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Mycotoxins in Food: Their occurrence, impact on health and Economy and control measures – A review article

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Abstract - Mycotoxins are naturally occurring toxins produced by certain moulds (fungi) and can be found in food. The moulds grow on a variety of different crops and foodstuffs including cereals, nuts, spices, dried fruits, apples and coffee beans, often under warm and humid conditions. Mycotoxins can cause a variety of adverse health effects and pose a serious health threat to both humans and livestock. The adverse health effects of mycotoxins range from acute poisoning to long-term effects such as immune deficiency and cancer. The economic impacts of mycotoxins to human society can be thought of in two ways: (i) the direct market costs associated with lost trade or reduced revenues due to contaminated food or feed, and (ii) the human health losses from adverse effects associated with mycotoxin consumption. This article is an effort to highlight different features of Mycotoxins and their economic impacts so that bad impacts of Mycotoxins can be minimised.
Key Words- Mycotoxins, Economy, Health impact, Moulds, cereals.
Introduction- Mycotoxins are toxic compounds that are naturally produced by certain types of moulds (fungi). Moulds that can produce mycotoxins grow on numerous foodstuffs such as cereals, dried fruits, nuts and spices. Mould growth can occur either before harvest or after harvest, during storage, on/in the food itself often under warm, damp and humid conditions. Most mycotoxins are chemically stable and survive food processing.
Several hundred different mycotoxins have been identified, but the most commonly observed mycotoxins that present a concern to human health and livestock include aflatoxins, ochratoxin A, patulin, fumonisins, zearalenone and nivalenol/deoxynivalenol. Mycotoxins appear in the food chain as a result of mould infection of crops both before and after harvest. Exposure to mycotoxins can happen either directly by eating infected food or indirectly from animals that are fed contaminated feed, in particular from milk.
Occurrence of Mycotoxins – Mycotoxins are found in various crops, cereals, millets, various plant processed products like coffee, groundnuts etc. There are three types of toxicogenic field fungi: plant pathogens such as *Fusarium graminearum* (deoxynivalenol, nivalenol); fungi that grow on senescent or stressed plants, such as *Fusarium moniliforme* (fumonisin) and sometimes *Aspergillus flavus* (aflatoxin); and fungi that initially colonize the plant before harvest and predispose the commodity to mycotoxin contamination after harvest, such as *Penicillium verrucosum* (ochratoxin) and *A. flavus (*aflatoxin).

- **Cereals and Millets -** Cereal grains and their processed food products are frequently contaminated with mycotoxins. Among many, five major mycotoxins of aflatoxins, ochratoxins, fumonisins, deoxynivalenol, and zearalenone are of significant public health concern as they can cause adverse effects in humans. Being airborne or soilborne, the cosmopolitan nature of mycotoxigenic fungi contribute to the worldwide occurrence of mycotoxins. On the basis of the global occurrence data reported during the past 10 years, the incidences and maximum levels in raw cereal grains were 55% and 1642 µg/kg for aflatoxins, 29% and 1164 µg/kg for ochratoxin A, 61% and 71,121 µg/kg for fumonisins, 58% and 41,157 µg/kg, for deoxynivalenol, and 46% and 3049 µg/kg for zearalenone. The concentrations of mycotoxins tend to be lower in processed food products; the incidences varied depending on the individual mycotoxins, possibly due to the varying stability during

processing and distribution of mycotoxins. It should be noted that more than one mycotoxin, produced by a single or several fungal species, may occur in various combinations in a given sample or food. Most studies reported additive or synergistic effects, suggesting that these mixtures may pose a significant threat to public health, particularly to infants and young children.

- **Spices and Herbs** - Spices are vulnerable to fungal infection, leading to mycotoxin contamination if the conditions are favourable for fungal growth. However, the level of mycotoxins in spices varies depending on the types of spices, processing methods, storage conditions, and others. AFs and OTA are the main mycotoxins reported in spices, especially chilli products. The high consumption of chilli-based products may expose consumers to the harmful effect of mycotoxins.
- **Beverages** - Mycotoxins are secondary metabolites of filamentous fungi that contaminate food products such as fruits, vegetables, cereals, beverages, and other agricultural commodities. Their occurrence in the food chain, especially in beverages, can pose a serious risk to human health, due to their toxicity, even at low concentrations. Mycotoxins, such as aflatoxins (AFs), ochratoxin A (OTA), patulin (PAT), fumonisins (FBs), trichothecenes (TCs), zearalenone (ZEN), and the alternaria toxins including alternariol, altenuene, and alternariol methyl ether have largely been identified in fruits and their derived products, such as beverages and drinks.

Mycotoxins commonly found in food and why they are of concern

The effects of some food-borne mycotoxins are acute with symptoms of severe illness appearing quickly after consumption of food products contaminated with mycotoxins. Other mycotoxins occurring in food have been linked to long-term effects on health, including the induction of cancers and immune deficiency. Of the several hundred mycotoxins identified so far, about a dozen have gained the most attention due to their severe effects on human health and their occurrences in food.

Aflatoxins are amongst the most poisonous mycotoxins and are produced by certain moulds (*Aspergillus flavus* and *Aspergillus parasiticus*) which grow in soil, decaying vegetation, hay, and grains. Crops that are frequently affected by *Aspergillus* spp. include cereals (corn, sorghum, wheat and rice), oilseeds (soybean, peanut, sunflower and cotton seeds), spices (chili peppers, black pepper, coriander, turmeric and ginger) and tree nuts (pistachio, almond, walnut, coconut and Brazil nut). The toxins can also be found in the milk of animals that are fed contaminated feed, in the form of aflatoxin M1. Large doses of aflatoxins can lead to acute poisoning (aflatoxicosis) and can be life threatening, usually through damage to the liver. Aflatoxins have also been shown to be genotoxic, meaning they can damage DNA and cause cancer in animal species. There is also evidence that they can cause liver cancer in humans.

Ochratoxin A is produced by several species of *Aspergillus* and *Penicillium* and is a common food-contaminating mycotoxin. Contamination of food commodities, such as cereals and cereal products, coffee beans, dry vine fruits, wine and grape juice, spices and liquorice, occurs worldwide. Ochratoxin A is formed during the storage of crops and is known to cause a number of toxic effects in animal species. The most sensitive and notable effect is kidney damage, but the toxin may also have effects on fetal development and on the immune system. Contrary to the clear evidence of kidney toxicity and kidney cancer due to ochratoxin A exposure in animals, this association in humans is unclear, however effects on kidney have been demonstrated.

Patulin is a mycotoxin produced by a variety of moulds, particularly *Aspergillus*, *Penicillium* and Byssochlamys. Often found in rotting apples and

apple products, patulin can also occur in various mouldy fruits, grains and other foods. Major human dietary sources of patulin are apples and apple juice made from affected fruit. The acute symptoms in animals include liver, spleen and kidney damage and toxicity to the immune system. For humans, nausea, gastrointestinal disturbances and vomiting have been reported. Patulin is considered to be genotoxic however a carcinogenic potential has not been demonstrated yet.

Fusarium fungi are common to the soil and produce a range of different toxins, including trichothecenes such as deoxynivalenol (DON), nivalenol (NIV) and T-2 and HT-2 toxins, as well as zearalenone (ZEN) and fumonisins. The formation of the moulds and toxins occur on a variety of different cereal crops. Different fusarium toxins are associated with certain types of cereal. For example, both DON and ZEN are often associated with wheat, T-2 and HT-2 toxins with oats, and fumonisins with maize (corn). Trichothecenes can be acutely toxic to humans, causing rapid irritation to the skin or intestinal mucosa and lead to diarrhoea. Reported chronic effects in animals include suppression of the immune system. ZEN has been shown to have hormonal, estrogenic effects and can cause infertility at high intake levels, particularly in pigs. Fumonisins have been related to oesophageal cancer in humans, and to liver and kidney toxicity in animals.

Market and trade impacts of mycotoxins

The primary way in which mycotoxins affect markets is to lower the value of the commodity being traded. The price paid for a particular lot of food or feed is reduced, or the lot is rejected entirely, or the lot must be treated at additional cost before being sold at a higher price. This can occur at multiple different levels of trade, from local all the way to international. Depending on the demands of the buyer, the stakeholder group that bears the burden of mycotoxin cost can be individual farmers, handlers, processors, distributors, consumers, or government.

The economic impacts of mycotoxins to human society can be thought of in two ways: (i) the direct market costs associated with lost trade or reduced revenues due to contaminated food or feed, and (ii) the human health losses from adverse effects associated with mycotoxin consumption. Losses related to markets occur within systems in which mycotoxins are being monitored in the food and feed supply. Food that has mycotoxin levels above a particular maximum allowable level is either rejected outright for sale or sold at a lower price for a different use. Such transactions can take place at local levels or at the level of trade among countries. Sometimes this can result in heavy economic losses for food producers, but the benefit of such monitoring system is a lower risk of mycotoxins in the food supply.

How to minimise the risk of Mycotoxins

Mould that produces mycotoxins can grow on a variety of different crops and foodstuff and can penetrate deep into food and do not just grow on the surface. Mould usually does not grow in properly dried and stored foods, so efficient drying of commodities and maintenance of the dry state, or proper storage, is an effective measure against mould growth and the production of mycotoxins.

Health risks can be minimised in following ways:

- inspect whole grains (especially corn, sorghum, wheat, rice), dried figs and nuts such as peanuts, pistachio, almond, walnut, coconut, Brazil nuts and hazelnuts which are all regularly contaminated with aflatoxins for evidence of mould, and discard any that look mouldy, discoloured, or shrivelled;
- avoid damage to grains before and during drying, and in storage, as damaged grain is more prone to invasion of moulds and therefore mycotoxin contamination;
- buy grains and nuts as fresh as possible;

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- make sure that foods are stored properly – kept free of insects, dry, and not too warm;
- not keep foods for extended periods of time before being used; and
- ensure a diverse diet – this not only helps to reduce mycotoxins exposure, but also improves nutrition.

Strategies for prevention and control of mycotoxins

The prevention of mycotoxins in our environment is a big task. In general, prevention of the contamination of fungi and their mycotoxins in agricultural commodities can be divided into these following three levels.

1. Primary prevention

The step of prevention should be initially carried out before the fungal infestation and mycotoxin contamination. This level of prevention is the most important and effective plan for reducing fungal growth and mycotoxin production. Several practices have been recommended to keep the conditions unfavorable for any fungal growth. These include:

- development of fungal resistant varieties of growing plants;
- control field infection by fungi of planting crops;
- making schedule for suitable pre-harvest, harvest and post-harvest;
- lowering moisture content of plant seeds, after post harvesting and during storage;
- Store commodities at low temperature whenever possible;
- Using fungicides and preservatives against fungal growth;
- Control insect infestation in stored bulk grains with approved insecticides.

Secondary prevention

If the invasion of some fungi begins in commodities at early phase, this level of prevention will then be required. The existing toxigenic-fungi should be eliminated or its growth to be stopped to prevent further deterioration and mycotoxin contamination. Several measures are suggested as follows:

- Stop growth of infested fungi by re-drying the products;
- Removal of contaminated seeds;
- Inactivation or detoxification of mycotoxins contaminated;
- Protect stored products from any conditions which favour continuing fungal growth.

3. Tertiary prevention

Once the products are heavily infested by toxic fungi, the primary and secondary preventions would not be then feasible. Any action would not be as effective as the practices mentioned above, since it will be quite late to completely stop toxic fungi and reduce their toxin formation. However, some measures should be done to prevent the transfer of fungi and their health hazardous toxins highly contaminated in products into our daily foods and environment. For example, peanut oil extracted from poor-graded peanut seeds always contains very high levels of aflatoxins and the oil-soluble toxin has to be eliminated by absorption and alkalinization during oilrefining process. Only a few practices are recommended:

- Complete destruction of the contaminated products;
- Detoxification or destruction of mycotoxins to the minimal level.

Conclusion – This review summarized all possible sites where mycotoxins are found. These mycotoxins are very important to notice as it affects the health as well as economy of a country. Its very important find out effective control measures of minimising the mycotoxins. These are sometimes lethal when consumed in high quantity. The paper has covered economic and health impact of Mycotoxins. From this study, it can be concluded that its very important to control Mycotoxins as it affects the health which results in economic as well as human loses. It also affects the animals as well which may result in International business

like poultry, fish culture and many more. The Government must take serious actions to reduce such risks. Different Government policies must be made to control their risks so that health and economy both could be saved.

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