PERSPECTIVE

A summary of current cutting-edge methods for reducing mycotoxins in food

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ABSTRACT

Food safety and quality are seriously threatened by mycotoxin contamination from mycotoxigenic fungi such Aspergillus, Alternaria, Fusarium, and Penicillium species. It has been shown that the immunological toxicity, carcinogenicity, nephrotoxicity, hepatotoxicity, neurotoxicity, and teratogenicity activities of the aflatoxins, ochratoxins, fumonisins, deoxynivalenol, zearalenone, trichothecenes, and patulin in humans and animals. While standard chemical, biological, and physical approaches can be used for detoxification after contamination, the implementation of precursor programmes such HACCP-based protocols can reduce mycotoxin contamination. However, the constraints and growing fungal resistance associated with conventional methods force the development of novel approaches for quick eradication with minimal processing time and impact on quality. This review assessed recent novel approaches for reducing mycotoxin in foods, including Cold Atmospheric Plasma (CAP), polyphenols and flavonoids, magnetic materials and nanoparticles, and Natural Essential Oils (NEOs). Although the existing data suggested that these techniques had a bright future, full decontamination was not accomplished. The disruption of the fungal cell membrane, zthe structural degradation of complex biochemical molecules by the oxidative effects of reactive species, the inhibition of enzymes that break down carbohydrates, and the adsorption and binding of functional groups of mycotoxins in food substrate were some of the mechanisms for the reduced bioactivity of mycotoxins. To increase efficiency and improve flexibility to various food matrices, integrated management systems that include numerous strategies might be investigated. To ensure widespread adoption and economically viable commercialization of sustainable food processing, more research on the toxicity of food matrices, degraded products, and industrial up-scaling is required.

Key Words: *Food safety; Mycotoxin contamination; Neurotoxicity, Immunological toxicity; Detoxification`*

INTRODUCTION

Due to their negative effects, mycotoxins are a major global concern and a major challenge to food safety. Their prevalence in food crops is estimated to be between 60% and 80%, and there are reports of annual financial losses of over USD 932 million due to agricultural products contaminated with mycotoxins worldwide. These mycotoxigenic fungus, like *Aspergillus, Alternaria, Fusarium*, and *Penicillium* species, produce low molecular weight toxic metabolites that contaminate a variety of food and feed categories before, after, and during the food's storage management chain. The negative effects of mycotoxicosis from mycotoxin poisoning in humans can include necrosis, hepatitis, haemorrhage, gynecomastia with testicular atrophy, neurological diseases, cancer, and, in severe cases, death. Over 400 mycotoxins have been classified as toxic. Similarly, mycotoxin-contaminated animal feedstuff can result in decreased availability of feed ingredients, chronic illnesses, harm to animals' health, eventual death, and decreased productivity. Aflatoxin (AF) and ochratoxin are the two mycotoxins that are the most dangerous (OT) While OTA with hepatotoxic and nephrotoxic effects is primarily found in cereals, coffee, wine, grape juice, and dried fruits, AFB1 is a strong hepatocarcinogenic mycotoxin that is mostly detected in cereals, nuts, grains, and feeds. Additionally, AFB1 and AFB2 can be converted into hydroxylated AFM1 and AFM2 in lactating cattle after ingestion via contaminated feedstuff. As a result, there is a critical need for proper strategies and methods to decrease and/or completely eradicate the occurrence of mycotoxins in food. Environmental, agronomic, and socioeconomic factors can increase the risk of food contamination by mycotoxins, but food safety can be controlled by monitoring at all stages and implementing appropriate processing conditions to reduce mycotoxigenic fungi and, as a result, control the presence of mycotoxins in food products. The traditional approaches—physical, chemical, and biological ones—are demonstrated with the help of literature that reviews the mechanisms, benefits, and applicability of these approaches. The majority of these methods may cause significant changes in the food substrate, such as colour, flavour, texture, and nutritional content,

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such as lipid oxidation, vitamin breakdown, and depolymerization and re-polymerization of polysaccharides, even though they can reduce fungi and mycotoxin contamination to safe levels. Additionally, most mycotoxins are chemically and thermally stable throughout standard food processing. As a result, there is growing interest in novel methods that don't need direct heat applications and which will reduce the amount of mycotoxin in foods while also enhancing their organoleptic quality. Infected cereals, cereal-based goods, and food made from animals exposed to mycotoxins are the most prevalent sources of exposure for people to mycotoxins, which can grow on a wide variety of agricultural and food products. Along the food management chain, contamination can happen at any point from pre-harvest to post-harvest, and the presence of fungi does not guarantee the presence of mycotoxins because the conditions under which mycotoxins are produced are distinct from those for fungal development. One strategy that has been suggested as a potential means of influencing or preventing the production of mycotoxin in agricultural products and foods is the Food Safety Management System (FSMS), which is a system of readiness, checks, and prevention for managing food hygiene and safety in food businesses. The FSMS is typically comprised of procedures and management policies based on Good Hygiene Practices (GHP), Good Agricultural Practices (GAP), Good Storage Practises (GSP), Good Manufacturing Practices (GMP), hazard analysis, and Critical Control Point (CCP) in order to control the food production process and environment and ensure the safety of the finished products for consumption (HACCP). Since the HACCP system ensures the achievement of good practices in the field, storage, sorting, monitoring, and segregation stages with improvement measures, it can play a critical role in mycotoxin inhibition and control. The stages for monitoring systems and processes in processing where mycotoxins can be avoided or eliminated are identified in a thorough manual on the implementation of the HACCP system for controlling and avoiding mycotoxin generation. The most significant pre-harvest practises that can affect/control mycotoxin production, according to a recent study on mycotoxin hazard analysis, are planting and intercropping, applying botanical extracts and fungal biocontrol agents, and preparing the land (through tillage, crop rotation, and cover cropping). Important postharvest operations also included intervention therapies, including cold plasma, UV light, and ozone. However, local peculiarities and climate conditions may have an impact on these activities. Mycotoxins develop and intensify differently depending on the climate, changes in the micro ecosystem, and moisture of the surrounding environment. For instance, the optimal temperature range for the growth of fungi and the formation of mycotoxins is between 5°C and 40°C, with an optimal value at 25° C. This temperature range is regulated by the strains, species, growth conditions, and postharvest temperature. Although mycotoxins have been observed to withstand cooking up to 110°C for 20 min., higher temperatures prevent fungal growth and the formation of mycotoxins due to disruption to the gene expression profile. In general, fungi are aerobic. However, some, like yeasts, can be facultative anaerobic organisms, which means that greater CO_2 levels have no effect on their biomass. Mycotoxins are produced in an acidic environment with a pH range of 4–4.5, whereas alkaline circumstances inhibit the growth of fungi and the release of mycotoxins. While mycotoxin formation is restricted at water activities below 0.93, numerous mould kinds can flourish there between 0.87 and 0.99. Extremely wet spells and showers just before harvest have reportedly had an impact on the levels of mycotoxins in wheat and aflatoxin release in corn. Contrary to tropical environments, which are unfavourable for fungal growth and the formation of mycotoxin, agricultural goods in subtropical and temperate regions are typically more prone to contamination by mycotoxin. Additionally, drying cereals after harvest reduces the moisture content, which prevents the growth of fungi and the creation of mycotoxins. Drying at temperatures below 42°C has been advised.