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Mycotoxins contamination in maize alarms food safety in sub-Sahara Africa

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ABSTRACT

Maize is a major staple food in sub-Sahara Africa. Maize grains are susceptible to mycotoxin contamination during production and storage. Tropical weather, poor agricultural practices, poor storage conditions and little knowledge on mycotoxins exposes sub-Sahara Africa (SSA) community at high risk of mycotoxin. Studies in SSA demonstrated that, maize grains are infested by toxigenic fungi and contaminated with mycotoxins to varying degree. Mycotoxins frequent occurring in maize include; aflatoxins, deoxynivalenol, fumonisins, ochratoxins and zearalenone. Their effect can be acute and/or chronic leading to health problems such as; liver cancer, immunosuppression, irritation, and respiratory problem among others. Local practices, maize seems to be less contaminated are used for human consumption while those unfit for human are used as feeds exposing human health at high risk of mycotoxins toxicity. It is important for sub-Sahara Africa countries to invest in infrastructures and enforce practices which leads to prevention and control of mycotoxins in maize before they become real risks. Also, interventions on public awareness on the effect of mycotoxins to human health should be promoted to guarantee safe maize and maize products. In this review, mycotoxins occurrence, incidences, prevention, control, decontamination and inactivation in maize are scrutinized and presented.

Contents

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1. Introduction

Maize is consumed as human food and small proportion used as animal feed in sub-Sahara Africa (SSA) (Baffes, Kshirsagar, & Mitchell, 2017; Ranum, Peña-Rosas, & Garcia-Casal, 2014). However, maize grains are highly susceptible to mycotoxigenic fungi contamination both in the field and during postharvest handling, processing and storage (Geary et al., 2016). Mycotoxins are secondary toxic fungal metabolic which can contaminate crops throughout the food chain (Ezekiel et al., 2014). They are of diverse chemical structure, varied toxicity and stable to most of food processing methods (Probst, Bandyopadhyay, & Cotty, 2014; Temba, Njobeh, & Kayitesi, 2017). As the consequence, mycotoxins are carried over in the food and feed chain. *Aspergillus, Fusarium* and *Penicillium* are among fungal strains commonly reported to colonize maize and maize products (Wu, Groopman, & Pestka, 2014). Their corresponding mycotoxins are; aflatoxins, fumonisins, zearalenone, deoxynivalenol and ochratoxins frequently identified in maize (Udomkun et al., 2017). Their toxic effect can be acute or chronic. Acute toxicity is indicated with fever, vomiting, abdominal pain, portal hypertension and death (Ostry, Malir, Toman, & Grosse, 2017). Teratogenicity, carcinogenicity, immune-toxicity, cancer incidences, liver cirrhosis, kidney failure and stunted growth are some of conditions associated with chronic mycotoxins exposure (Kimanya, 2015; Ostry et al., 2017). Furthermore, mycotoxins are the third most cause of death from cancer in SSA (Kimanya, 2015). Children, women and elderly are at high risk as most of their food such as porridge are maize based (Magoha et al., 2016).

Broad effect of mycotoxins, necessitates protection of maize and maize products from toxigenic fungi along the value chain. Fungal growth and mycotoxins accumulation are accelerated by several factors such as temperature, substrate, water activity, humidity, pH and time (Bankole, Schollenberger, & Drochner, 2006). Humidity and temperature are critical factors for fungi growth and mycotoxins production in maize during drying, processing and storage (Kachapulula, Akello, Bandyopadhyay, & Cotty, 2017). Tropical region such as SSA, are highly affected due to extreme temperatures and humidity favorable for mold to synthesize mycotoxins in maize (Bandyopadhyay et al., 2016; Ochungo et al., 2016).

Globally, about 25% of maize and maize based products were reported to be contaminated with mycotoxins at different levels, making mycotoxins a worldwide food safety and public health problem (Chilaka, De Boevre, Atanda, & De Saeger, 2017). The status in SSA is enormously huge contributing to 90% of the global incidences (Wu et al., 2014). For instance; in Kenya in 2004, 2005 and 2007 acute toxicity and fatality were reported following consumption of contaminated maize (Bandyopadhyay et al., 2016). Additionally, millions of hepatocellular carcinoma and cancer death incidences in SSA occur annually, mostly attributed to mycotoxins contamination in maize (Kimanya, 2015; Wild & Gong, 2010).

Therefore, this review puts together facts on mycotoxins occurrence, exposure, associated health risks and their implication to food safety in SSA. Also, examines different initiatives and options to prevent and control mycotoxins in maize.

2. Types of mycotoxins

Aflatoxins, deoxynivalenol, fumonisins, ochratoxins and zearalenone are most important mycotoxins due to their toxicity, economic importance and the frequencies at which they occur in maize (Misihairabgwi, Ezekiel, Sulyok, Shephard, & Krska, 2017).

2.1. Aflatoxins

Aflatoxins are highly toxic and carcinogenic mycotoxins produced by *Aspergillus* fungal strains. They are classified as group 1 carcinogens by the International Agency for Research on Cancer (IARC) (Ostry et al., 2017). *Aspergillus flavus* and *A. parasticus* are important mold associated with aflatoxins production in maize (Kachapulula et al., 2017). There are four main types of aflatoxins; aflatoxin B1 (AFB1), aflatoxin B2 (AFB2), aflatoxin G1 (AFG1) and aflatoxin G2 (AFG2) (MdQuadri, Niranjan, Chaluvaraju, Shantaram, & Enamul, 2017). The most frequent occurring and highly carcinogenic is aflatoxin B1. Also, aflatoxin can be hydrated and converted into toxic metabolites in animal and animal products. For instance, aflatoxin M1 and M2 are corresponding hydroxylated metabolite of AFB1 and AFB2, reported in milk and milk products from cattle fed with contaminated feeds (Popovic, Radovanov, & Dunn, 2017).

Headache, vomiting, pulmonary edema, liver failure and even death are among the acute aflatoxins toxicity effect (Yard et al., 2013). Chronic toxicity is indicated with carcinogenicity, immune suppression, teratogenicity, hepatotoxicity and stunting (Kang et al., 2015; Shirima et al., 2015). For instance, liver cancer incidences in most part of SSA have been associated with aflatoxin exposure (Kimanya, 2015; Wild & Gong, 2010). The chronic incidence of aflatoxin exposure is evidenced from human breast milk and umbilical cord blood sampled in Kenya, Nigeria, Sierra Leone, Ghana and Sudan (Udomkun et al., 2017). Also, aflatoxin has been associated with impaired nutrient utilization hence suggested as the causal factor for stunting in most of SSA countries (Smith, Stoltzfus, & Prendergast, 2012).

2.2. Deoxynivalenol

Deoxynivalenol (DON) is reported to influence decreased growth and feed intake in pigs and other monogastric animals (Beukes, Rose, Shephard, Flett, & Viljoen, 2017). Human exposure to DON has been associated with nausea, vomiting, gastrointestinal inflammation and diarrhea (Wu, Kuča, Humpf, Klímová, & Cramer, 2017). DON can persist in eggs, meat and milk after poultry and animal have been fed with DON contaminated feeds (Wang, Wu, Kuča, Dohnal, & Tian, 2014). Also, deoxynivalenol exhibit immunomodulating effects in human (Wu et al., 2017). The most important DON producing fungi are *Fusarium graminearum* and *F. culmorum* (Malachová et al., 2015). Maize, wheat, oat and barley are the crops mostly contaminated with DON (Jovana Kos et al., 2017).

2.3. Fumonisins

Fumonisins are produced by several *Fusarium* species (Beukes