

The risks of mycotoxins in animal feed and their negative effects: A new and important review discussion

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ABSTRACT:

Mycotoxins are toxic secondary metabolites produced by certain filamentous fungi, such as *Aspergillus*, *Fusarium*, and *Penicillium*. These mycotoxins can contaminate animal feed, including grains, cereals, soybeans, and other crops, either directly from plant-based food components or through the growth of toxigenic fungi on food. The presence of mycotoxins in animal feed can have detrimental effects on animal health and performance, as well as pose a risk to human health through the consumption of animal-derived food products. Mycotoxins are toxic secondary fungal metabolites that can contaminate animal and poultry feed. These mycotoxins can have adverse effects on animal health and productivity when ingested through feed. Additionally, mycotoxins can be transferred into animal products such as meat, eggs, and milk, posing a risk to human health. Therefore, it is crucial to monitor the occurrence of mycotoxins in animal and poultry feed. To address mycotoxin contamination in feed, various regulatory guidelines and strict guidelines have been adopted by national and international public health and governmental. These guidelines aim to ensure the safety of animal feed and minimize the risk of mycotoxin exposure to animals and humans. Mycotoxins are toxic metabolites produced by fungi that can contaminate livestock and poultry feed, posing significant threats to animal health and productivity. Several mycotoxins have been reported to contaminate poultry feed and their ingredients, including aflatoxins (AFs), cyclopiazonic acid (CPA), fumonisins (FUMs), nivalenol (NIV), and zearalenone (ZEN). These mycotoxins can have destructive effects on animals, leading to various health issues.

Keywords: Contamination; fungi; Hygiene; mycotoxin

INTRODUCTION:

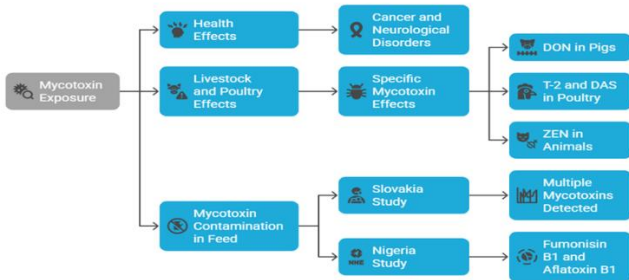
Exposure to mycotoxins can result in severe health effects in both humans and animals (Bhat et al., 2010). Some mycotoxins are highly toxic and can cause toxic syndromes in livestock and poultry (Bhat et al., 2010). Additionally, certain mycotoxins have been linked to the incidence of certain types of cancer and neurological disorders (Bhat et al., 2010). Mycotoxin contamination in agricultural commodities has gained worldwide attention due to its detrimental effects on human health, poultry, and livestock (Fraga et al., 2006). Mycotoxins can be carcinogenic, mutagenic, teratogenic, nephrotoxic, and immunosuppressive agents (Fraga et al., 2006).

Different mycotoxins have specific adverse effects on animals. For example, deoxynivalenol (DON), a

trichothecene mycotoxin, is associated with emesis, feed refusal, and depressed feed intake in pigs (D'Mello et al., 1999). T-2 toxin and diacetoxyscirpenol (DAS) have been linked to oral lesions in poultry (D'Mello et al., 1999). Zearalenone (ZEN), another mycotoxin, has raised concerns due to its estrogenic response in animals (Liu & Applegate, 2020). ZEN is mainly produced by *Fusarium* species and often co-occurs with deoxynivalenol in grains (Liu & Applegate, 2020). Chronic low-level mycotoxin consumption can also have negative impacts on broiler performance and health (Weaver et al., 2020). Broilers may be sensitive to moderate levels of DON, resulting in reduced weight gain and feed efficiency (Weaver et al., 2020). Pigs, on the other hand, are more exposed to deoxynivalenol due to their cereal-rich diet and have a low ability to

detoxify mycotoxins (Serviento et al., 2018). A reduction in feed intake is a common effect of dietary exposure to DON in pigs (Serviento et al., 2018). Specifically focusing on poultry feed, studies have found high levels of mycotoxin contamination (Sharifi et al., 2025). In Slovakia, a study on poultry feed samples found that 84% of the samples contained more than one mycotoxin, with a four-toxin combination of

DON, ZEN, T-2, and HT-2 being the most frequently detected (Streit et al., 2012). In Nigeria, a study analyzed poultry feed samples and found that fumonisin B1 and aflatoxin B1 were the most frequent mycotoxins, occurring in 97% and 83% of the samples, respectively (Akinmusire et al., 2018). These findings highlight the need for effective strategies to mitigate mycotoxin contamination in poultry feed (Picture 1).



Picture 1.

MATERIALS AND METHODS:

Ruminant diets, which include cereals, protein feeds, by-products, and forages, are particularly susceptible to mycotoxin exposure compared to swine and poultry diets (Gallo et al., 2015). A study analyzing over 19,000 feed samples found that 72% of the samples contained detectable amounts of mycotoxins such as aflatoxins, fumonisins, deoxynivalenol, zearalenone, or ochratoxin A (Schatzmayr & Streit, 2013). Co-contamination with multiple mycotoxins was detected in 38% of the samples, highlighting the need for strategies to counteract the negative effects of mycotoxins (Schatzmayr & Streit, 2013). Mycotoxin contamination in animal feed is a significant concern due to its potential toxic effects on animals and the transfer of mycotoxins into animal products (Gruber-Dorninger et al., 2019). A global survey conducted over a ten-year period found that 88% of feed samples collected from 100 countries were contaminated with at least one mycotoxin (Gruber-Dorninger et al., 2019). The occurrence of mycotoxins

in feed showed regional differences, with higher contamination rates in South Asia, Sub-Saharan Africa, and Southeast Asia (Gruber-Dorninger et al., 2019). Climate was identified as a key determinant governing these regional trends, with warm and humid regions being more favorable for mold growth and mycotoxin production in cereals (Ma et al., 2018). Aflatoxins, which have the highest toxicity among mycotoxins, are of particular concern (Baeelashaki et al., 2025). Climate change is expected to increase aflatoxin contamination in maize crops in Europe, especially under a +2 °C scenario (Battilani et al., 2016). Similarly, a study in China found that aflatoxin B1, deoxynivalenol, and zearalenone were present in a high percentage of feed samples, with aflatoxin B1 being the most prevalent mycotoxin (Zhao et al., 2021). These findings highlight the need for monitoring mycotoxin levels in feed ingredients to ensure animal health and food safety (Ma et al., 2018).

(Table 1)

- Section	Details
Types of Mycotoxins	- Aflatoxins (B1, B2, G1, G2) - Ochratoxin A - Fumonisin (FB1, FB2) - Zearalenone - Deoxynivalenol (DON) - T-2 toxin
Sources of Mycotoxins	- Fungal contamination in feed ingredients - Environmental conditions (humidity, temperature) - Crop storage practices

- Section	Details
Affected Animal Species	- Poultry - Swine - Ruminants - Aquaculture species - Companion animals
Health Effects on Animals	- Acute toxicity - Chronic health effects - Immune suppression - Reproductive issues - Growth retardation
Economic Impact	- Loss of productivity - Veterinary costs - Feed disposal costs - Trade restrictions
Detection Methods	- Chemical assays (HPLC, ELISA) - Molecular techniques (PCR) - Rapid test kits
Regulatory Standards	- International (FAO, WHO) - Regional (EU, USA) - Country-specific regulations
Prevention and Control	- Good agricultural practices (GAP) - Proper storage conditions - Use of mycotoxin binders - Regular monitoring and testing
Future Trends	- Advances in detection technology - Research on biocontrol agents - Genetic approaches for crop resistance

DESCRIPTION OF PROBLEM:

The occurrence of mycotoxins in feed shows distinct regional trends, with higher contamination rates observed in South Asia, Sub-Saharan Africa, and Southeast Asia (Gruber-Dorninger et al., 2019). Climate plays a significant role in mycotoxin occurrence, and climate change is expected to increase the prevalence of mycotoxin contamination in crops (Battilani et al., 2016). A study predicted that aflatoxin B1 contamination in maize in Europe will become a food safety issue, especially under a +2 °C climate change scenario (Battilani et al., 2016). Climate change has been identified as a potential driver for the increased occurrence of mycotoxins in crops (Baeelashaki et al., 2025). A study predicted that aflatoxin B1 contamination in maize in Europe will become a food safety issue, especially under a +2 °C climate change

scenario (Battilani et al., 2016). Climate change and global warming can increase the susceptibility of staple crops to fungal colonization and mycotoxin contamination (Ma et al., 2018).

The ingestion of mycotoxin-contaminated feed can have adverse effects on animal health and performance. Poultry, for example, can experience reduced productivity and increased mortality due to mycotoxin exposure (Murugesan et al., 2015). Mycotoxins can affect various organs, including the gastrointestinal tract, liver, and immune system, leading to decreased feed intake and impairment of the immune system (Wu et al., 2016). Pigs, which have a similar gastrointestinal tract and immune system to humans, are also susceptible to the negative effects of mycotoxins (Wu et al., 2016). The ingestion of mycotoxin-contaminated feed can increase the susceptibility to infectious

diseases, reactivate chronic infections, and decrease vaccine efficacy in pigs (Pierron et al., 2016). Several studies have been conducted to assess the occurrence and prevalence of mycotoxin contamination in feed (Baeelashaki et al., 2025). A global survey conducted from 2008 to 2017 analyzed 74,821 samples of feed and feed raw materials from 100 countries and found that 88% of the samples were contaminated with at least one mycotoxin (Gruber-Dorninger et al., 2019). Regional differences in mycotoxin occurrence were observed, with higher contamination rates in South Asia, Sub-Saharan Africa, and Southeast Asia (Gruber-Dorninger et al., 2019). Another survey conducted in 2013 analyzed around 3,000 grain and feed samples and found that 81% of the samples had at least one mycotoxin (Murugesan et al., 2015). The prevalence of mycotoxin contamination in feed ingredients and complete feeds in China was also investigated, with aflatoxin B1, zearalenone, and deoxynivalenol being the most commonly detected mycotoxins (Wu et al.,

2016). Similarly, a study in China from 2018 to 2020 found that more than 81.9% of feed samples were contaminated with aflatoxin B1, deoxynivalenol, and zearalenone (Zhao et al., 2021). Preventing mycotoxin contamination in feed can be achieved through various strategies (Baeelashaki et al., 2025). Proper silage management is crucial to reduce mycotoxin contamination in dairy cow feeds, as ensiled forages, particularly corn silage, can be contaminated with mycotoxins (Ogunade et al., 2018). This can be achieved by preventing fungal growth before and after ensiling and using mold-inhibiting chemical additives or microbial inoculants to reduce contamination levels (Ogunade et al., 2018). Additionally, mycotoxin adsorbing agents can be added to diets to reduce mycotoxin levels (Baeelashaki et al., 2025). These agents, such as minerals, organic compounds, and synthetic materials, have the ability to bind to multiple mycotoxins, making them more effective in feed decontamination (Vila-Donat et al., 2018).

Table 2. Percentage of animal feed contamination with mycotoxins in the world.

Region	Feed Type	Mycotoxin(s) Tested	Approximate Contamination Rate (%)	Reference / Source
Global	Mixed feed	Aflatoxins	20-40%	FAO, IFIF reports
Global	Mixed feed	Fumonisin	30-50%	FAO, various surveys
Global	Mixed feed	Deoxynivalenol (DON)	40-60%	FAO, scientific literature
North America	Corn, grains	Aflatoxins	10-25%	USDA, FDA reports
North America	Corn, grains	DON, Zearalenone	25-45%	USDA, university studies
Europe	Cereal-based feeds	DON, Zearalenone, T-2 toxin	40-70%	EFSA reports
South America	Corn, soy	Aflatoxins, Fumonisin	30-55%	Local agricultural surveys
Asia	Mixed feed	Multiple mycotoxins (multi-contamination)	50-70%	Various regional studies

Region	Feed Type	Mycotoxin(s) Tested	Approximate Contamination Rate (%)	Reference / Source
Africa	Maize, sorghum	Aflatoxins	40-60%	WHO, FAO regional reports

- Contamination rates refer to the percentage of tested samples with detectable levels above regulatory or recommended limits.
- Multi-mycotoxin contamination is common, especially in tropical and subtropical regions.
- Levels and types of mycotoxins vary depending on climate, storage conditions, and crop type.

DISCUSSION:

Preventing mycotoxin contamination in feed can be challenging, as mycotoxins can occur in the field before harvest, during harvesting, or during storage and processing (Kabak et al., 2006). Pre-harvest strategies, such as crop rotation, use of resistant varieties, and timely harvesting, can help reduce mycotoxin contamination (Kabak et al., 2006). Harvesting and post-harvest strategies, such as proper drying, cleaning, and storage conditions, are also important in preventing mycotoxin contamination (Kabak et al., 2006). However, complete elimination of mycotoxin-contaminated commodities is currently not achievable (Kabak et al., 2006).

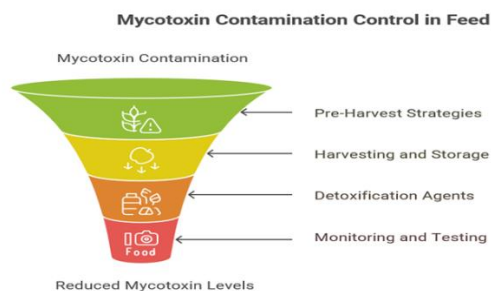
To mitigate mycotoxin contamination in feed, mycotoxin-detoxifying agents can be used as feed additives (Vila-Donat et al., 2018). These agents, such as minerals, organic compounds, and synthetic materials, have the ability to bind to multiple mycotoxins, making them more effective in reducing mycotoxin levels in feed (Vila-Donat et al., 2018). However, further research is needed to explore the efficacy of these adsorbents in farm settings (Vila-Donat et al., 2018).

Another survey conducted in 2013 analyzed around 3,000 grain and feed samples and found that 81% of the samples had at least one mycotoxin (Murugesan et al., 2015). The prevalence of mycotoxin contamination varied over the years, with improvements in detection methods and sensitivity contributing to the increase in the number of positive samples (Murugesan et al., 2015). Liquid chromatography coupled with mass spectrometry was found to be the most selective, sensitive, and accurate method for mycotoxin analysis (Murugesan et al., 2015). The presence of mycotoxins in feed can have adverse effects on animal health and performance (Baeelashaki et al., 2025). Mycotoxins can affect various organs, including the gastrointestinal tract, liver, and immune system, leading to reduced

productivity and increased mortality in extreme cases (Murugesan et al., 2015). The co-occurrence of multiple mycotoxins in contaminated swine diets has been shown to result in synergistic toxicity beyond that observed for individual toxins (Swamy et al., 2002). In dairy cows, mycotoxin exposure through silage ingestion can negatively impact performance and health (Ogunade et al., 2018).

Monitoring mycotoxin levels in feed ingredients and complete feeds is crucial to ensure animal health and the safety of human food products (Ma et al., 2018). Regular testing of feed for mycotoxin contamination is necessary to diagnose feed quality and prevent adverse effects on animals (Pinotti et al., 2016). Additionally, the use of mycotoxin binding agents and other detoxification strategies can help mitigate the toxic effects of mycotoxins in animals (Murugesan et al., 2015; Pierron et al., 2016). Various methods have been employed to reduce mycotoxin levels in feed (Picture 2). These include the use of mycotoxin binding agents, such as glucomannan polymer, which can adsorb mycotoxins and prevent their absorption in the gastrointestinal tract (Swamy et al., 2002). Other strategies include proper silage management to prevent fungal growth and the use of mold-inhibiting chemical additives or microbial inoculants (Ogunade et al., 2018). However, the efficacy of these strategies may vary depending on the type and level of mycotoxin contamination (Ogunade et al., 2018).

Ruminants, such as dairy cows, are particularly vulnerable to mycotoxin exposure due to their varied diets, which include forages that can be contaminated by mycotoxigenic fungi (Gallo et al., 2015). Silage, a common component of ruminant diets, can also be contaminated with mycotoxins during pre-harvest, storage, or feed-out stages (Ogunade et al., 2018). Proper silage management and the use of mold-inhibiting additives or microbial inoculants can help reduce mycotoxin contamination in dairy cow feeds (Ogunade et al., 2018).



Picture 2.

FINDINGS AND RESULTS:

In the field, prevention of mycotoxin formation is the best approach (Baeelashaki et al., 2025). This can be achieved through pre- and post-harvest strategies. These strategies include proper crop rotation, use of resistant varieties, timely harvesting, and adequate drying and storage conditions (Jard et al., 2011). However, prevention in the field may not always be sufficient, and additional methods are needed to decontaminate and detoxify mycotoxin-contaminated feed. One approach is the inclusion of sorbent materials in the feed, which can selectively remove toxins by adsorption during passage through the gastrointestinal tract (Jard et al., 2011). Another approach is the use of enzymes or microorganisms capable of detoxifying some mycotoxins (Jard et al., 2011).

To mitigate the risks associated with mycotoxin contamination in feed, monitoring and testing of feed ingredients and complete feeds are crucial (Baeelashaki et al., 2025). Regular feed testing can provide a quick and accurate diagnosis of feed quality and help ensure compliance with regulations and guidance values (Pinotti et al., 2016). Additionally, the use of mycotoxin binding agents has been a commonly used strategy to counteract mycotoxin contamination in feed (Murugesan et al., 2015). However, it is important to note that mycotoxin co-contamination can still have adverse effects on animals due to additive or synergistic interactions (Pinotti et al., 2016). Mycotoxin binding agents, such as glucomannan polymer, have been used to adsorb mycotoxins and reduce their bioavailability (Swamy et al., 2002). Proper silage management and the use of mold-inhibiting chemical additives or microbial inoculants can also help reduce mycotoxin contamination in dairy cow feeds (Ogunade et al.,

2018). However, the efficacy of mycotoxin binding agents and other mitigation strategies may vary depending on the type and level of mycotoxin contamination (Vila-Donat et al., 2018). To mitigate the destructive effects of mycotoxins, various strategies have been employed. Good feed management practices are crucial in controlling mycotoxicosis in livestock and poultry (Grenier et al., 2013). However, prevention of mycotoxin formation in stored feeds is not always feasible, leading to the use of feed additives to inhibit the intestinal absorption of mycotoxins (Grenier et al., 2013). Bentonite and yeast cell wall binders have been used to mitigate the effects of mycotoxins on laying hen performance, egg quality, and health (Zhao et al., 2021). Studies have shown that mycotoxin co-contamination is a widespread issue in the feed industry (Zhao et al., 2021). For example, a study in China found that more than 97% of complete feeds for pigs, poultry, and ruminants were co-contaminated with aflatoxin B1, deoxynivalenol, and zearalenone (Zhao et al., 2021). The combined toxicity of these mycotoxins on animal health and production may be underestimated, highlighting the need for further research and consideration in setting regulatory limits (Zhao et al., 2021).

In order to reduce mycotoxin exposure in animal feed, mineral adsorbents such as bentonite, zeolite, montmorillonite, and hydrated sodium calcium aluminosilicate are commonly used (Elliott et al., 2019). These adsorbents have the ability to bind or adsorb mycotoxins, reducing their toxic effects (Elliott et al., 2019). However, it is important to note that these adsorbents may also have undesirable effects on farm animals, and their efficacy can vary depending on the specific mycotoxin and animal species (Vila-Donat et al., 2018).

Table. 3

Mycotoxin Mitigation Strategies				
Characteristic	Prevention	Decontamination	Feed Management	Adsorbents
 Method	Crop rotation, resistant varieties, timely harvesting, drying, storage	Sorbent materials, enzymes, microorganisms	Regular feed testing, mycotoxin binding agents, silage management	Bentonite, zeolite, montmorillonite
 Goal	Reduce mycotoxin formation	Remove or detoxify mycotoxins	Control mycotoxicosis	Bind or adsorb mycotoxins
 Limitation	May not always be sufficient	Efficacy may vary	Co-contamination can have adverse effects	May have undesirable effects on animals

CONCLUSIONS AND APPLICATIONS:

In conclusion, mycotoxin contamination in livestock and poultry feed can have destructive effects on animal health and productivity. Various mycotoxins, such as AFs, CPA, FUMs, NIV, and ZEN, have been reported to contaminate feed ingredients. These mycotoxins can cause toxic syndromes, impact feed intake, and have long-term health effects. Strategies such as good feed management practices and the use of feed additives have been employed to mitigate the detrimental effects of mycotoxins. Further research is needed to develop effective and sustainable methods for mycotoxin control in animal feed. Therefore, the presence of mycotoxins in livestock and poultry feed is a global concern that can have significant impacts on animal and human health. Monitoring and testing of feed ingredients and complete feeds, as well as the development of strategies to counteract mycotoxin contamination, are essential to ensure the safety of animal products and protect animal and human health. The occurrence of mycotoxins in feed varies by region and can be influenced by climate and storage conditions (Gruber-Dorninger et al., 2019; Schatzmayr & Streit, 2013). The presence of mycotoxins in feed can lead to adverse health effects in animals and potential transfer to humans through animal-derived food products (Alshannaq & Yu, 2017). Therefore, it is crucial to monitor mycotoxin occurrence in feed and implement effective strategies to mitigate contamination (Gruber-Dorninger et al., 2019; Murugesan et al., 2015; Ogunade et al., 2018).

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