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Prevention and Mitigation of Mycotoxin Contamination of Food and Feed Caused by Climate Change

Introduction

Mycotoxins are fungal metabolites that can be present in human food and beverages as well as animal feeds. The unavoidable presence of these secondary metabolites in food has increased the public concern due to their severe toxic effects. It is estimated that up to 60–80% of food crops worldwide are contaminated with mycotoxins, with this trend on the rise due to climate change (Eskola et al. 2019). Depending on the geographic area, weather, the agricultural crop and other non-environmental factors such as harvesting and storage practices, different types of mycotoxins, usually multiple chemically unrelated metabolites, are expected to be present. Drinkable products such as fruit juices, wine, beer and other traditional drinks can be also contaminated with mycotoxins. This is related to the fact that mycotoxins are not usually affected by technological treatments employed during food production in case the fruits such as apple pears, grapes or cereals such as barley or wheat crops are contaminated with mycotoxins.

On the other hand, forages and cereals are particularly susceptible to mycotoxin contamination, with these being the main components of animal feed. Consumption of mycotoxin contaminated animal feed can have negative effects on the animal's growth, reproduction, welfare and productivity. Furthermore, the carryover of mycotoxins into livestock products such as milk, meat and eggs threatens the safety and quality of these products. A recent global feed survey showed that world compound feed production reached over 1 billion metric tons, with commercial production of animal feeds taking place in 144 countries and generating an annual turnover of more than US$400 billion (IFIF 2018). This is expected to increase with the industry under pressure to increase the amount of safe and nutritious feed to meet the global demand for livestock products, with recovery from the current Covid-19 pandemic no doubt adding to this further. Therefore, beside their potential threat to public health, mycotoxins cause also enormous economic losses.

Although several national and international organizations have set particular regulations, i.e. maximum permissible levels for mycotoxins in food and feedstuffs in order to protect the public, still there is an urgent need to control mycotoxin producing fungi and to reduce mycotoxin concentrations both in the pre-and post-harvest stages. The use of binders or adsorbents as a physical technique to remove food and feed contaminants especially for certain mycotoxins has been investigated over the recent years. Different materials have been proposed and tested, which can be in general classified as either carbon-based organic polymer such as yeast cell wall and glucommanan or inorganic compounds such as activated carbon, aluminosilicates l ike bentonite, montmorillonites and zeolite, and synthetic polymers. Figure 1 shows the main idea of using mycotoxin binders.

This 3rd e-newsletter highlights the recent research performed by Agritox partners on mycotoxin binders to mitigate mycotoxins in human drinkable products (beverages) and animal feeds. Needless to say, the integration of all the developed strategies to control toxigenic fungi and their mycotoxins in the pre-harvest and the post-harvest stages is of a paramount importance to ensure the safety of food throughout the food and feed chains.

For more newsletters, readers are advised to visit **Agritox** website. In the **1st** and the **2nd** e-newsletters an introduction to the project and the analytical capacity of Agritox partners for mycotoxin detection are described, respectively.

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Partners

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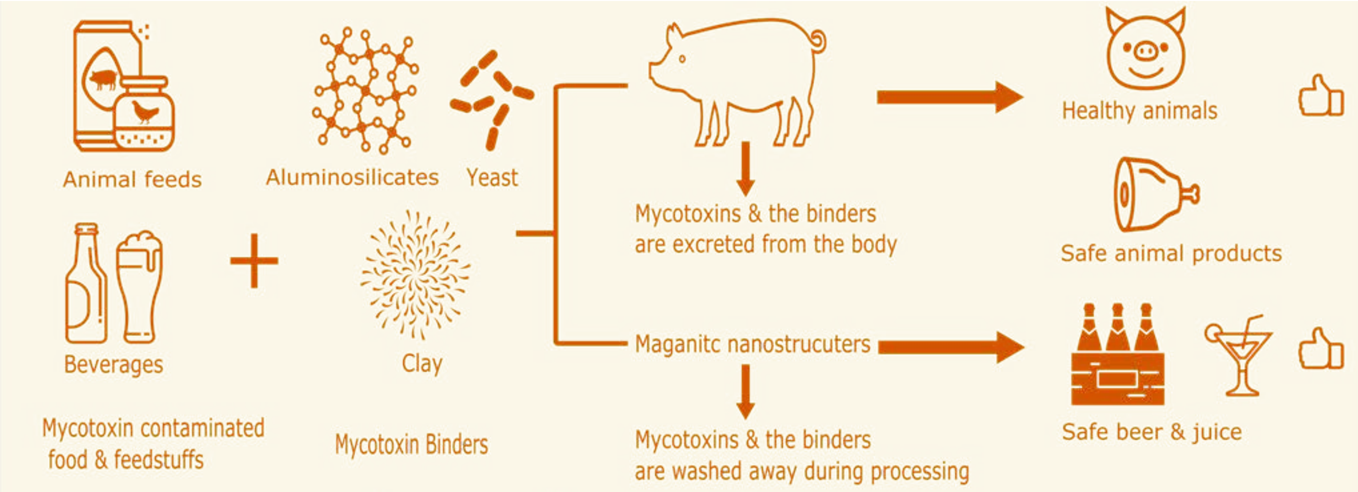

Fig 1. Mycotoxin binders approach to mitigate mycotoxins in food and feed.

Agritox Work on Mycotoxin Binders

Mycotoxin binders in beverages

The department of Pharmacology, Pharmacy and Pharmaceutical Technology (USC) have proposed a new methodology to remove mycotoxins from beverages as part of WP4. In this sense, 30 magnetic nanostructured materials of different sizes and compositions were developed to remove the main types of mycotoxins, namely deoxinivalenol (DON), zearalenone (ZEN), fumonisin B1 (FB1), aflatoxins (AFB_1, AFB_2, AFG_1, AFG_2) and ochratoxin A (OTA), from liquid food matrices. Particles showing high absorption capacity were tested in a highly contaminated beer (González-Jartín et al. 2019). According to the composition of the material different adsorption capacity was observed. The mixtures of magnetite, activated carbon, alginate and pectin were the most efficient allowing the elimination of 90% of ZEN, OTA and AFs, 65% of FB1, and 20% of DON **(Fig 2)**. This technology is now patented (EP18382104).

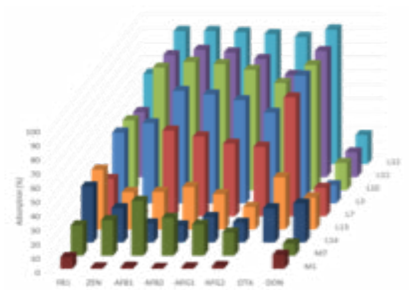

Fig 2. Mycotoxin absorption, expressed as percentage, reached by different nanostructures in beer. M1 and M7 were formed by mixtures of magnetite, bentonite and aluminium oxide. L particles were formed by mixtures of magnetite and alginate with humic acid (L14), sodium metabisulfite (L13), pectin (L7), activated carbon (L3) or pectin and activated carbon (L10-12).

Magnetic nanostructures can be removed from foodstuffs by using a magnet **(Fig 3)**. Therefore, this technology could be a useful tool for the food industry. Although the detoxification method was developed in beer, it is intended to be extended to other matrices as dairy milk.

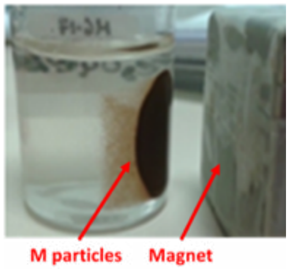

Fig 3. Type M particles, in aqueous solution, being attracted by a magnet.

Are mycotoxin binders safe for animals?

In order to mitigate the effects of mycotoxins on the animals, the European Commission has permitted the use of additives in animal feed which serve to reduce their absorption, promote their excretion or modify them in some way to reduce their overall toxicity. As a result, there are several different types of additive currently on the market advertised as having the ability to do so. One branch of commercially available additives are clay minerals or mineral adsorbents, added directly into the animal feed and which is the most widely used practice by farmers and the feed industry. A recent publication conducted by researchers at the Institute for Global Food Security, QUB (Partner 2) looked at the potential adverse effects on animal health caused by addition of mineral adsorbents to their feed in order to reduce their exposure (Elliott et al. 2020). Based on the work carried out in this publication and the available data, it was concluded that natural minerals (such as clay) and modified adsorbents can induce cytotoxic effects, bind essential micronutrients and vitamins and interact with some veterinary drugs.

All in, these deleterious effects include immunosuppression and low productivity as well as affecting the absorption of some veterinary substances such as antibiotics, therefore leading to failure of the administrated therapy and consequently on animal health. A further complicated consequence is that withdrawal period for antibiotics may change and this might lead to a potential public health issue in terms of human exposure to antibiotic residues present in livestock products. Mineral adsorbents may also contain heavy metals, dioxins, and other trace elements, which can induce toxicity in livestock animals, and therefore should be analysed before being administered to animal feed.

The efficacy of commercial mycotoxin binders as feed additives under *in vitro* conditions

Another study conducted by the same group at QUB in 2019 looked at the efficacy of a range of commercially available additives advertised as having multi-mycotoxin binding, and in particular some of the agriculturally important mycotoxins in pig feed such as; AFB_1, DON, ZEN, OTA, FB_1 and T-2 (Kolawole et al. 2019). In this study the mycotoxin binders were categorised into three groups based on their composition, with these being: Inorganic, organic and mixed additives. Most of the commercially available products were able to significantly bind all of the listed mycotoxins in either alkaline or acidic buffer conditions. However, under simulated *in vitro* conditions to mimic the gastrointestinal tract of monogastrics such as pigs, the efficacy of all the products was significantly reduced. This highlighted the fact that although the binders could work effectively in certain conditions, their efficacy under the conditions they would actually be subjected to prove that they would be ineffective.

More transparency is required to safeguard both the farmer and animals by ensuring appropriate and detailed labelling of products, such as:

- Composition
- Physicochemical properties
- Mode of action
- Dosage
- The target mycotoxin(s)

Overall, this work and that of others prove that although there are commercially available products for mycotoxin mitigation, their use must be carefully considered. This is to not only ensure that what they can do has been tested robustly, but also that they are not putting the animal at any further health risk. Overall, the use of mycotoxin binders whether natural or modified is an area that will no doubt continue to grow and evolve as mycotoxin contamination of animal feed increases due to climate change. It is therefore important that further research is conducted in this area to not only probe the efficacy and health implications of additives used in this manner, but to also look for more natural products that are both effective and safe to use.

Behind Agritox Project

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Her main research interests are the detection of fungi from animal feed and macroalgae samples, their identification using morphological and molecular tools, and the determination of their mycotoxinogenic potential using HPLC techniques.

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