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Mycotoxins, a Major Challenge in Global Food Security

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The world's population has recently reached to more than 7.5 billion and it is estimated to surpass 9 billion by the year 2050 (Unep, 2013). Since the condition of food-producing ecosystems necessarily affects the human health populations, food supply limitations may directly impact both the quantity and quality of available food. Mycotoxins, as low-molecular-weight natural products of common filamentous toxic fungi, can contaminate a wide variety of human and animals' food (Bennett, 1987). Mycotoxins are a structurally diverse group of small molecular weight compounds produced by several fungal genera such as *Aspergillus*, *Penicillium*, *Fusarium*, *Alternaria*, *Chaetomium*, *Cladosporium*, *Claviceps*, *Diplodia*, *Myrothecium*, *Monascus*, *Phoma*, *Phomopsis*, *Pithomyces*, *Trichoderma*, and *Stachybotry* (Magan *et al.*, 2011, Nielsen *et al.*, 2006, Streit *et al.*, 2012).

Although these metabolites have no biochemical significance in fungal growth and development, they cause serious risks for human and animal health upon ingestion, inhalation, or skin contact (Stoev, 2013).

The term mycotoxin was coined in 1962 following an unusual veterinary crisis in London, England, where approximately 100,000 turkeys died. The cause of such casualties was known as a mysterious turkey X-disease until scientists found a link to turkeys' meal, which was contaminated with secondary metabolites from *Aspergillus flavus* (aflatoxins). This guided scientists to investigate the possibility of the threats caused by fungal metabolites (Allcroft and Carnaghan, 1962).

These toxins have caused a worldwide problem in various agricultural commodities. Fungal contamination occurs to products within pre-harvest period in the farm and continues to post-harvest processes, such as drying storing, and consuming (Streit *et al.*, 2012). Usually mycotoxins are the crucial problem in developing countries, as they are not entirely protected, while usually developed countries' infrastructures have well-designed monitoring for their food quality (Stoev, 2013). The

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disease resulting from exposure to mycotoxins may be manifested as acute, can progress to a chronic disease, and then result in rapid death in acute forms to tumor formation, immunosuppression, estrogenic, and generic disorders in chronic forms (Marin *et al.*, 2013). However, about 18,000 fungal metabolites have been determined since 1960s, but only a few of them attracted the scientific interest (Cole and Cox, 1981, Science, 2003). Aflatoxins (AF), ochratoxins (OT), trichothecenes, zearalenone (ZEN), fumonisins (F), and ergot alkaloids are defined as the most important examples for mycotoxins that have the greatest public health and agro-economic significance.

Aflatoxins are defined as the most prevalent and dangerous fungal toxins, as produced by common worldwide toxic fungal species of *Aspergillus* and *Penicillium.* However, several species of *Aspergillus* and *Penicillium* can produce aflatoxin, but *A. flavus*, *A. parsiticus*, *and P. puberulum* are known as the most prevalent producers of aflatoxins including aflatoxin B1 (AFB_1), B_2 (AFB_2), G_1 (AFG_1), and Aflatoxin G_2 (AFG_2). These toxins, particularly AFB_1, are determined as the most potent hepatocarcinogenic substances, which have been recently proven to also be genotoxic as well. In dairy cattle, another problem arises from the transformation of AFB_1 and AFB_2 into hydroxylated metabolites, known as aflatoxins M_1 and M_2 (AFM_1 and AFM_2), which are found in milk and milk products obtained from livestock that have ingested contaminated feed (Boudra *et al.*, 2007). In addition to aflatoxins, ochratoxin, trichothecenes, fumonisins, and zearalenone were also evaluated as the carcinogenic potential mycotoxins by the WHO-International Agency for Research on Cancer (WHO-IARC, 1993). Ochratoxins especially Ochratoxin A, as the toxic metabolite of *Aspergillus ochraceus* has also been shown to be hepatotoxic, teratogenic, immunotoxic, and carcinogenic in experimental models. Trichothecenes mainly produced by *Fusarium sp.* can cause neurotoxicity, immunosuppression, and renal toxicity (Richard, 2007).

Zearalenone is an esterogenic mycotoxin produced by several species of *Fusarium* in cereals, mainly in maize. This mycotoxin exhibited two different reactions in females and males; it caused precocious puberty in females and degrees of infertility in males with anabolic effects (Goertz *et al.*, 2010). Fumonisins are usually seen in contaminated maize and other cereal grains produced by *Fusarium verticilliodies* and *F. proliferatum* at high temperatures in humid climates that often co-occur with aflatoxins especially in corns (Sun *et al.*, 2011). This mycotoxin is nephrotoxic, hepatotoxic, and possibly human carcinogen (Alizadeh *et al.*, 2012, Humans *et al.*, 2002).

Ergot alkaloids that include several mycotoxins are produced by the fungus *Claviceps purpure* and cause ergotism. They are also named as St Anthony's fire, which is known as one of the oldest food-borne diseases in human beings. Ergotism caused hallucinatory symptoms and death of many people in France and other European countries during the middle ages (Betina, 1989).

Despite the widely neglected problem of mycotoxins, the Food and Agriculture Organization of the United Nations (FAO) estimated that approximately 25% of worldwide crops and cereals are contaminated by molds and affected with mycotoxins (Rice and Ross, 1994). So, in the present global environment, mycotoxicosis and contamination of human and animal foods with mycotoxins are still unavoidable especially in developing countries such as Iran. Therefore, this is a crucial responsibility for health authorities to train the public and design strategies that allow us to cope with this burden of mycotoxins in order to improve peoples' food security.

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