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An Evolution in Mycotoxin Mitigation:
Toward a Holistic and Robust Multimodal Strategy

Mycotoxins are a diverse group of naturally occurring toxic secondary metabolites produced by filamentous fungi such as *Fusarium, Aspergillus, Penicillium and Alternaria.* They represent one of the most pervasive challenges to agriculture, particularly to animal nutrition, as they compromise feed safety and animal performance across all regions of the world. These compounds frequently contaminate a wide range of agricultural commodities, including cereal grains, forages and stored feed ingredients, both pre- and post-harvest. Their resilience to environmental changes, resistance to standard feed processing, and ability to persist across diverse commodities mean they remain a constant risk. The economic impact of mycotoxins extends beyond immediate animal health problems, creating long-term losses due to reduced productivity, impaired fertility, suppressed immunity, and decreased efficiency of nutrient utilisation. Over the past few decades, the issue has become even more complex, with producers increasingly facing multiple co-occurring toxins and emerging fungal metabolites not captured in traditional monitoring systems.

A Complex and Growing Challenge

During the 1980s, the U.N. Food and Agriculture Organisation (FAO) estimated that 25% of the world's crops were contaminated by mycotoxins. Improvements in analytical chemistry, particularly the development of liquid chromatography coupled with tandem mass spectrometry, have revealed that this figure was a vast underestimate. Contemporary data indicate that between 60% and 80% of feedstuffs worldwide are contaminated.

Alltech's global monitoring program, which has operated for more than 15 years and analyses about 15,000 samples annually, confirms the breadth of the problem. More than 92% of tested samples contain detectable mycotoxins, and the average number of co-occurring toxins has risen from five to as many as eight per sample. The profiles vary by geography, crop, storage and climate, but across datasets, the most frequent are B trichothecenes such as deoxynivalenol (DON), along with fumonisins, aflatoxins, ochratoxin A (OTA) and zearalenone (ZEA).

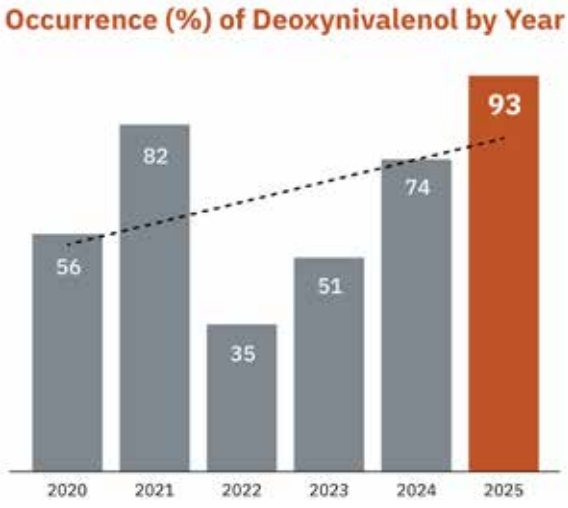


Figure 1. Alltech 37+ analysis of DON in European wheat and barley, 2022–2025

At the same time, the increased capabilities of modern detection has revealed the widespread presence of 'masked,' or conjugated mycotoxins, as well as emerging compounds such as fusaric acid, enniatins, beauvericin and moniliformin. The toxicological significance of some of these metabolites remains under investigation, but their prevalence indicates that animals are exposed to complex and unpredictable mixtures rather than to single compounds in isolation.

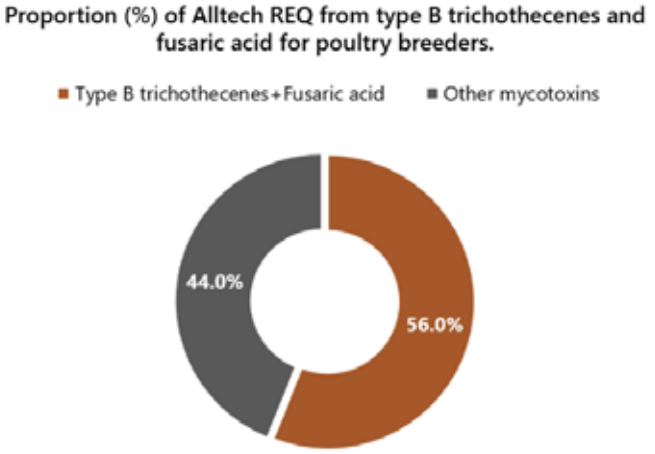
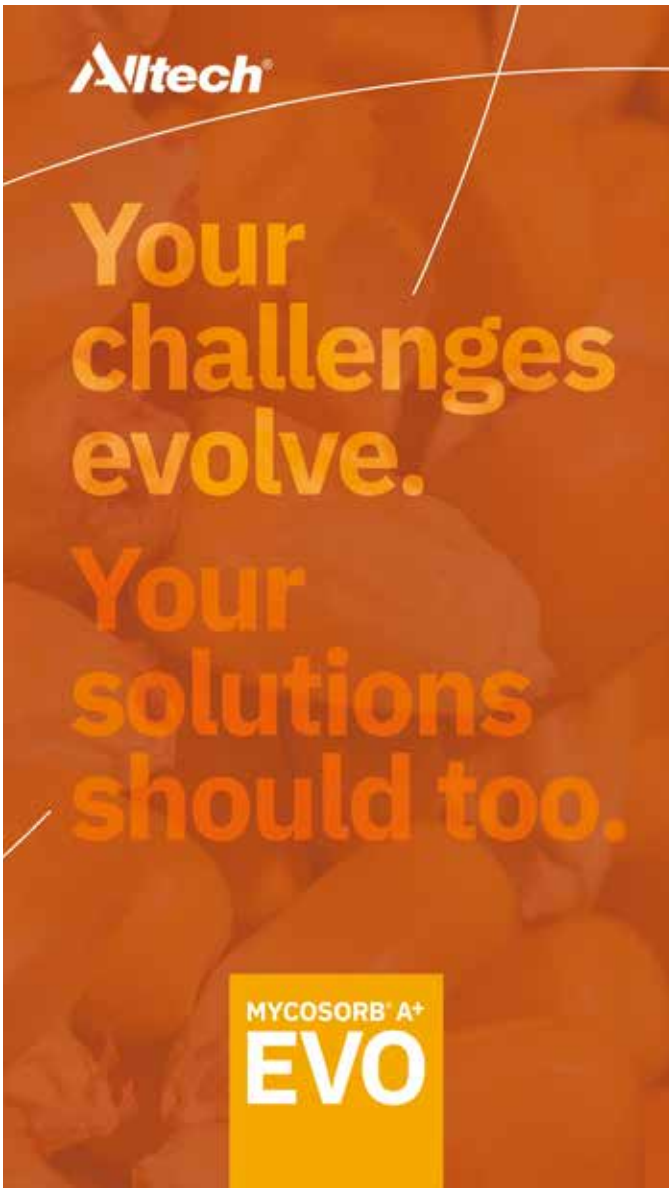


Figure 2. Alltech REQ global data for type B trichothecenes and fusaric acid in poultry breeders

Limitations in Regulatory Frameworks

Despite the well-established toxicity of major mycotoxins, regulatory frameworks remain limited. In regions such as the EU and the U.S., only aflatoxin B1 (AFB1) in animal feedstuffs, and its metabolite aflatoxin M1 (AFM1) in milk, are subject to strict legal limits. Other compounds, including DON, ZEA, OTA, patulin and fumonisins, are currently governed by guidance levels or non-binding recommendations. Lesser-studied or emerging mycotoxins such as fusaric acid (FA), beauvericin, moniliformin and enniatins are frequently detected but not yet regulated.

One of the critical limitations in current regulatory policies is the incapacity to account yet for the co-occurrence and potential interactive effects of multiple mycotoxins within a single feed matrix, because of the complexity of mixtures encountered in the field and the dose-dependent relationship between toxins and their effects on animals. Numerous *in vitro* and *in vivo* studies have demonstrated that mixtures of mycotoxins can exhibit additive, synergistic or antagonistic toxicological interactions, thereby amplifying their adverse effects on animal health and productivity beyond what would be predicted from individual toxin levels. While acute mycotoxicosis – often resulting in overt clinical signs and pathology – is well documented, chronic, low-dose exposure has now been characterised in the scientific literature as a major concern in livestock production and economics. Such exposure has been linked to subclinical effects including



immunosuppression, reproductive dysfunction, impaired gut integrity and reduced nutrient absorption, ultimately compromising animal performance and economic returns.

Emphasising Mitigation, Not Complete Prevention

Given the resilience of mycotoxins, complete prevention is unrealistic. Agronomic and storage interventions can reduce but not eliminate risk. Therefore, mitigation strategies incorporated into feed remain essential. Effective solutions have to demonstrate efficacy against a wide spectrum of toxins, function under gastrointestinal conditions, and be supported by mechanistic data as well as *in vivo* validation. In the portfolio of available mitigation strategies, early mitigation relied heavily on yeast cell wall components, particularly β-glucans, which adsorb toxins through non-covalent interactions made of hydrogen bonding and hydrophobic forces. These have shown to be an important initial step, but in some cases could be limited against the full diversity of contamination encountered. Climate change, shifting agronomic practices, and the globalisation of feed trade continue to reshape fungal ecology, further emphasising the need for more robust solutions.

Alltech's Mycosorb® Evo range:
The Next Evolution in Mycotoxin Mitigation

To address this challenge, Alltech and its research team developed Mycosorb® A+ Evo and Mycosorb® Evo as the next generation of its mycotoxin mitigation technology. The Mycosorb Evo range builds on the foundation of the original Mycosorb® but introduces a patent-pending formulation that combines functionalised yeast cell wall components with a novel bacterial ingredient. Through a process of targeted screening and optimisation, this formulation was shown to achieve synergistic interactions that significantly expand the range and strength of adsorption compared with conventional yeast-based products. The addition of algal-derived material in Mycosorb A+ Evo provides enhanced binding against difficult-to-bind toxins such as citrinin and penitrem A, adding modularity and versatility to the approach. The outcome is a composite material that reflects decades of research, yet responds directly to the realities of modern contamination.

Results of Biochemical Assays

Extensive biochemical assays confirmed that the Mycosorb Evo range delivers superior adsorption capacity. DON binding was improved twofold, and FA binding nearly threefold, compared to conventional yeast-based technologies. This is especially relevant because FA alone is not highly toxic, but in combination with DON it exacerbates cytotoxicity, making its mitigation particularly valuable. Broad-spectrum performance was also observed: aflatoxins were bound at levels exceeding 78%, OTA up to 66%, trichothecenes between 33% and 93%, and ZEA between 43% and 88%. *Aspergillus*- and *Penicillium*-derived toxins were sequestered with adsorption between 79% and 100%, and ergot alkaloids showed binding levels ranging from 45% to 87%. Emerging *Fusarium* metabolites such as enniatins demonstrated adsorption values ranging from 39% to 100%. In addition, algal supplementation improved the binding of citrinin to as much as 88% and of penitrem A to 74%. Together, these results confirm the broad spectrum of efficacy and indicate that the components act synergistically to yield adsorption beyond the performance of individual ingredients.

Synergistic Mitigation of Mycotoxins in IPEC-J2 Cells

Beyond binding assays, biological relevance was assessed using swine jejunal epithelial cells, which are physiologically pertinent because the small intestine is the site of first exposure to ingested mycotoxins. When cells were exposed to DON alone, Mycosorb Evo restored viability by an average of 33%. Under combined exposure to DON and FA, viability improved by 47%, with recovery reaching up to 58% at lower toxin concentrations. These findings confirm that Mycosorb Evo reduces the cytotoxicity of mycotoxins under biologically relevant conditions and demonstrates protective effects even when multiple toxins are present.

***In Vivo* Validation in Broiler Chickens**

In vivo validation was obtained through a broiler chicken trial. Birds were fed diets naturally contaminated with a mixture of *Fusarium* toxins, including DON, FA and ZEA. While body weight gain and feed intake did not differ significantly across treatments, improvements in feed conversion ratio were observed in birds receiving the formulation, particularly between days 22 and 28. Inflammatory biomarker analysis revealed modulation trends of calprotectin levels in blood and caecal tissues, suggesting mitigation of mycotoxin-induced immune disruption, possibly through reduced neutrophilic infiltration and local intestinal inflammation. Cecal volatile fatty acid profiles and genes related to butyrate synthesis remained stable, indicating preserved microbial function. Blood analysis demonstrated lower concentrations of DON in treated groups, confirming reduced systemic absorption. Collectively, these findings demonstrate a multimodal protective effect that includes improved efficiency, immune

function support, and limited translocation of toxins across the gut barrier.

Assessment with the REQ Model

To quantify overall impact, Alltech applied its Risk Equivalent Quantity (REQ) model, a composite index that integrates concentrations of multiple mycotoxins into species-specific and age-specific measures of burden. Application of this model demonstrated that the Mycosorb Evo range reduced residual risk by between 50% and 75%, depending on the toxin profile and species considered. This substantial reduction highlights the relevance of the formulation under commercial conditions, where animals are typically exposed to multiple interacting toxins.

Taken together, the evidence positions the Mycosorb Evo range as a next-generation advance in mycotoxin mitigation, a technology that preserves the foundation of yeast-based sequestration while incorporating additional biological components that expand efficacy and ensure relevance against emerging challenges. The formulation demonstrates superior adsorption across a broad spectrum of toxins and quantifiably decreases systemic exposure in animal models. These outcomes reflect a strategic shift from single-mode binding agents toward synergistic, multi-component solutions capable of addressing the complexity of modern contamination.

Setting a New Standard

The implications for animal agriculture are significant. As mycotoxins cannot be eliminated from feed, mitigation technologies must evolve in parallel with the changing landscape of contamination. Mycosorb A+ Evo and Mycosorb Evo exemplify this evolution, offering a scientifically validated and biologically relevant tool to reduce the burden of exposure. By lowering cumulative risk by up to 75%, preserving intestinal integrity and supporting feed efficiency, the new Mycosorb Evo range establishes a new standard for in-feed mitigation.

For researchers, the development of these technologies underscores the value of iterative, evidence-driven approaches that integrate biochemical, cellular and animal data into comprehensive solutions. For producers, these solutions offer greater assurance in safeguarding animal health and protecting productivity in an environment where mycotoxins remain a constant, if often invisible, threat.

Product availability and details may vary by country. Contact your local Alltech representative for specific information.

REFERENCES

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