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Aflatoxins control during pre and postharvest stages in commercial pistachio production

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ABSTRACT

A stable supply of agricultural products and food safety are among the most important national strategic priorities. Pistachios make a significant contribution to the export of agricultural products in Iran. However, contamination by *Aspergillus* species and mycotoxins hinders pistachio production, consumption, and export. Making policies and decisions regarding new technologies to control aflatoxins (AFs) production is crucial. Good agricultural practices can reduce sensitivity to AFs by strengthening the defense system and reducing stress. Orchard management strategies, physical isolation and moisture control, thermal and nonthermal treatment, essential oils and edible coating have been employed to control fungi and inhibit AFs production. Currently, biological control is considered an eco-friendly and safe method. This review offers efficient solutions to reduce the spread of AFs in both pre and post-harvest stages.

1. Introduction

Pistachios are native to the Middle East, with wild pistachio forests still in dry regions of northeastern Iran, southern Turkmenistan, and Afghanistan (Khezri et al., 2020). Currently, Iran and the United States are the world's top two producing and exporting countries (Iran Pistachio Association, 2016; FAOSTAT, 2020). The global tree nuts market was valued at $88.8 billion in 2020, projected to reach $103 billion by 2027 (Chen and Pan, 2022). Pistachio nuts are among the commodities most at risk for AFs contamination (Dini et al., 2022). Developed countries tend to have stricter standards for AFs in the pistachio market, while less developed countries often have more lenient regulations. However, the European Commission Regulation No. 2023/915 has established a maximum level of 4 mg/kg for the sum of AFB1, AFB2, AFG1, and AFG2, and 2 mg/kg for AFB1 alone in nuts (European Commission, 2023). The Codex Alimentarius sets a level of 15 μg of total aflatoxin/kg for pistachios meant for further processing and 10 μg total aflatoxin/kg for ready-to-eat pistachios (Codex Alimentarius, 2022). In Iran, the average total aflatoxin and AFB1 concentration in pistachios was 31.42 and 39.44 μg/kg, respectively (Ebrahimi et al., 2022). Therefore, control measures are necessary to prevent AFs contamination throughout the production, storage, transportation, and marketing chain.

AF-producing fungi are complex communities composed of diverse species and genotypes (Cotty et al., 2008). The toxigenicity of *Aspergillus* foodborne pathogens belongs to the Flavi section in several agricultural products. *Aspergillus flavus* and *A. parasiticus* are the most toxigenic strains of AFs (Perrone and Gallo, 2017; Kumar et al., 2021). *A. flavus* is the most common AF-producing fungus (Frisvad et al., 2019). AFs B1, B2, G1, G2 have been identified in pistachios (Aydin and Ulvi, 2019; Abdallah et al., 2020). One of the main problems with mycotoxins produced by filamentous fungi such as *Aspergillus* is their high stability and heat resistance, with a melting point above 250 °C and wide pH range tolerance. Additionally, mycotoxins have undetectable sensory characteristics and do not change organoleptic properties (Winter and Pereg, 2019; Babaee et al., 2022). Therefore, mycotoxin contamination poses a threat to the global economy and food security.

AF contamination is influenced by various factors, including variety, agroecology, pre-harvest, and post-harvest conditions (Mutegi et al., 2009). The distribution and abundance of *Aspergillus* species/genotypes vary depending on the region and type of crop, and the potential for AF production differs among areas (Cotty et al., 2008). Therefore, AFs contamination may depend on how fungi interact in a particular agroecosystem (Singh and Cotty, 2019). It appears that crop-related genotypes with high AFs production potential play a significant role in AFs contamination and are important etiological factors. Genotypically and

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