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Review

Mycotoxin occurrence in grains and the role of postharvest management as a mitigation strategies. A review

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ABSTRACT

Mycotoxins are poisonous compounds produced by certain species of fungi found in contaminated grain. There are five major groups of mycotoxins which can occur in grains: Aflatoxin, fumonisin, deoxynivalenol (DON), ochratoxin (OT), and zearalenone (ZEN). Their occurrence may start in the field, harvesting, handling, storage, and processing. DON, ZEN, and fumonisins may start to cause the grains at the field/or pre-harvest while aflatoxin and OT are mostly occurring during storage due to improper postharvest handling. Most of the grains susceptible to mycotoxins such as maize, peanut/groundnut, sorghum, millet, wheat, and rice were reviewed. The main postharvest factors for the cause of grain mycotoxin contamination are mechanical injury, insect infestation, time of harvesting, drying method, types of storage structure and conditions, handling and processing. Temperature, moisture and humidity are the main factors for the growth and development of mycotoxins. Developing countries especially African are more vulnerable for the causes due to lack of well-established infrastructures, regulations, and standards. Postharvest mitigation strategies are an important and cost-effective method to control the cause. The core grain postharvest interventions used as mitigating strategies of mycotoxin includes rapid and proper drying, postharvest insect control, proper transportation and packaging, good storage conditions, use of natural and chemical agents and irradiation. Grain processing such as sorting, cleaning, milling, fermentation, baking, roasting, flaking, nixtamalization and extrusion cooking are also reported to reduce mycotoxin concentration. In general, system approach to good manufacturing practice and HACCP based implementation are important to mitigate mycotoxins in grains.

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1. Introduction

Under certain environmental conditions, some fungal species that can infect grains, produce toxic byproducts called mycotoxins (Benbrook, 2005). Mycotoxins are poisonous compounds produced by certain species of fungi found in contaminated grain. Fungal infection and production of mycotoxins may start in the field, at harvesting, handling, storage, and processing. Critical factors for fungal postharvest infection and subsequent synthesis of mycotoxins include initial grain moisture content, timeliness of harvest, length of wet holding before drying, the amount of grain and foreign materials, the amount of grain dust, the type and quality of storage structures, grain temperature, the interstitial air relative humidity, headspace condensation, bulk grain moisture movement, and insect infestation (Channaiah & Maier, 2014).

The condition of grains especially during storage are the main factors for the growth of mycotoxins. Especially, the conditions like moisture and temperature are critical factors for determining the safety of stored grain. The main factors that favor fungal growth and mycotoxin biosynthesis in stored grain are high grain moisture (16–30%), warm grain temperature (25–32 °C), and high air RH (80–100%) (Shanahan, Brown, & Blunt, 2003).

Viewed globally, food safety is regularly compromised by the presence of mycotoxins occurring in grains (D'Mello, 2003). Mycotoxin problems in agricultural commodities confronting the food industry, scientists, and governments in both the developed and developing the world (Benbrook, 2005). There is a huge economic impact of mycotoxin infection in the world. Some of it may include loss of human and animal health and life, increased healthcare costs, reduced livestock production, disposal costs of contaminated foods and feeds, pre- and postharvest losses in crops, research investment, and regulatory programs aimed at reducing or excluding mycotoxins from end products (Zain, 2011).

Postharvest losses due to mycotoxins are an emerging issue of the globe where especially it is significantly influencing African countries. Worldwide, approximately 25% of food crops are affected by mycotoxins causing a loss of nearly 1 billion tons of foodstuff per year (Bryden, 2007; Channaiah, 2011). International Agency for Research on Cancer (IARC) reported an estimated 500 million of the poorest people in sub-Saharan Africa, Latin America, and Asia are exposed to mycotoxins at levels that substantially increase mortality and morbidity (Pitt et al., 2012; Wild, Miller, & Groopman, 2015, p. 9). Most developing countries are in the world's tropical zones and are subjected to monsoons and high temperature and humidity levels, which contribute to large postharvest crop losses (Wild et al., 2015, p. 9). So, effective mitigation strategies are vital for the world to control the huge effect of mycotoxins.

A lot of research are focusing on the mitigation strategies of mycotoxin due to their severity on human health risks (Bullerman & Bianchini, 2014; Jans, Pedrosa, Schatzmayr, Bertin, & Grenier, 2014; Munkvold, 2003, 2014; Ochieng, Okun, Runo, Njagi, & Murage, 2013; Wild et al., 2015, p. 9). It is the aim and need of every country to enhance the control strategy of food quality and safety. Control strategies are being developed around attempts to influence some of these conditions through the management of agricultural practices prior to and at harvest (Richard et al., 2003). Multidisciplinary integration of know-how and technology is required to address the broad requirements for reducing mycotoxins in agro-food chains (Logrieco & Visconti, 2014). Cost effective and safe treatment techniques to control mycotoxins entering the food chain are important. There are pre- and postharvest mitigation strategies of mycotoxin in grains. Postharvest management has a significant role in mitigation of mycotoxins through good management in grain food chains during harvesting, cleaning, drying, storage, and processing. Sanitation, screening, aeration and monitoring of stored grain are important good management practices during grain storage.

Control of moisture, temperature, and humidity to safe storage level is a key to mitigating mycotoxin in grains. Good postharvest and processing techniques and strategies to control mycotoxins begin with harvesting at grain moisture levels low enough to prevent fungal growth, or drying to such levels (Bullerman & Bianchini, 2014). Effective implementation of good manufacturing practices in grain elevators and hazard analysis at critical control points (HACCP) will reduce levels of mycotoxins in the food supply chain (Channaiah, 2011).

Research efforts to mitigate mycotoxin contamination in grain are focusing on breeding and genetic engineering for crop resistance, manipulation of agronomic practices, the use of biological control and proper postharvest management. Of these postharvest management options is perhaps the most promising and cost-effective method for management of mycotoxin contamination in grains. So, the aim is to review the common type of mycotoxins affecting grains, their occurrence and role of postharvest management as a mitigation strategy.

2. Mycotoxins and their occurrence in grains

Over 300 species of fungi produce byproducts called mycotoxins. Mycotoxins are a diverse and ubiquitous group of fungal compounds specifically associated with the precipitation of deleterious effects in humans and animals (D'Mello, 2003). They are toxic secondary metabolites produced by fungi that commonly called mold. The mycotoxins of major concern for human health are produced by three main genera of fungi: *Aspergillus* (produces aflatoxins and OTA), *Fusarium* (produces fumonisins, ZEN, and