Isolation and Screening of Chilli Pepper for Fungal Contamination and Aflatoxin Production

Sasireka Rajendran¹, Ganapathy Shunmugam¹*, Paranidharan Vaikuntavasen², Jeevanand Palanisamy³ and Srinivasan Subbiah⁴

¹Department of Food Process Engineering, Agricultural Engineering College and Research Institute, Tamil Nadu Agricultural University, Coimbatore, India.
²Department of Plant Pathology, Tamil Nadu Agricultural University, Coimbatore, India.
³Agro Climate Research Centre, Tamil Nadu Agricultural University, Coimbatore, India.
⁴Regional Research Station, Tamil Nadu Agricultural University, Virudhunagar, India.

Authors’ contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJPSS/2021/v33i930462

Received 05 March 2021
Accepted 11 May 2021
Published 12 May 2021

ABSTRACT

Improper postharvest management of red chili pepper results in the invasion of Aspergillus spp. It is the most common pathogen that infects chili resulting in the production of aflatoxin - the most potent biological toxin. The present study was aimed to study the occurrence of naturally occurring fungal pathogens in the commercially available chilli pepper in India. About twenty samples were collected from retail stores and commercial markers of Tamil Nadu, India. Isolation and purification of the naturally occurring fungal pathogens were carried out using a potato dextrose agar medium. Results showed that the samples were contaminated with Aspergillus flavus, A. parasiticus, and A. niger. Scanning electron microscopy (SEM) was done to morphologically confirm the pathogens. SEM analysis also showed the internal structural damage caused by the pathogens. Followed by the isolation, all the samples that contained A. flavus were tested for aflatoxin production using the thin layer chromatography (TLC) method. It was found that a total of 16 chilli samples were tested positive for aflatoxin production. It could be seen that the tropical climatic conditions of India increased the probability of aflatoxin production in the chilli pepper.

*Corresponding author: E-mail: ganapathy.s@tnau.ac.in;
Keywords: Chilli pepper; fungal contamination; Aspergillus spp.; TLC; aflatoxin.

1. INTRODUCTION

Chilli is one of the most commonly consumed spices in the world, known for its pungency, anti-inflammatory and anti-bacterial properties. India is the leading country in the production of chillies contributing 41.11% of the world’s production with around 55.11% of the total vegetable cultivated area. India is also the largest consumer and exporter of dry Chilli. About 20% of produced vegetables are lost due to spoilage by pathogenic contamination [1]. Common pathogens that cause spoilage of harvested chilli are Aspergillus flavus, A. parasiticus and A. niger. Among these mentioned pathogens, A. flavus is the commonly occurring pathogen in chilli pepper that has the tendency to produce secondary metabolites called aflatoxins. The aflatoxins are the most potent naturally occurring mycotoxins and are a huge health concern due to their high toxicity as manifested by their lowest tolerable daily intake (TDI) compared with that of other known mycotoxins [2].

Aflatoxin production by Aspergillus spp. was highly reported in tropical countries. Pre-harvest stress caused by poor agricultural practices like irregular irrigation/drought conditions, and poor postharvest practices like improper drying, poor transportation and storage of harvested chilli are major causes of Aspergillus spp. contamination. Aflatoxins B1, B2, G1, G2, M1 and M2 are different types of aflatoxins with varying degrees of toxicity. Among these, Aflatoxin B1 is of particular importance, as it is highly carcinogenic [3] and classified by the International Agency for Research on Cancer (IARC) as a class I carcinogen [4]. Hence, it is necessary to screen the harvested chillies for the presence of aflatoxins to avoid health implications and economic loss. Several chromatographic methods are available for the screening and detection of aflatoxins. The traditional thin layer chromatography (TLC) method is considered a powerful screening tool for the presence of aflatoxins. Hence, the present study was conducted to understand the occurrence of naturally contaminated fungal pathogens in the commercially sold chilli samples. The samples were also tested for the presence of aflatoxin production by the pathogens.

2. MATERIALS AND METHODS

2.1 Materials

Red chilli samples were collected from retail and commercial stores of Tamil Nadu and stored in Ziplock bags until further analysis. Potato dextrose agar, TLC plates, aflatoxin B1 standard, chloroform, acetone, sodium hypochlorite, ethanol and methanol were procured from sigma chemicals for the analysis.

2.2 Screening of Samples for Fungal Contamination

Chilli samples collected from retail stores were sterilized using 1% sodium hypochlorite followed by 80% ethanol. The sterilized samples were pat dried with filter papers. After sterilizing the samples, they were plated in the potato dextrose agar medium and incubated for 48 h (Fig. 1). Agar block containing different species was then aseptically transferred into new plates for purification and screening [5].

2.3 Scanning Electron Microscopy Analysis

A scanning electron microscope was used to study the morphological changes in chilli pepper (Model: Quanta 250, FEI, Asia). The samples were sputter-coated with gold to avoid sample damages during analysis [6].

2.4 Aflatoxin Production

The samples that contained A. flavus were tested for the production of aflatoxin using the TLC method [7]. Methanolic extract of chilli pepper was prepared by grinding 10 g of whole dry chilli with 50 ml of sterile water and filtered through two layers of muslin cloth. This extract was used for TLC. Chloroform and acetone (9:1) were used as the developing solvent. The solvent was taken to completely cover the bottom of the chamber to a depth of approximately 0.5 cm. The chamber is covered to prevent evaporation of the solvent. The chilli extract was placed on the TLC plate using a Pasteur pipette against the aflatoxin standard. The loaded TLC plate was placed in the TLC chamber with the sample line towards the bottom and the chamber was covered. When the solvent reached 1/3rd length of the plate, the plate was removed and the chromatogram was viewed under UV light at 365 nm [7].

Rajendran et al.; IJPSS, 33(9): 20-25, 2021; Article no.IJPSS.68528
3. RESULTS AND DISCUSSION

The number of samples contaminated with the fungal pathogens is presented in table 1. It was found that all the samples tested were contaminated with *A. flavus* and *A. niger*. Almost 6 samples had *A. parasiticus* contaminations in them. Drought stress results in the reduction of the plant’s natural defence mechanism, making it prone to *Aspergillus spp.* infection and increases the production of the secondary metabolite aflatoxin by *Aspergillus spp.* [8,9]. Aflatoxin production by *Aspergillus sp.* was reported in locations with high temperature (25-42°C), dryer climate (with humidity of 60%) to wetter climate (with humidity of 85%) [10,11].

SEM analysis to study the morphology of the *Aspergillus spp.* in the chilli pepper was performed. The morphology of *A. flavus* with the conidia is presented in Fig. 2. The growth of pathogens in the chilli samples resulted in damage of the internal chemical structures of the samples (Fig. 3).

| Pathogen      | No. of samples |
|---------------|----------------|
| *A. flavus*   | 20             |
| *A. parasiticus* | 6              |
| *A. niger*    | 20             |

Table 1. Number of samples contaminated with selected fungal pathogens

Fig. 1. Plating of chilli samples in potato dextrose agar medium

Fig. 2. SEM imaging of *A. flavus* in chilli pepper
Under favourable environmental conditions of tropical temperature (24 - 43°C) and relative humidity (60-85%), *A. flavus* produce secondary metabolites called aflatoxins [10]. Aflatoxins are the most toxic and common mycotoxins in food and feed [12]. *A. flavus* produces aflatoxin B₁ and B₂, whereas *A. parasiticus* isolates produce aflatoxin G₁, G₂, M₁, B₁, and B₂. *A. flavus* produces a number of airborne conidia and propagules that infect plants [13]. Changes in environmental temperature influence the expression levels of regulatory genes (aflR and aflS) and aflatoxin production in *A. flavus* and *A. parasiticus* [14–16]. Hence, India being a tropical country, it is important to understand the ability of the pathogens in chilli samples to produce aflatoxins. Thin layer chromatography (TLC) is among one of the oldest techniques used for aflatoxin detection [17]. The higher sample throughput of TLC suggests that it is one of the quickest, simplest and most effective analytical techniques and is most suitable for the screening routine which is usually important in the duration of the storage and exchange of commodities.
such as foodstuffs and feedstuffs etc [18]. In the present study, all the samples tested contained A. flavus and hence it was assumed that aflatoxin was produced by A. flavus. No tests were performed to identify the fungal source for aflatoxin. TLC was used to screen the presence of aflatoxin irrespective of its production by A. flavus or A. parasiticus. TLC analysis followed by the pathogen screening showed that 16 out of 20 samples were contaminated with aflatoxin B1 (Fig. 4). Fast screening of the pathogens using TLC will help in sorting and reducing the aflatoxin development in the produces.

4. CONCLUSION

The results showed the presence of Aspergillus spp. in the chilli samples collected from retail stores of Tamil Nadu, India. All the samples tested contained A. flavus and A. niger. TLC confirmed the production of aflatoxin by the naturally occurring A. flavus present in the chilli samples. Sorting and reducing the aflatoxin contaminated samples is highly important to avoid spreading in the value chain. Creating awareness as a public health issue, surveillance, following good agricultural practices and proper postharvest practices will help in aflatoxin mitigation.

ACKNOWLEDGEMENT

This study was funded by the School of Post Graduate Studies, Tamil Nadu Agricultural University.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Barth M, Hankinson TR, Zhuang H, Breidt F. Microbiological spoilage of fruits and vegetables. In: Compendium of the microbiological spoilage of foods and beverages, Springer. 2009;135–183.
2. Benkerroum N. Mycotoxins in dairy products: A review. Int. Dairy J. 2016;62:63–75.
3. Abdel-Fattah H, Kamel Y, Megalla S, Hafez A. Aflatoxin and aflatoxicosis. I. Fungal flora of some food and animal feeds with special references to aflatoxin-producing abilities. Mycopathologia. 1982;77(3):129–135.
4. International Agency for Research on Cancer. IARC monographs on the evaluation of carcinogenic risks to humans: some traditional herbal medicines, some mycotoxins, naphthalene and styrene. IARC Press Lyon Fr. 2002;82:118.
5. Somashekar D, Rati ER, An, S, Chandrashekar A. Isolation, enumeration and PCR characterization of aflatoxigenic fungi from food and feed samples in India. Food Microbiol. 2004;21(6):809–813.
6. Manikandan A, Subramanian K. Fabrication and characterisation of nanoporous zeolite based N fertilizer. Afr J Agric Res. 2014;9(2):276–284.
7. Velazhahan R, Vijayanandraj S, Vijayasamudreswari A, et al. Detoxification of aflatoxins by seed extracts of the medicinal plant, Trachyspermum ammi (L.) Sprague ex Turrill – Structural analysis and biological toxicity of degradation product of aflatoxin G1. Food Control. 2010;21(5):719–725.
8. Klich MA. Aspergillus flavus: The major producer of aflatoxin. Mol. Plant Pathol. 2007;8(6):713–722.
9. Pitt JI, Taniwaki MH, Cole MB. Mycotoxin production in major crops as influenced by growing, harvesting, storage and processing, with emphasis on the achievement of Food Safety Objectives. Food Control. 2013;32(1):205–215.
10. Sétaomu M, Cardwell KF, Schultness F, Hell K. Aspergillus flavus Infection and Aflatoxin Contamination of Preharvest Maize in Benin. Plant Dis. 1997;81(11):1323–1327.
11. Gnonlonfin GJB, Herr K, Adjovi Y, et al. A Review on Aflatoxin Contamination and Its Implications in the Developing World: A Sub-Saharan African Perspective. Crit. Rev. Food Sci. Nutr. 2013;53(4):349–365.
12. Gizachew D, Chang C-H, Szonyi B, De La Torre S, Ting WE. Aflatoxin B1 (AFB1) production by Aspergillus flavus and Aspergillus parasiticus on ground Nyjer seeds: The effect of water activity and temperature. Int. J. Food Microbiol. 2019;296:8–13.
13. Lee L, Goyes W, Lacey P. Aflatoxin in arizona cottonseed - simulation of insect vectored infection of cotton bolls by (Aspergillus flavus). J. Oil Fat Ind. 1986;63:468–468.
14. Schmidt-Heydt M, Rüfer CE, Abdel-Hadi A, Magan N, Geisen R. The production of aflatoxin B1 or G1 by Aspergillus parasiticus at various combinations of temperature and water activity is related to the ratio of aflS to aflR expression. Mycotoxin Res. 2010;26(4):241–246.

15. Schmidt-Heydt M, Parra R, Geisen R, Magan N. Modelling the relationship between environmental factors, transcriptional genes and deoxynivalenol mycotoxin production by strains of two Fusarium species. J. R. Soc. Interface. 2011;8(54):117–126.

16. Kumar P, Mahato DK, Kamle M, Mohanta TK, Kang SG. Aflatoxins: A global concern for food safety, human health and their management. Front. Microbiol. 2017;7:2170.

17. Fallah AA, Rahnama M, Jafari T, Saei-Dehkordi SS. Seasonal variation of aflatoxin M1 contamination in industrial and traditional Iranian dairy products. Food Control. 2011;22(10):1653–1656.

18. Lin L, Zhang J, Wang P, Wang Y, Chen J. Thin-layer chromatography of mycotoxins and comparison with other chromatographic methods. J. Chromatogr. A. 1998;815(1):3–20.