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SUMMARY

Mycotoxins are secondary metabolites of fungi that exert toxic effects on animals and humans and animals. Generally, mycotoxins are low-molecular-weight natural products produced as secondary metabolites by filamentous fungi. These metabolites establish a toxic and chemically heterogeneous assemblage that is assembled only because the members can cause serious ailments and death in human beings and other vertebrates. Unsurprisingly, many mycotoxins display overlapping toxicities to plants, invertebrates and microorganisms. The toxic effect of mycotoxins on animal and human health is referred to as mycotoxicosis, the severity of which depends on the toxicity of the mycotoxin, the extent of exposure, age and nutritional status of the individual and possible synergistic effects of other chemicals to which the individual is exposed. The chemical structures of mycotoxins vary considerably, but they are all relatively low molecular mass organic compounds. The mycotoxins can be detected by various technologies such as DNA based ones and ELISA. To reduce the damage of mycotoxins to humans and other mammals, a proper management strategy should be adopted.

INTRODUCTION

Mycotoxins are the poisonous toxic compounds released by fungi. These compounds are lethal to both humans and other mammals as they taint staple food and feed. In the present period, it is a threat to our food security as well as safety. Mycotoxins can cause serious contamination at small concentrations and are frequently estimated in parts per million (ppm) or parts per billion (ppb). There are a few mycotoxins revealed yet just a couple of causes of plant and animal diseases. The component of mycotoxins is to obstruct have guard reactions or to ensure the parasite against different microorganisms (de Rocha *et. al.*, 2014). The harmful effects of moulds and fungi was documented since ancient ages. During the 7th and 8th centuries BC, a festival called “Robigalia" was celebrated to pay homage to the god Robigus, who had to be placated to protect grain and trees. It was celebrated on 25th April as that was the most possible time for crops to be attacked by rust or mildew (Ovidius, 1845). In the Middle Ages, outbreaks of ergotism caused by ergot alkaloids from *Claviceps purpurea* reached epidemic proportions, mutilating and killing thousands of people in Europe. Ergotism was also known as *ignis sacer* (sacred fire) or St Anthony's fire because at the time it was thought that a pilgrimage to the shrine of St Anthony would bring relief from the intense burning sensation experienced. The victims of ergotism were exposed to lysergic acid diethylamide (LSD), a hallucinogen, produced during the baking of bread made with ergot-contaminated wheat, as well as to other ergot toxins and hallucinogens, as well as belladonna alkaloids from mandragora apple, which was used to treat ergotism (Van Dongen and De Groot,1995). While ergotism no longer has such important implications for public health, recent reports indicate that outbreaks of human mycotoxicoses are still possible. The main interest in mycotoxins have arisen when an incident led to the unexpected passing of 100,000 young turkeys after devouring a peanut that was contaminated with mycotoxin known as aflatoxins. This disease is usually known as 'Turkey-X disease'. Subsequently, it came to light those aflatoxins are hepatocarcinogens in humans and animals, and this stimulated research on mycotoxins. After this monstrous casualty, other essential mycotoxins including fumonisins, ochratoxins, trichothecenes, and zearalenone have been found and described by other researchers.

However, few mycotoxicoses were removed owing to intense hygiene measures viz., citreoviridin-related malignant acute cardiac beriberi “yellow rice disease" or shoshin-kakke disease in Japanese) which haven’t arisen for several decades, due to exclusion of mouldy rice from the markets. Citreoviridin is a toxic metabolite of *Penicillium citreonigrum*, which readily grows on rice during storage, especially in the temperate regions of Japan (Ueno, 1985). Another mycotoxicosis that has disappeared for decades is the alimentary toxic aleukia, common in the 1930s and 1940s in Russia. This disease was primarily caused by trichothecenes produced by Fusarium strains on unharvested grain.

Table 1. List of few major mycotoxins along with their target organisms and symptoms.

Mycotoxin	Causal organism	Contaminated items	Target organisms	Symptoms
Aflatoxin	*Aspergillus flavus, A. parasiticus*	Corn, peanuts, cottonseed, tree nuts, dairy products	Human, Swine, Dogs, Cats, Cattle, Sheep, Young birds	Liver damage, intestinal bleeding
Ergot alkaloids	*Claviceps perpurea, C. fusiformis*	Rye, sorghum, pasture grasses	Human, Cattle, Sheep	Hallucinations, gangrene, loss of limbs, hastening of birth
Citrinin	*Penicillium citrinum, Aspergillus terreus, A. niveus*	Wheat, oats, rye, corn, barley, and rice	Swine, Dairy Cattle, Duck, Chicken	Toxic to nephrons
Trichothecenes	*Fusarium, Myrothecium, Phomopsis, Stachybotrys, Trichoderma, Trichothecium*	Wheat, barley, oats, corn	Swine, Cattle, Poultry, Horse, Human	Feed refusal, diarrhoea, vomiting, skin disorders, reduced growth
Fumonisin	*Fusarium verticillioides, F. proliferatum, F. nygamai, Alternaria alternata* f. sp. *lycopersici*	Corn, silage	Human, Horses, Swine,	Pulmonary edema, hydrothorax, leukoencephalomalacia, oesophagal cancer, neural tube defects, apoptosis
Ochratoxin	*Aspergillus ochraceus, A.alliaceus, A. auricomus, A. carbonarius, A. glaucus,*	Cereal grains, Grapes, coffee	Human, Swine	Kidney and liver damage, cancer
Zearalerones	*Fusarium* sp.	Corn, hay	Swine, Cattle	Enlargement of the uterus, abortion, malformation of testicles and ovaries
Patulin	*Penicillium patulum, P. expansum*	Grains, fruits, and vegetables, rotting apples	Human, Poultry	Pulmonary congestion, and edema, gastrointestinal problems, neurotoxicity (i.e. convulsions)

Effect of Mycotoxins

The mycotoxin can cause mild to severe losses because of the joined impact of yield losses, decrease in crop esteem, decrease in animal productivity and human wellbeing costs (Peraica *et. al.*, 1999). Additional expenses related to mycotoxins include the administration cost during all stages like anticipation, testing, relief, suit, and exploration costs. Its impact is knowledgeable about food and feeds supply chains: crop and animal producers, grain overseers and wholesalers, processors, purchasers, and society all in all (because of medical services effects and usefulness misfortunes). The effect of mycotoxins on human wellbeing is truly challenging to measure. Notably, mycotoxins influence human health, particularly aflatoxins in non-industrial nations. These

impacts are a direct result of intense (single openness) toxicoses and immunosuppression by mycotoxins, just as chronic (rehashed openness) impacts (Galtier, 1998).

Methods of Detection and Quantification of Mycotoxins

The detection and quantification of mycotoxins in food and feed are generally practised through techniques that are mainly based on antibody assays, chromatography and DNA methodologies. The pioneer detection method is ELISA, for which commercial ELISA kits are also available in the market. Moreover, High-Performance Liquid Chromatography (HPLC) and Gas Chromatography/Mass Spectrometry (GC/MS) can also be useful in this regard (Bajpai, 2018).

Management Strategies

The mycotoxins can be managed at different stages such as pre-harvest, harvest and post-harvest. The strategies for different stages have been described as follows:

Preharvest-

- Use of resistant seeds should be selected for raising crops to minimize the chances of attack of toxin-producing pathogens.
- Proper cultural practices like sowing time, tillage, crop rotation, sanitation practices should be advocated as fungi survive in crop residues. Other operations such as fertilizer application, irrigation, plant protection measures etc should be planned accordingly to promote environmental conditions that are detrimental to pathogen perpetuation.

During harvest-

Precautions should be applied to reduce the contamination of healthy seeds with infected seeds.

Post-harvest

- **Drying**- Dried seeds are mostly free from insects and moulds as requirements for their growing conditions are not met. Most commonly, grains are dried under direct sunlight. It has been found that exposure of aflatoxin-contaminated groundnut oil to sunlight destroys nearly about 99 per cent of the toxicant. Other drying methods involve mechanical drying, in-bin drying, infrared, microwave or sonic and solar energy drying.
- **Storage**- The seeds should be stored in air-tight storage to prevent the oxygen requirements of fungi. Natural cooling is another effective method of grain preservation.
- **Physical separation**- It can be carried out either by manual methods or with an electronic sorter, optical sorters, air-screen cleaners or through density gradient separations. The infected seeds have a characteristic colour or other physical properties which can be easily distinguished.
- **Detoxification**- It can be done by thermal, chemical or biological methods. Thermal inactivation is usually practised during industrial processes. Heating at high pressure can eliminate about 50 per cent of the toxins. Moreover, the roasting of peanuts reduces aflatoxins to a significant degree. For the destruction of aflatoxin in crude groundnut oil light has also been used. It is reported that visible light is more effective than either ultra-violet or infra-red light.

CONCLUSION

Fungi are responsible for causing human diseases differently. The term mycotoxin is a term used to portray pharmacologically dynamic contagious metabolites described by vertebrate toxicity. They can be categorized into a few synthetically unrelated classes, and are created in a strain-explicit way. Their destructive influence might incorporate cancer-causing nature, hindrance of protein blend, immunosuppression, dermal irritation, and other metabolic fomentations. Mycotoxins ordinarily enter the body utilizing ingestion of contaminated food varieties, however, inward breath of toxigenic spores and direct dermal contact are additionally significant courses. The frequency of mycotoxicosis might be more normal than assumed. It is not difficult to credit the side effects of intense mycotoxin harming to different causes; the inverse is valid for etiology. It isn't

difficult to demonstrate that malignancy and other constant conditions are brought about by mycotoxin exposure. In rundown, without any proper analytical measures and dependable lab tests, mycotoxicosis will remain indicatively overwhelming sicknesses. To prevent the adverse effects of mycotoxins, proper care and precautions should be taken during each step of crop production.

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