The impact of in-feed mycotoxins and the need for pig-specific solutions

Although mycotoxins in feed ingredients pose a significant threat to the health and performance of all livestock species, pigs are known to be particularly susceptible. The Fusarium-derived mycotoxins fumonisin (FUM) and zearalenone (ZON), for example, are acutely toxic to pigs, but are much less damaging to poultry.

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Yet until recently, the impact of such species-specific aspects of the mycotoxin threat has been largely overlooked, and the development of in-feed adsorbents and deactivators has focused primarily on a one-size-fits-all strategy.

However, as evidence of clear differences in mycotoxin exposure and susceptibility between species has mounted, so too has the demand for solutions that target the specific threat and physiological characteristics of each species individually.

Differing priorities

For pigs, the greatest risk to health and performance comes from the various mycotoxins produced by Fusarium infection of feed ingredients, namely FUM and ZON, plus the trichothecenes deoxynivalenol (DON) and T2 toxin.

Aflatoxins produced by Aspergillus are also important, and the differences in relative toxicity compared to other species can be seen in Table 1.

Each mycotoxin also produces a variety of negative effects in the pig (Table 2), with pulmonary oedema characteristic of acute poisoning with FUM, whilst the trichothecenes are toxic to gut epithelial cells and known to cause intestinal lesions. Since gut health and integrity are critical to efficient nutrient digestion and absorption, such exposure leads to poorer feed conversion efficiency, lower feed intakes and reduced liveweight gain.

Along with FUM, the trichothecenes also impair immune function, increasing susceptibility to disease.

Additional losses

In contrast, ZON is the mycotoxin most commonly implicated in reproductive failure, including reduced conception rates – ZON mimics oestrogen – and in extreme cases, embryonic loss.

Particularly noticeable in second parity sows, which make up approximately 19% of the reproductive herd, ZON exposure can exacerbate the delayed return to oestrus and smaller litter size that typically follows the stress of first lactation, further reducing productivity.

Aflatoxins are important for their effects on both productivity and health. Acting at the cellular level, aflatoxins bind to DNA and prevent RNA synthesis, reducing protein synthesis and cutting growth rates by up to 3.9% for every 1ppm increase.

Table 1. Relative toxicity of different mycotoxins on different livestock species (+: mild toxicity, ++: moderate toxicity, +++: high toxicity)

Toxin	Swine	Poultry	Ruminant
Fumonisin	+++	+	+
Zearalenone	+++	+	++
Deoxynivalenol	++	+	++
T2 toxin	+++	+++	+++
Aflatoxins	+	+++	+
Ochratoxins	++	+++	+

Posing greatest risk in tropical regions where warm, humid conditions encourage the growth of Aspergillus moulds during feed transport and storage, aflatoxins have also been implicated as carcinogens.

Any potential residue in muscle tissues is therefore important from a human health perspective, whilst transfer to the milk in lactating sows has been reported to reduce immune function in piglets.

Commercial impact

It is these younger pigs that are at greatest risk. A meta-analysis of over 85 published studies revealed age and total mycotoxin exposure as the two factors having greatest influence on the growth rate effects of mycotoxins. Young animals were found to be most susceptible, with male pigs more affected than females.

Although risk decreases with age and so is clearly linked to stage of production, in-feed mycotoxins remain a threat throughout the pig's productive life. The negative effects on growth, reproduction and disease susceptibility have the capacity to substantially reduce overall production efficiency and profitability even at low, chronic levels of contamination.

On most commercial pig units, however, total mycotoxin load is relatively high, due primarily to the heavy reliance on cereal grains in pig feeds. The Fusarium fungal diseases prevalent in those cereal crops

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produce high levels of contamination with FUM, ZON and DON in particular.

Of these, DON is the mycotoxin most frequently found in pig feed, although individual mycotoxins are rarely found in isolation.

In-feed mycotoxin load

In 2014 and 2015, Micron Bio-Systems carried out an analysis of common pig feed ingredient samples from across Europe and the Middle East – wheat, wheatfeed, maize, distillers' grains – and found DON, FUM and ZON in 66%, 56% and 53% of samples respectively. Maize contained mycotoxins most frequently and at the highest levels.

Overall, nearly half the samples contained a total mycotoxin load classed as high risk (over 500ppb, Fig. 1A). Similar results have been reported in pig feed analysed through the Mycocheck mycotoxin testing service (Fig. 1B).

Pig diets also rely heavily on human-edible ingredients, and those batches failing to meet the more stringent mycotoxin limits for human consumption often find their way into animal feed. In addition, pigs are regularly fed co-products from the human food chain, where processing can concentrate the mycotoxin load.

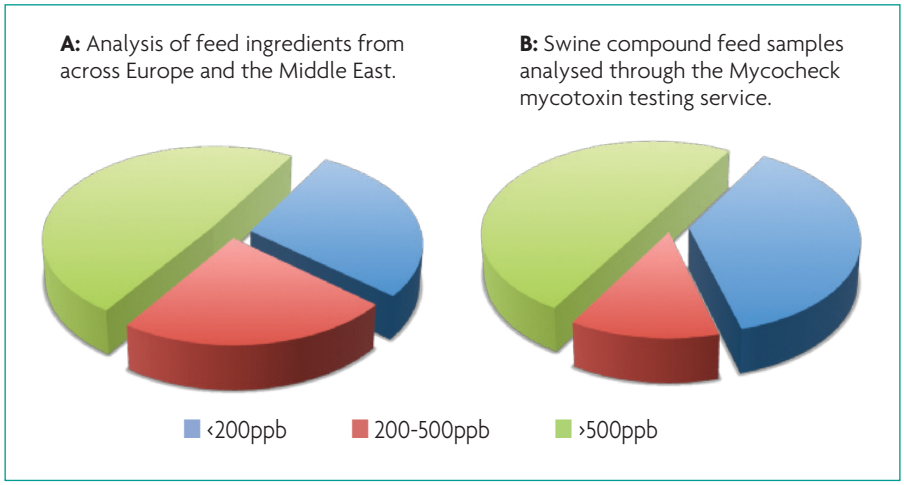

Fig. 1. Proportion of feed ingredients and swine compound feed classed as low, medium and high risk based on total mycotoxin load.

Remediation strategies

With these mycotoxin threats now widely recognised, the use of in-feed mycotoxin deactivators and binders has increased markedly in recent years.

Designed to bind, transform or degrade mycotoxins, there is a wide range of such products available commercially.

Binding (adsorption) is the most common approach within the feed industry, with clay minerals such as bentonite used to bind with polar mycotoxins (aflatoxin) and yeast cell walls demonstrating some efficacy against non-polar Fusarium mycotoxins.

The ability to maintain efficacy within the pH range typically found in the pig's gastro-intestinal tract (pH 3-7) is critical to success.

An additional strategy, particularly for non-polar mycotoxins, is to remove or modify a particular functional site on the surface of the mycotoxin.

This transformation can render the mycotoxin harmless, or expose the binding site of the molecule to mineral binding agents, and is typically achieved using components targeted at either pH 3 or pH 7. Finally, degradation is the application of multiple transformations to ensure that any mycotoxin fragments remaining after transformation – even if bound to a mineral binder – do not retain any toxic effect.

For swine producers, the strategy of transformation and degradation is particularly pertinent, since it is the most effective in eliminating the effects of DON, which is both highly prevalent in pig feeds and acutely toxic to pigs.

Table 2. Negative effects of different mycotoxins in swine.

Symptoms	Mycotoxins				
	Aflatoxin	Fumonisin	Trichothecenes (DON/T2)	Zearalenone	Ochratoxin A
Intestinal haemorrhages			✓		✓
Skin lesion			✓		
Kidney damage		✓	✓		
Diarrhoea			✓		
Reduced conception rates/ irregular heats			✓	✓	
Immune suppression	✓	✓	✓		✓
Embryonic loss/ abortion/stillborns			✓	✓	
Reduced growth/weight gain	✓		✓		
Vomiting			✓		
Feed refusal			✓		
Reduced feed intakes			✓		
Oral lesions			✓		
Pulmonary oedema		✓			
Liver damage	✓	✓	✓		✓

Targeted swine solutions

The most effective approach is typically a combination of all three strategies, and it is clear from the information above that it is the specific nature of the mycotoxin threat that will dictate how such strategies should be prioritised. It also highlights just how important it is to understand the differences between species, both in terms of exposure and vulnerability.

In pigs, for example, ZON is metabolised to the more toxic alpha-zearalenol, whereas in poultry it is the less toxic beta-zearalenol that is produced instead, and such differences are already recognised by key regulatory authorities.

In the EU, maximum permitted limits for FUM and ZON in pig feed are set at 5ppm and 0.1ppm, respectively, whereas in poultry the limit for FUM is 20ppm and there is no specific limit for ZON.

The recent development of swine-specific in-feed mycotoxin solutions, such as Ultrasorb S, therefore represents a major advance in mycotoxin remediation and is already leading the way towards potential customised, bespoke solutions based on individual farm mycotoxin profiles.

Although reliant on effective and timely testing of feed samples for actual mycotoxin loading, the potential benefits from such a flexible, yet highly targeted, approach are likely to generate considerable interest in years to come. ■