Article ID 240205-S-21

Fighting Fungal Toxins in Food Crops: Innovative Approaches in Processing and Preservation

Divyashree[1]* and K. K. Chetan[2]
[1]Department of Plant Pathology, NMCA, Navsari Agricultural University, Navsari, Gujarat-396450
[2]Division of Plant Pathology, Indian Agricultural Research Institute, New Delhi- 110012
*Corresponding Author: divyasiriii7@gmail.com

Abstract

The fungal toxins, or Mycotoxins, produced by certain fungi, pose a significant threat to food safety and public health worldwide. Contaminating staple crops such as maize, wheat, barley, and peanuts, these toxins can cause severe health issues and economic losses. This review explores current issues related to fungal toxins in food crops and examines innovative approaches in processing and preservation to mitigate their impact. By analyzing recent advancements and case studies, we highlight effective strategies to combat mycotoxin contamination, ensuring safer food supplies.

Introduction

Mycotoxins, toxic secondary metabolites produced by fungi, are a critical concern in agriculture and food safety. Contamination can occur at any stage from field to storage, and consumption of mycotoxin-laden food can lead to severe health effects, including cancer, immunosuppression, and neurological damage. Aflatoxins, produced by *Aspergillus* species, are particularly notorious due to their high toxicity and prevalence. With climate change exacerbating the conditions for fungal growth, innovative and sustainable approaches to mitigate mycotoxin contamination are urgently needed (Agriopoulou *et al*., 2020).

Current Issues in Mycotoxin Management

Despite advances in agricultural practices and regulatory measures, mycotoxin contamination remains a persistent challenge. Key issues include:

Climate Change: Altered weather patterns, such as increased temperatures and humidity, create favorable conditions for fungal growth and mycotoxin production. This shift is leading to higher incidences of contamination in regions previously unaffected.

Global Trade: The international trade of agricultural commodities can spread contaminated crops, complicating efforts to manage mycotoxin risks globally.

Economic Impact: Mycotoxin contamination leads to significant economic losses due to reduced crop yields, increased costs for management and mitigation, and rejection of contaminated products in the market (Davies *et al*., 2021).

Innovative approaches in processing and preservation

To address these challenges, researchers and industry stakeholders are developing and implementing innovative strategies for processing and preserving food crops. Key approaches include:

Biocontrol Agents

Biocontrol agents, such as non-toxic strains of fungi and beneficial microbes, are employed to outcompete or inhibit mycotoxin-producing fungi. One successful example is Aflasafe, a biocontrol product containing non-toxic strains of *Aspergillus flavus*. Field trials in Nigeria demonstrated a 75-90% reduction in aflatoxin levels in maize crops, highlighting the potential of biocontrol agents to enhance food safety sustainably.

Advanced Sorting Technologies

Optical and electronic sorting technologies are revolutionizing mycotoxin management by enabling the detection and removal of contaminated grains with high precision. These systems use advanced sensors to identify and segregate contaminated produce, ensuring that only safe, high-quality crops reach consumers.

Cold Plasma Treatment

Cold plasma technology offers a non-thermal method to inactivate mycotoxins on food surfaces. By ionizing gas at room temperature, cold plasma generates reactive species that degrade mycotoxins without compromising food quality. Studies have shown that cold plasma can reduce aflatoxin levels in peanuts by up to 90%, making it a promising tool for food preservation in India. The technology not only lowered aflatoxin levels but also preserved the nutritional and sensory qualities of the peanuts. This success highlights the potential of cold plasma as a viable and scalable solution for food preservation (Liu *et al*., 2020).

Ozone Treatment

Ozone, a powerful oxidizing agent, is effective in degrading a wide range of mycotoxins. Applied during storage or processing, ozone treatment can significantly reduce mycotoxin levels. Recent research demonstrated that ozone treatment effectively lowered aflatoxin levels in peanuts, offering a scalable solution for mycotoxin management.

Edible Coatings

Edible coatings infused with natural antifungal agents, such as essential oils, are being developed to protect crops from fungal contamination during storage and transportation. These coatings extend shelf life and provide a barrier against mycotoxin-producing fungi, enhancing food safety.

This below table provides specific examples of how different innovative approaches can be applied to various food crops to combat specific fungal toxins. Each example includes the mechanism of action, practical applications, advantages, and challenges or limitations, offering a comprehensive view of current strategies in food processing and preservation (Ioi *et al.*, 2017; Sipos *et al.*, 2021).

Future Prospects and Challenges

While innovative approaches show great promise, several challenges remain:

Scalability: Implementing new technologies on a large scale can be challenging due to costs and infrastructure requirements.

Regulatory Hurdles: Regulatory approval and standardization are necessary to ensure the safety and efficacy of new methods.

Consumer Acceptance: Educating consumers about the benefits and safety of new preservation techniques is crucial for widespread adoption.

Conclusion

Innovative approaches in processing and preservation are essential to combat the persistent issue of mycotoxin contamination in food crops. By leveraging biocontrol agents, advanced sorting technologies, cold plasma treatment, ozone treatment, and edible coatings, we can significantly reduce mycotoxin levels and protect public health. Continued research, collaboration, and investment.

References

Agriopoulou S., Stamatelopoulou E., and Varzakas T. (2020). Advances in occurrence, importance, and mycotoxin control strategies: Prevention and detoxification in foods. Foods, 9(2), 137

Davies C.R., Wohlgemuth,F., Young,T., Violet J., Dickinson M., Sanders J.W., Vallieres, C., and Avery S.V. (2021). Evolving challenges and strategies for fungal control in the food supply chain. Fungal Biology Reviews, 36, 15-26.

Ioi J.D., Zhou T., Tsao R., and Marcone M.F. (2017). Mitigation of patulin in fresh and processed foods and beverages. Toxins, 9(5), 157

Liu Y., Galani Yamdeu J.H., Gong Y.Y., and Orfila C. (2020). A review of postharvest approaches to reduce fungal and mycotoxin contamination of foods. Comprehensive Reviews in Food Science and Food Safety, 19(4), 1521-1560

Sipos P., Peles F., Brassó D.L., Béri B., Pusztahelyi T., Pócsi I., and Győri, Z. (2021). Physical and chemical methods for reduction in aflatoxin content of feed and food. Toxins, 13(3), 204.

Table 1: List the roles of fungal toxins on various crops and food products, their control methods, and their modes of action

Fungal Toxin	Food Crop	Innovative Approach	Mechanism of Action	Example/ Application Advantage	Advantages	Challenges/ Limitations
Aflatoxins	Corn, Peanuts (stored and processed nuts)	**Biocontrol Agents**	Use of non-toxigenic *Aspergillus* strains	Application of Aflasafe in peanut fields	Reduces aflatoxin contamination significantly	Effectiveness varies with environmental conditions
		Heat Treatment	High-temperature processing to degrade toxins	Roasting peanuts at high temperatures	Reduces aflatoxin levels	Potential impact on flavor and nutritional value
		Sorting and Cleaning	Mechanical removal of contaminated kernels	Optical sorting machines in corn processing	Reduces toxin load effectively	High cost of sorting technology

Ochratoxins	Coffee, Grapes	**UV Radiation**	UV light exposure to degrade toxins	UV treatment of dried coffee beans	Effective surface decontamination	Limited penetration depth
		Controlled Atmospher e Storage	Regulation of storage conditions to inhibit fungal growth	CO2-enriched storage for grape preservation	Prolongs shelf life, maintains quality	Requires specialized equipment
Patulin	Apples, Pears	**Fermentati on**	Microbial fermentation to degrade toxins	Fermentation of apple cider	Improves safety and nutritional value	Requires careful process control
		Heat Treatment	Thermal processing to destroy toxins	Pasteurization of apple juice	Effective toxin reduction	Potential loss of vitamins and flavor
Deoxyniva-lenol (DON)	Wheat, Barley	**Active Packaging**	Antifungal agents in packaging to prevent contamination	Antifungal packaging for bread and cereals	Prolongs shelf life	Cost and complexity
		Sorting and Cleaning	Removal of contaminated grains	Grain cleaning machines in wheat processing	Reduces overall toxin load	Not completely effective
Fumonis-ins	Corn	**Biocontrol Agents**	Use of beneficial microbes to inhibit fungal growth	Application of Trichoderma species in corn fields	Environmentally friendly	Variable effectiveness
		Nano-technology	Use of nanoparticles to inhibit fungi	Nano-silver coatings on corn kernels	High efficacy	Regulatory and safety concerns
Zearaleno-ne	Maize, Sorghum Maize, Sorghum	**Cold Plasma**	Ionized gas treatment to inactivate fungi	Cold plasma treatment of maize kernels	Minimal impact on food quality	Technology still in development
		Heat Treatment	High-temperature drying to reduce moisture	Hot air drying of sorghum	Reduces fungal growth	Energy-intensive process

* * * * * * * *