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Infrared Spectroscopy Detection of Fungal Infections and Mycotoxins for Food Safety Concerns

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Abstract

Mycotoxins, which are toxins produced by fungi, can pose great danger to human health with their acute and chronic effects when contaminated foods (grains, fruits, meat, or milk) are ingested. Fungal infections in food crops are extremely common and many developed countries have set standards to monitor and control their imported and exported food products. The analytical methods required to quantify the toxin concentrations are accurate and sensitive but often destructive thus rely on sampling to determine the contamination status. Infrared spectroscopy has gained a lot of attention for its ability to non-destructively provide critical information of samples, which can help reduce the uncertainties inherited from the sampling methods. Several successful examples in identifying fungal infection from agricultural commodities provide great hope for a faster and more cost-effective screening method to help eliminate the health threats.

Keywords: Infrared spectroscopy; Fungal infections; Mycotoxins; Food safety

Commentary

When discussing fungal infections and the human diseases they cause, it is important to separate them into mycoses and mycotoxicoses. While mycoses are diseases caused by the growth of fungi (e.g. athlete's foot, candidiasis, etc.), mycotoxicoses are diseases caused by mycotoxins (i.e. toxins produced by fungi). The majority of mycotoxicoses are the result of ingesting contaminated food products.

Common major mycotoxins include (but are not limited to) aflatoxins, fumonisins, ochratoxins, citrinin, patulin, and trichothecenes. Among these mycotoxins, aflatoxins, which are mainly produced by two types of fungi: *Aspergillus flavus* and *Aspergillus parasiticus*, are the most well-known and studied as they infect a wide range of commodities including cereals, nuts, corn, figs, and many others. Fumonisins are produced by several *Fusarium* species and is often found in corn products. Ochratoxins, citrinin and trichothecenes are then often found in barley, rye, oats, wheat and other grains, and patulin is often found in unfermented apple juice [1]. Some mycotoxins also pose threats to human health as residues or biotransformation products when they are ingested by animals that are used for food or to produce milk for human consumption.

Fungal infections in food crops are extremely common and affect the agricultural industry and consumers' health greatly every year. Besides the infamous "Turkey 'X' disease" in the 1960s that caused the death of more than 100,000 turkeys and led to the discovery of aflatoxins, there were major acute mycotoxicosis outbreaks such as the aflatoxin contaminated corn in India in 1974, which caused 106 deaths and in Kenya in 2004, which caused 125 deaths among 317 reported cases [2-5]. Many mycotoxins are also found to be immunosuppressive and have chronic effects; for example, aflatoxins are hepatotoxic and carcinogenic (hepatocellular carcinoma), fumonisins are reported to be more prevalent in corn from a high incidence area of human esophageal cancer and are demonstrated to induce liver cancer in rats, and ochratoxin A is observed to induce kidney tumors in animals and humans [6-8].

Many developed countries have regulations in place for monitoring the mycotoxins in food products to protect consumers from the health risks and agricultural industries all over the globe spend a significant amount of money every year to monitor and control their products. This is especially true for products that are exported to Europe due to strict regulations among the EU. Despite regulation and monitoring efforts, fungal infections can happen in the field and postharvest (i.e. during handling, storage, and shipping), which worsens the problem and makes quality control along the whole production line more tedious and complicated (e.g. samples can be clean when harvested but become infected later during storage). It is estimated that one quarter of the world's crops are contaminated to some extent with mycotoxins [9]. It is also estimated that crop losses (corn, wheat, and peanuts) from mycotoxin contamination in the United States amount to $932 million annually, in addition to losses averaging $466 million annually from regulatory enforcement, testing, and other quality control measures [10].

While monitoring food products for mycotoxin contamination, many analytical methods are used and the choices and details of the methods depend on the nature of the toxins and the substrates they are in [11,12]. These methods include high-performance liquid chromatography (HPLC), gas spectrometry coupled methods, thin-layer chromatography based methods and immunoassays (e.g. ELISA). These analytical methods are sensitive and accurate, and some can be relatively quick (30 min to 1 hr), however the procedures often require the destruction of the samples (i.e. grinding, mixing, extraction, etc.), expensive instruments, and the processes can also be labor-intensive. Since the methods are destructive, the importance of the sampling is further emphasized (i.e. the minimum number of samples that are needed to be representative of the population). Additionally, in many

cases, fungal infection does not mean mycotoxin contamination and the event of contamination can be very rare, meaning: 1) sorting (manually or automatically based on appearance) may be reliable in most cases but can also miss the samples that are highly contaminated if there are no visual indicators, and 2) sampling from a large population (i.e. a lot or a truckload) to determine if contamination has occurred is not always reliable since the contamination is not a normal distribution.

There are many research studies conducted to develop non-destructive methods to detect mycotoxins in various commodities in order to eliminate the problems that come with sampling. During the past decades, infrared (IR) spectroscopy has gained a lot of attention for its potential to non-destructively provide information for an individual sample in a timely fashion. IR spectroscopy utilizes the vibrational energy levels that are associated with various chemical bonds (e.g. C-H, N-H, etc.). By analyzing the absorbance, reflectance, or transmittance spectrum of a sample in the IR region of light, one can infer the chemical composition of a sample. The acquired spectra (absorbance/reflectance/transmittance vs. wavelength/wavenumber) are commonly pre-treated and analyzed using multivariate statistical techniques to reveal information about the samples and their relation to the spectra. IR spectra can also be affected by the physical structure of the samples, usually in the form of light scattering, thus sometimes the spectra can also provide insights into the physical properties of the samples.

Pearson et al. and Tallada et al. have used both visible and near infrared (Vis-NIR) and only NIR spectroscopy for corn kernels. The former aimed for discriminating kernels with higher concentrations of aflatoxins from the lower concentrations and uninfected ones, and the latter used NIR spectroscopy for discriminating different levels of infections as well as several different fungal species [13,14]. Liang et al. used NIR spectroscopy to classify between *Aspergillus flavus* and *Aspergillus parasiticus*-infected and uninfected almond kernels as well as attempted to discriminate between different fungal species. Dowell et al. used visible and NIR spectroscopy to classify *Fusarium verticillioids*-infected corn kernels. Galvis-Sánchez et al. used mid-infrared spectroscopy to separate dried vine fruit with higher concentrations of ochratoxin A from the lower and uncontaminated ones [15-17].

In all these examples, IR (or Vis-NIR) spectroscopy was able to successfully, non-destructively discriminate individual infected or contaminated samples from uninfected ones, which provides great possibility for the agricultural industries to more effectively screen all samples for infections to reduce the sampling uncertainties and help eliminate the health threats. Recent developments in spectroscopy and imaging (e.g. miniature spectrometers, hyperspectral imaging systems, etc.) also offer the potential to improve detection speed and industrial applicability. As more mycotoxins are being discovered and more research studies are being conducted to understand the effects and significance of mycotoxins for human health, studies and development in these non-destructive detection methods and technologies will continue to be in great demand.

References

1. Bennett JW, Klich M (2003) Mycotoxins. Clin Microbiol Rev 16: 497-516.
2. Amaike S, Keller NP (2011) Aspergillus flavus. Annu Rev Phytopathol 49: 107-133.
3. Richard JL (2008) Discovery of aflatoxins and significant historical features. Toxin Reviews 27: 171-201.
4. Lewis L, Onsongo M, Njapau H, Schurz-Rogers H, Luber G, et al. (2005) Aflatoxin contamination of commercial maize products during an outbreak of acute aflatoxicosis in eastern and central Kenya. Environ Health Perspect 113: 1763-1767.
5. Krishnamachari KA, Bhat RV, Nagarajan V, Tilak TB (1975) Hepatitis due to aflatoxicosis. An outbreak in Western India. Lancet 1: 1061-1063.
6. International Agency for Research on Cancer (2012) A review of human carcinogens. Part F: Chemical agents and related occupations. IARC monographs on the evaluation of carcinogenic risks to humans. IARC, Lyon, France.
7. Jackson LS, DeVries JW, Bullerman LB (2013) Fumonisins in food. Springer Science & Business Media.
8. International Agency for Research on Center (1993) Some naturally occurring substances: food items and constituents, heterocyclic aromatic amines and mycotoxins. IARC, Lyon, France.
9. Fink-Gremmels J (1999) Mycotoxins: their implications for human and animal health. Vet Q 21: 115-120.
10. Schatzmayr G, Zehner F, Täubel M, Schatzmayr D, Klimitsch A, et al. (2006) Microbiologicals for deactivating mycotoxins. Mol Nutr Food Res 50: 543-551.
11. Trucksess MW, Pohland AE (2001) Mycotoxin protocols. Humana Press Inc., Totowa, NJ.
12. Wilson DM, Sydenham EW, Lombaert GA, Trucksess MW, Abramson D, et al. (1998) Mycotoxin analytical techniques. In: Sinha KK, Bhatnagar D (eds.) Mycotoxins in agriculture and food safety. CRC Press, Boca Raton, FL.
13. Pearson TC, Wicklow DT, Maghirang EB, Xie F, Dowell FE (2001) Detecting aflatoxin in single corn kernels by transmittance and reflectance spectroscopy. Transactions of the ASAE 44: 1247-1254.
14. Tallada JG, Wicklow DT, Pearson TC, Armstrong PR (2011) Detection of fungus-infected corn kernels using near-infrared reflectance spectroscopy and color imaging. Transactions of the ASABE 54: 1151-1158.
15. Liang P, Slaughter DC, Ortega-Beltran A, Michailides TJ (2015) Detection of fungal infection in almond kernels using near-infrared reflectance spectroscopy. Biosystems Engineering 137: 64-72.
16. Dowell FE, Pearson TC, Maghirang EB, Xie F, Wicklow DT (2002) Reflectance and transmittance spectroscopy applied to detecting fumonisin in single corn kernels infected with Fusarium verticillioides. Cereal Chem 79: 222-226.
17. Galvis-Sánchez AC, Barros A, Delgadillo I (2007) FTIR-ATR infrared spectroscopy for the detection of ochratoxin A in dried vine fruit. Food Addit Contam 24: 1299-1305.