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Review article

# Strategies to prevent and reduce mycotoxins for compound feed manufacturing

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ABSTRACT

Mycotoxins are the secondary metabolites of fungi, especially moulds. They have over 300 types and can be easily produced ubiquitously by moulds. Many mycotoxins have been found to be toxic to most farmed animals through the diets. With the globalization of feed ingredient trade and the rapid climate changes, occurrence of mycotoxins become increasingly difficult to be predicted. Thus, the unnoticeable mycotoxin hazards can directly impact the animal production systems. Preventing or minimizing mycotoxins in feed ingredients has become an important topic from the aspect of feed manufacturing industry. The aim of this literature review is to summarize the effective strategies for feed manufacturers to minimize the mycotoxin hazards. Prevention methods, including pre-harvest field management and post-harvest storage management, are still the most effective strategies, since mycotoxins are hardly to be eliminated once they are present in the ingredients. Moreover, mycotoxin reducing effects of several feed manufacturing technologies are also reviewed. In this review, the mycotoxin reducing methods are mainly categorized into 4 methodologies: physical methods, thermal methods, chemical methods, and mycotoxin controlling feed additives. The first three methodologies mainly focus on how to reduce mycotoxins in feed ingredients during processes, while the last one on how to compensate the adverse impacts of mycotoxin-contaminated diets in animal bodies. The results showed that most of the methods reviewed show evident mycotoxin reducing effects, but of different consistencies. On the other hand, many practical factors that can affect the feasibility of each method in practical manufacturing are also discussed in this review. In conclusion, mycotoxin prevention management and the processing stage of cleaning and sorting are still the most efficient strategies to control mycotoxin hazards in current feed manufacturing.

## 1. Introduction

### 1.1. Overview: mycotoxins

Mycotoxin contamination is one of the most severe threats to modern feedstuff manufacturing and animal husbandry. Modern academic detection of mycotoxins started in 1961, when mass mortality of turkeys occurred in England and then aflatoxin was discovered and accused as the culprit (Richard, 2007). In following decades, more mycotoxins and their toxicities were gradually discovered, and some mass health problems recorded before 1960s were retrospectively found related to mycotoxins (Richard, 2007).

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**Table 1**
Brief information of some concerned mycotoxins (Hussein and Brasel, 2001; Richard, 2007; Streit et al., 2012).

| Mycotoxin | Main origin | Host crop | Main adverse effects |
|---|---|---|---|
| Aflatoxin | *Aspergillus flavus*<br>*A. parasiticus* | Wheat<br>Barley<br>Maize<br>Peanut | Decreased feeding performance, acute damage in organs, carcinogen and sudden death |
| Deoxynivalenol | *Fusarium species* | Wheat<br>Barley<br>Oats<br>Maize | Impaired feeding performance, immune-suppressive, |
| Zearalenone | *Fusarium species* | Maize<br>Wheat<br>Barley<br>Sorghum,<br>Rye | Little acute toxicity, disorder of female estrus and reproduction, smaller litter size and weak piglets |
| Fumonisin | *F. proliferatum*<br>*F. verticillioides* | Maize<br>Sorghum<br>Rice | Carcinogen to humans, pulmonary oedema in swine and leukoencephalomalacia in horses |
| Ochratoxin A | *A. ochraceus*<br>*Penicillium viridicatum*<br>*P. cyclopium* | Maize,<br>Raisins<br>Barley<br>Soy<br>Coffee | kidney and liver damage, immune suppression, infant deformity |
| T-2/HT-2 | *F. sporotrichioides*<br>*F. poae* | Corn<br>Wheat<br>Barley<br>Oats<br>Rice<br>Rye | Inhibition of protein synthesis, disruption of DNA and RNA synthesis |

Modern animal feed/human food manufacturing suffers from increasing risks of mycotoxin contamination, since mould infection can occur in almost all sectors involved, from crop cultivation in the field to the storage and logistics of finished commodities. Compared to those man-made toxins such as pesticides, preservatives and some feed/food additives, mycotoxins, as a group of natural toxins, are more difficult to be controlled because of the absence of standardized management and sufficient toxicological data (Berthiller et al., 2013).

'Mycotoxin' refers to a group of toxic compounds which are produced by fungi and are toxic to vertebrates and other animals in low concentrations, which excludes fungi-originated chemical compounds respectively threatening bacteria (categorised as 'antibiotics') and plants (categorised as 'phytotoxins'). In addition, general discussion of mycotoxicology tends to focus on unnoticeable toxic compounds produced by moulds and exclude mushroom poisons, which threaten animals or human mainly through avoidable accidental ingestions (Bennett and Klich, 2003). Thus, discussion on mycotoxin contamination is highly related to issues of mould infection. One mould species can produce different mycotoxins, and on the other way one mycotoxin can be produced by different mould species. Currently, most concerned mycotoxins are mainly synthesized by five fungal genera: *Alternaria*, *Aspergillus*, *Cladosporium*, *Fusarium* and *Penicillium* (Bryden, 2012). Several dangerous mycotoxins that are frequently detected are introduced in this part (Table 1).

### *1.2. Most detected mycotoxins in feed manufacturing*

#### *1.2.1. Aflatoxin*

Among mycotoxins, aflatoxin (AFL) is the most notorious one, not only because it is the first mycotoxin discovered that lead to animals' mass mortality, but also due to its current high adverse effects on human and animal health. The major aflatoxins consist of aflatoxin $B_1$, $B_2$, $G_1$ and $G_2$, and they are mainly synthesized by *Aspergillus flavus* or *Aspergillus parasiticus*. Aflatoxin $B_1$ ($AB_1$) is listed as a severe carcinogen by World Health Organization (WHO). Aflatoxin $M_1$, a metabolic in ruminants of $B_1$ appearing in animal tissues and fluids (such as milk and urine), has also raised special attention for its residual levels in milk products. Aflatoxins have been observed to be immunosuppressive, teratogenic and mutagenic to animals. In addition, aflatoxins can impair the intestines and decrease the feed intake of animals and animals' growth performance (Richard, 2007), which have been supported by several long-term studies (Bailey et al., 2006; Dersjant-Li et al., 2003; Han et al., 2008).

#### *1.2.2. Deoxynivalenol*

Deoxynivalenol (DON) is the most detected mycotoxin in the ingredients for feed/food production (Richard, 2007; Wu et al., 2007). DON is mainly produced by *Fusarium*, like *F. graminearum*, *F. crookwellense* and *F. culmorum* (Eckard et al., 2011). Grains of some common crops, including wheat, barley, oats and maize, are common hosts of these fungi. Rachis of maize, which can be applied as silage feed material, could also suffer from attack of these fungal. Symptoms of fungal attacks occurring in maize rachis are