Mycotoxins and food safety concerns

by Lakshmikantha Channaiah, Director of Microbiology, and Mirka Morales, Microbiology Subject Matter Expert, AIB International, USA.

Mycotoxins are a significant food safety concern in the grain supply chain. Contaminated food and feed products represent a major threat to human and animal health. These toxic fungi are present throughout distribution and have adapted to a wide range of habitats, including deserts, high salinity, and extreme temperature environments. There are hundreds of mycotoxins known to exist, but nearly 30 of them have been well characterised and are considered harmful to humans and animals.

The most important mycotoxins that cause severe economic and health damages are aflatoxins, vomitoxin/deoxynivalenol (DON), fumonisins, ochratoxin A, zearalenone, patulin and T-2 toxin.

Table 1 gives additional details on mycotoxins, fungal sources, and target commodities. Aflatoxins are likely the most widely occurring and studied mycotoxins in the world implicated with various diseases. To protect consumers from mycotoxins, several countries have implemented regulations to limit the exposure of mycotoxins in food and feed products.

Mycotoxins	Fungal source	Target commodities
Vomitoxin/DON	F. graminearum F. culmorum	Wheat, corn, barley
Aflatoxins (B1, B2, G1, G2)	A. flavus A. parasiticus	Corn, peanuts, oilseeds
Fumonisin	F. moniliforme F. proliferatum	Corn
Ochratoxin A	A. ochraceus P. verrucosum	Wheat, barley, coffee
Zearalenone	F. graminearum	Corn, sorghum, wheat
Patulin	P. expansum	Cereals, apple, olives, grapes, peach

Table 1. List of major mycotoxins, fungal sources and target commodities.

Moulds and mycotoxins: what you need to know

- Fungi are throughout distribution.
- Most fungi do not produce mycotoxins.
- More than 400 identified mycotoxins.
- 30 well characterised mycotoxins are considered harmful to animals and humans.
- Usually ingested in contaminated food.
- Most are thermostable and cannot be destroyed in normal cooking conditions.
- Usually no treatment for mycotoxin poisoning.
- Drying will not detoxify mycotoxins.

Five important facts

- Mycotoxins are not detectable by sight or smell.
- Not all mouldy grains/foods contain mycotoxins.
- Grain/food does not have to look mouldy to be contaminated.
- Not all grains/foods containing mycotoxins are toxic.
- Mycotoxins may not be uniformly distributed.

Economic impact

Consumption of foods contaminated with mycotoxins can lead to serious health implications if the toxins are present at high levels. A disease or disorder caused due to mycotoxin contamination is called mycotoxicoses. Some mycotoxins can be acutely or chronically toxic, depending on the type of toxin, dosage, age, and susceptibility (immunocompromised patient).

The long term exposure to mycotoxin-contaminated foods can increase cancer risk and suppress the immune system.

Diagnosing a patient for suspected mycotoxicoses is challenging because the symptoms are similar to those caused by other pathogenic micro-organisms.

Worldwide, approximately 25% of food crops are affected by mycotoxins, causing a loss of billions of dollars every year. The presence of mycotoxins at levels higher than the US Food and Drug Administration limits can have an adverse effect on the economy. Grain producers and food manufacturers would suffer the consequences of the reduced marketability or recall of their products both domestically and internationally. The economic impact of mycotoxins includes loss of human and animal life, increased health care cost, reduced livestock production, losses in crops, product recalls, increased research investment, and cost associated with regulatory programs directed toward mycotoxins.

Field and storage fungi

Fungal infection and subsequent production of mycotoxins can occur at the field during crop growth or harvesting, and may continue during storage. Although it is very difficult to classify them based on origin, fungal contamination can be divided into two major groups: field fungi (Fusarium and Alternaria spp.) and storage fungi (Aspergillus and Penicillium spp.). Generally, the original source of fungi is from the field.

Mycotoxin synthesis

Temperature, water, salinity, nutrient stresses, and pest infestation are important reasons for fungal infection of field crops. In

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general cool and wet weather favours Fusarium toxins, while hot and humid weather favours Aspergillus toxins. High moisture content (water activity (aw)), temperature, and poor sanitary conditions are associated with fungal infection and subsequent mycotoxin synthesis in stored grain.

Fungus grows in a temperature range of 50-105°F, above 0.7aw, and a pH range of 4-8. It is possible to predict the type of fungal growth and subsequent mycotoxin production to some extent depending upon the type of grain, moisture content, and temperature of the stored grain.

However, the conditions for mycotoxin synthesis are generally more critical and complex than those for fungal growth. For grain handlers and food producers, it is important to monitor the temperature and relative humidity during storage at regular intervals.

Relative humidity influences the moisture content of stored grain, resulting in more or less water available for fungal growth and subsequent mycotoxin synthesis.

Additionally, storage fungi are more frequent in bins infested with stored product insects. These stored product insects act as potential routes for distributing fungal spores.

Sampling and testing

Proper grain sampling and sample preparation are important for accurate test results. There are several testing tools available to detect and quantify mycotoxins in grain and grain-based products.

Various testing tools, such as thin layer chromatography, high-performance liquid chromatography (HPLC), gas chromatography, and enzyme-linked immunosorbent assays (ELISA) can be used depending on the needs. Since fungi can still grow and synthesise mycotoxins in a sample, samples should be properly preserved (dried, frozen, or treated with mould inhibitor) and shipped quickly for analysis to avoid variation of test results.

Management

Mycotoxin content increases with delayed harvest, rain, and cool weather. Proper cleaning of harvested grain is a must to reduce mycotoxin content as mycotoxin concentration is greatest in damaged kernels and fine material. Drying harvested commodities to a safe moisture level (aw of about 0.7) and maintaining grain moisture during storage is crucial for controlling or minimising fungal growth and subsequent mycotoxin synthesis.

Maintaining uniform grain temperatures throughout the grain mass is important to avoid moisture imbalance. This can be achieved by passing large volumes of ambient air (aeration) through the grain mass.

Detoxifying mycotoxins in grain and grain-based products is a complex and expensive process. Several detoxification methods have been developed (ammonification, ClO2, ozone, etc) to treat mycotoxin contaminated grain and feed products. However, there are several limitations and challenges that still remain. Most mycotoxin-contaminated grain detoxification methods are either too expensive, have safety concerns, or leave residues in the commodities that would affect the end use. Therefore, preventing fungal infection, rather than trying to treat infected grain or products, is the best practice.

The CO2-sensing technology developed in recent years is one of the most promising technologies for early detection of spoilage due to moulds during grain storage.

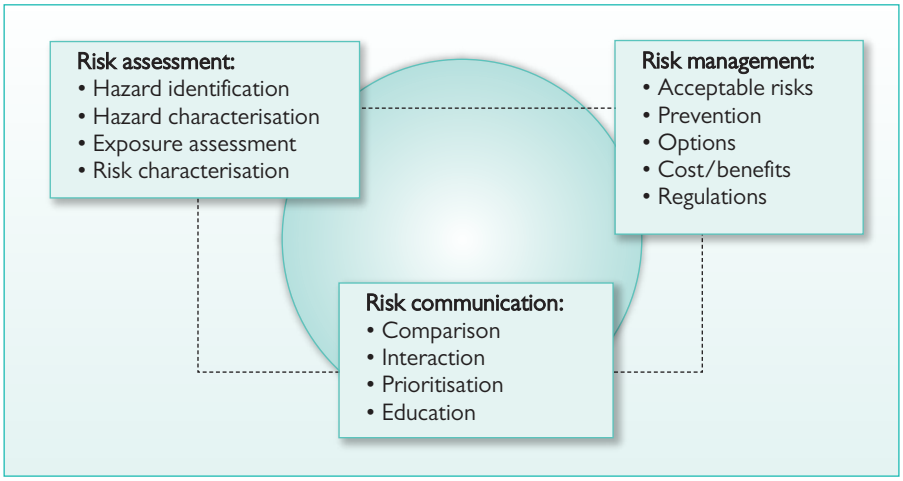

Fig. 2. Mapping concepts of risk (FAO).

Assessing risk

Increasing awareness among grain handlers and food producers and encouraging good agricultural and manufacturing practices, as well as HACCP, are the most common and best strategies to lower health risks and the economic losses.

Risk analysis platforms exist for both food safety as well as for more technical risk assessment purposes for the associated food product.

The Food and Agriculture Organization of the United Nations (FAO) and the World Health Organization (WHO) have devised chemical and microbiological benchmarks that are used by national and worldwide authorities for food safety risk assessments. These benchmarks use three main principles of risk: assessment, management, and communication and serve as a guide to the industry to minimise unforeseen negative health and economic impacts.

It is key to include within these principles the hazard identification, characterisation, exposure assessment, and likelihood. Using this information, such risks may be prioritised and proactive prevention protocols for risk management alternatives can become part of existing food safety programs at the agricultural site or plant processing facility.

Also, using resources from the latest legislative and regulatory safety margins, guidance documents, emerging news, or scientific studies relating to mycotoxins should be considered to aid food businesses in product monitoring, use of effective sampling techniques to determine risk, product trending history, regular risk reevaluation, and business programs and internal policies.

There have been several and varied regulations pertaining to mycotoxins over the years. Initially, many were not based on sound scientific evaluations.

Currently, there is a lack of concurrence among countries, but in recent years the Codex Committee on Food Additives and Contaminants (CCFAC) has inclined toward harmonisation by inviting position papers on proposed regulatory limits for several mycotoxins. The ultimate goal is to achieve optimal regulations for human safety which do not become trade barriers for food commodities that can be impacted by these toxins. ■

Risk-based sampling: How to prioritise and set a sampling rate to verify food safety measures are working:

- Document risk assessments for mycotoxin/product combinations.
- Incorporate best practice guidelines published by food regulators and professional bodies.
- Use appropriate sampling and analytical methods to generate sound results.
- Review analytical results, food surveys, food safety measures effectiveness, food regulator guidelines and other sources of information to update risk assessment and set new priorities and sampling rates.