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Significance of Mycotoxin in Health and Advance

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ABSTRACT

In this review article, the recognized effects of mycotoxins on human health, the types of mycotoxins that affect human health, and their control methods were discussed in detail. Mycotoxins are harmful substances produced by fungi in various foods. Most of these mycotoxins belong to the three genera of fungi: Aspergillus, Penicillium, and Fusarium. Acute mycotoxicoses can cause serious and sometimes fatal diseases. Depending on their precise nature, these toxins may be carcinogenic, teratogenic, mutagenic, immunosuppressive, tremorgenic, hemorrhagic, hepatotoxic, nephrotoxic, and neurotoxic. Mycotoxin is known for its teratogenic effect that can cause an adverse effect on the fetus in the womb owing to its ability to cross the placenta and cause the malformation of the central nervous system and damage to the brain. Control of mold growth in feeds can be accomplished by keeping moisture low, feeding fresh, equipment clean, and using mold inhibitors. In tallying, control of mycotoxins in animal diets would reduce the likelihood that mycotoxin residues would appear in animal products destined for human consumption.

Keywords: Aflatoxins, Mycotoxicoses, Lethal, Human health, Carcinogenic

INTRODUCTION

Mycotoxins are toxic agents produced by toxigenic fungi. Mycotoxins are metabolites produced by fungi causing acute and chronic adverse effects in humans and animals. Mycotoxin contamination of foodstuffs and feedstuffs continues to represent an economic and health risk [1,2]. Acute poisoning can be lethal. Some mycotoxins are genotoxic, immunotoxic, allergenic, carcinogenic, mutagenic, or teratogenic. Mycotoxins are poisonous chemical compounds produced by certain fungi. There are five mycotoxins or groups of mycotoxins that occur quite often in food: Deoxynivalenol/Nivalenol, zearalenone, ochratoxin, fumonisins, and aflatoxins [3]. The fungi that produce mycotoxins in food fall broadly into two groups: Those that invade before harvest, commonly called field fungi, and those that occur only after harvest, called storage fungi [4]. There are three types of toxicogenomic field fungi: Plant pathogens such as *F. graminearum* (deoxynivalenol, nivalenol); fungi that grow on senescent or stressed plants, such as *F. moniliforme* (fumonisin) and sometimes *A. flavus* (aflatoxin); and fungi that initially colonize the plant before harvest and predispose the commodity to mycotoxin contamination after harvest, such as *P. verrucosum* (ochratoxin) and *A. flavus* (aflatoxin).

LITERATURE REVIEW

Assets of mycotoxins on human health

Mycotoxins are secondary metabolites of molds that exert toxic effects on animals and humans. The toxic effect of mycotoxins on animal and human health is referred to as mycotoxicoses, 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 [4,5]. Most of these mycotoxins belong to the three genera of fungi: *Aspergillus, Penicillium*, and *Fusarium* [6]. Fungal contamination affects both the organoleptic characteristics and the alimentary value of feeds and entails a risk of toxicosis. Mycotoxin contamination of agricultural products still occurs in the developed world, the application of modern agricultural practices and the presence of a legislatively regulated food processing and marketing system has greatly reduced mycotoxin exposure in these populations [7]. At the mycotoxin contamination levels generally found in food products traded in these market economies, adverse human health effects have largely been overcome. However, in the developing world, where climatic and crop storage conditions are frequently conducive to fungal growth and mycotoxin production. Thus, food safety remains an important opportunity for addressing current health problems in developing countries.

Recognized effects of mycotoxins on human health

The improvements in food safety in developed countries mentioned above have eliminated acute human mycotoxicoses such as ergotism, after consumption of grain contaminated with *Claviceps purpurea*. The most tragic outbreaks of human mycotoxicosis have happened in Kenya, where deaths due to aflatoxin exposure have occurred over a number of years. Aflatoxicosis is toxic hepatitis leading to jaundice and, in severe cases, death. Repetitive incidents of this nature have occurred in Kenya [8]. AFB1 has been extensively linked to human primary liver cancer in which it acts synergistically with HBV infection and was classified by the International Agency for Research on Cancer (IARC) as a human carcinogen. This combination represents a heavy cancer burden in developing countries [9]. Of the other health risk factors, the morbidity and mortality associated with unsafe sex, unsafe water, and indoor smoke, arise from infectious diseases, such as HIV/AIDS, infectious diarrhea, and lower respiratory tract infection, respectively. The immunological suppression associated with aflatoxin and possibly DON could adversely affect all these outcomes. The modulating effect of aflatoxins in cases of zinc, iron, and vitamin A deficiency in human health is less clear, but evidence from animal nutrition would suggest it could be significant [1,10].

Types of mycotoxins that affects human health

Most mycotoxins currently known are grouped based on their toxic activity under chronic conditions, into mutagenic, carcinogenic, or teratogenic mycotoxins [11]. The effect of mycotoxins on human health can be influenced by age, sex, weight, diet, exposure to infectious agents, the number of toxins exposed, and the presence of other mycotoxins (synergistic effects) and pharmacologically active substances [12-14]. In humans, the degree to which disclosure of mycotoxins occurs will affect a young person or an infant to a greater degree than an adult. The quantity of exposure is a major determinant of the degree of toxicity to the consumer. However, the severity of poisoning by these toxins can be complicated by factors such as vitamin deficiency, low-calorie intake, alcohol abuse, and the presence of an infectious disease.

Aflatoxins

Aflatoxins are the most agriculturally important mycotoxins that originate from liver cancer and are implicated in child growth impairment. Acute toxicoses, fumonisins associated with Esophageal Cancer (EC) and Neural Tube Defects (NTDs), deoxynivalenol (DON), trichothecenes which are immunotoxic and cause gastroenteritis, and ochratoxin A (OTA), which cause renal diseases [15]. Aflatoxins are extremely toxic secondary metabolites of certain Aspergillus molds, such as *Aspergillus flavus*, *Aspergillus parasiticus*, and Aspergillus nomius [16]., which have been classified by the WHO as genotoxic and carcinogenic. When ingested, inhaled, or absorbed through the skin, aflatoxins have carcinogenic, hepatotoxic, teratogenic, and mutagenic effects on human health, even at very small concentrations [17]. According to Makun et al., AFB1 is the most potent mycotoxin and is known to be hepatotoxic and hepatocarcinogenic is the most potent mycotoxin and is known to be hepatotoxic and

hepatocarcinogenesis [18,19]. Generally, aflatoxins are a group of approximately 20 chemically related metabolites produced primarily by the food-borne fungi *Aspergillus flavus* and *A. parasiticus*. Aflatoxins contaminate a variety of staple foods, including maize, peanuts, and tree nuts, and cause an array of acute and chronic human health disorders. AFB1, the most toxic of the aflatoxins, is a potent liver carcinogen, causing Hepatocellular Carcinoma (HCC) in humans [20].

DISCUSSION

Hepatocellular carcinoma

For decades it has been known as aflatoxin exposure causes liver cancer in humans and numerous animal species [21]. Associated exposure to aflatoxin and the Hepatitis B Virus (HBV) is common in developing countries and greatly increases HCC risk [22]. Individuals with both exposures have a multiplicatively greater risk of developing HCC than those exposed to aflatoxin alone [23,24]. The incidence of HCC varies enormously worldwide; the encumbrance of this nearly always fatal disease is much higher in developing countries of Asia and sub-Saharan Africa [25].

Ochratoxins

Ochratoxins, produced by *Penicillium, Fusarium*, and *Aspergillus* species, are found naturally in various plant products such as cereals, coffee, beans, pulses, and dried fruits [26]. It has been found in rice and maize samples obtained from West Africa, specifically Nigeria [27]. Ochratoxin causes nephropathy in humans and is suspected to be the cause of Tunisian nephropathy and human Balkan Endemic Nephropathy (BEN) [28,29]. This mycotoxin is known for its teratogenic effect; it can cause an adverse effect on the fetus in the womb owing to its ability to cross the placenta and cause the malformation of the central nervous system and damage to the brain.

Mycotoxin control methods

Microbiological methods: Microbes and their enzymes can be applied for mycotoxin detoxification [30]. Several reports have described the OTA-degrading activities of the microbial flora of the mammalian gastrointestinal tract, including the rumen microbes of cows and sheep [31]. In addition, numerous other bacteria, protozoa, and fungi were shown to be able to degrade OTA. It has been ascertained that lactic acid bacteria, propionic acid bacteria, and *Bacillus* sp. can inhibit the growth of fungi and mycotoxin production [32,33]. Some enzymes, such as carboxypeptidase-A lipases from *Aspergillus niger*, and some commercial proteases have also been identified as capable of performing this reaction [34].

Chemical methods: Many chemicals have been found to be effective in the elimination of mycotoxins these include various acids, bases, salts, oxidizing agents, chlorinating/reducing agents, salts, and others, such as formaldehyde [35]. Ammoniation is a widely-known method that has received attention for the detoxification of aflatoxin or ochratoxin-contaminated feeds and has been used successfully in several countries [36]. It completely decomposes OTA in corn, wheat, and barley [37]. Ammoniation is used for mycotoxin detoxification in contaminated peanut, cotton, and maize meals. Alkaline hydrogen peroxide, sodium hydroxide, and monomethyl amine or ammoniums with calcium hydroxide treatments have also been found to be effective methods for OTA decontamination in this matrix. The control of fungi producing mycotoxin has been achieved by using plant extracts and essential oil (plant products) as fungicides. In stored grains, chemicals such as sodium bisulfite, ozone, and ammonia can be used to prevent the growth of fungi and the biosynthesis of mycotoxins [32].

Mechanical control: The deterrence of mycotoxin production in fungi from the field is typically considered the best approach to impede the harmful effects of mycotoxins on animals and human health. This can be attained by all-encompassing agricultural practices that involve crop rotation techniques such as cultivating and harvesting at the appropriate time and seasons/conditions, and the reduction of stress in the plants [30]. Inoculum sources that can produce mycotoxins when decaying, such as weeds or agricultural residues, should be minimized to avoid contamination. According to Merrill, et al., Chang et al. mechanical sorting implies that clean products are separated from moldy or infected products that may contain mycotoxins. Consequently, postharvest strategies aimed at

reducing fungal contamination. The improvement of drying and storage conditions, the use of chemical and natural agents, and irradiation [7].

Physical control: This involves thorough cleaning to remove general dirt and may also involve washing with Na_2CO_3 solution or water [32]. Research has shown that the exposure of food items to very high temperatures, of at least 150°C, which is above cooking temperature, can reduce the mycotoxin content of food [33]. Heat treatment is about 84% loss of mycotoxins in food exposed to high temperatures (approximately 150°C and above). The reduction of the moisture content of plants and seeds after harvest and during storage, the use of fungicides and preservatives against fungal growth, the prevention of insect infestation in stored products, as well as the removal of contaminated seeds. Furthermore, Whitlow, et al., and Bunaciu et al. suggested that insect-resistant seeds, which can resist insect damage and also fungal disease, must be planted as this will prevent the contamination of crops by mycotoxins while they are still in the field [38]. The use of accepted and standard methods for making silage cannot be overemphasized; they should be followed strictly to ensure the output of non-contaminated foods [4].

CONCLUSION

Mycotoxins are metabolites formed by fungi causing acute and chronic adverse effects in humans. The toxic outcome of mycotoxins on human health is referred to as mycotoxicoses, the harshness 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. Most mycotoxins currently known are grouped based on their toxic activity under chronic conditions, into mutagenic, carcinogenic, and teratogenic mycotoxins. There are numerous methods of prevention and control of mycotoxins such as microbiological control, and physical, chemical, and mechanical control strategies.

RECOMMENDATIONS

The study suggests the need for increased IPC training for healthcare workers, improved availability and accessibility of PPE, implementation of a robust needle stick injury reporting system, promotion of post exposure prophylaxis utilization, enhanced education on proper disposal of used needles, ensuring adequate disinfection of surfaces, provision of spill kits in wards/labs and comprehensive training in hospital waste management program for healthcare workers.

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AUTHOR'S CONTRIBUTION

Girma Waktola designed the review article concept, drafted the manuscript, and revised the literatures and write manuscript. The author provided valuable suggestions and approved the final version of the manuscript.

CONFLICT OF INTERESTS

The author declares that there is no conflict of interest with respect to the publication of this article.

AVAILABILITY OF DATA AND MATERIAL

All data supporting the result of this study are included in the article. The statement of this article was found in the article and is appended with the article from Excel as a supplement.

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