

Mycotoxins - Part 1

Today's global threat to poultry

The frequency of mycotoxin contamination of poultry feeds appears to be on the increase globally. This is a serious threat, since complex poultry rations are highly susceptible. As a result, such contamination can seriously affect bird performance. Proper measures are needed to minimise losses.

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Do you know that mycotoxins are the second most important issue faced by the animal industry today next to feed cost? This sentiment was expressed by 30 animal industry leaders, representing 15% of world feed production, who recently attended Alltech's President Club.

Mycotoxins are metabolites produced by fungi (moulds) that can infest crops pre-harvest and can continue to flourish under sub-optimal storage conditions. Grains with high moisture content are particularly unstable and prone to mould proliferation and possible mycotoxin production. Excess rainfall at harvest and at key periods during the growing season can be a major promoter of mycotoxin contamination of feedstuffs.

Aspergillus mainly in tropics

The most significant species of mycotoxin-producing fungi that have an impact on poultry production would include *Aspergillus* and *Fusarium*. The most significant mycotoxin produced by *Aspergillus* fungi are the aflatoxins. The fungi that synthesise aflatoxins *A. flavus* and *A. parasiticus* are considered to be tropical or semi-tropical moulds that thrive under conditions of high moisture and temperature. The effects of feed-borne aflatoxin on poultry production have been extensively studied and we have a good understanding of the tolerance of various classes of poultry. This is partly



due to concern for human health and food safety issues arising from contamination of poultry products with aflatoxin, since aflatoxin is a potent hepatocarcinogen. Analytical techniques for aflatoxin analysis in feeds are very practical due to the small number of different compounds that allow their simultaneous analysis.

Another important mycotoxin is the nephrotoxin ochratoxin A. This compound is produced by *Aspergillus ochraceus* and *Penicillium verrucosum*. As with aflatoxin, there is concern that residual ochratoxin A in poultry products could pose a threat to human health due to the possible carcinogenic nature of this compound.

Fusarium in temperate climates

Fusarium fungi flourish in more temperate climates. Our understanding of *Fusarium* mycotoxicoses in poultry is much less complete than our understanding of aflatoxicosis. This is in part because of the very large number of *Fusarium* mycotoxins, more than 100 that have been chemically characterised, which makes complete analysis of feedstuffs for *Fusarium* mycotoxins impractical, if not impossible.

The most commonly recognised *Fusarium* mycotoxins include the trichothecenes, a large family of structurally-related compounds including deoxynivalenol (DON, vomitoxin), T-2 toxin, nivalenol, diacetoxyscirpenol (DAS) and over 100 others, zearalenone, an oestrogenic compound, fumonisins and fusaric acid.

Analysis in poultry feeds

A major source of error in mycotoxin analysis is inadequate sampling of feedstuffs, with sampling accounting for approx. 82% of the variability in analysis. Proper sampling protocols have been developed and published in an effort to minimise this source of error. However, even with such protocols, error is unavoidable as mycotoxins are not evenly distributed within a batch, but occur in hotspots. Even with correct sampling, as an example, from a 25 t batch of feed, approx. 100 sub-samples should be taken comprising a total of 25 kg. From this a 250 g sub-sample is taken and eventually a 1 g sample analysed. Considering that only 1 g is analysed from 25 t, it is hardly surprising that mycotoxin analysis is not accurate!

Another source of error is the potential presence of different chemical forms of mycotoxins that may escape routine analysis. Attention has been focused on the presence of conjugated forms of mycotoxins that are produced by plants. This may be the result of detoxification of mycotoxins by plant metabolism, and it has been suggested that the presence of conjugated mycotoxins might be used in genetic selection of plant resistance to fungal invasion. Although conjugated forms of deoxynivalenol (DON, vomitoxin) were identified many years ago (1992), little information is available regarding the relative significance of conjugated and free mycotoxins in poultry diets. Schneweis and co-workers identified glucose conjugated zearalenone in samples of wheat. Naturally-contaminated

wheat and corn samples from Slovakia have been found to contain glucose-conjugated DON with up to 29% of deoxynivalenol in a glucose conjugated form (2005). More recently, an increase in DON concentrations of up to 88% were found when barley samples from North Dakota were treated with trifluoroacetic acid prior to analysis. Such acid treatment would hydrolyse all different conjugates of DON. Similar acid treatment of different barley samples showed up to 21% of total DON found in conjugated forms. Most recently, even higher levels of bound DON were found in barley and beer using a variety of analytical techniques.

Correct values underestimated

The frequency of bound fumonisin routinely exceeded free fumonisin in samples of European corn and corn-based foods. It is not yet clear if the conjugated forms of mycotoxins are as harmful to poultry as the parent compounds, but it has been shown that some conjugated mycotoxins can be hydrolysed in the digestive tracts of animals.

It must be concluded that until we have a better understanding of the frequency, toxicity and nature of conjugated mycotoxins, current mycotoxin analysis of poultry feeds should often be considered to be an underestimate of correct values. To further complicate matters, there exists a number of different analytical techniques (for example ELISA and HPLC) that vary in accuracy and can be sensitive to interference from some dietary components (such as in DDGS). It should also be noted that typically feeds are only analysed for the presence of certain 'indicator' mycotoxins. It is well established that mycotoxins rarely occur in isolation and that mycotoxins, when present in combination, can act synergistically to produce more pronounced detrimental effects in the bird. It is necessary at this time, therefore, to consider mycotoxin analysis of feeds as offering only an approximation of the true hazard posed by the feeding of contaminated materials to poultry.

Effects on performance

A series of studies has been conducted to determine the effects of feeding blends of naturally-contaminated feedstuffs, largely corn and wheat, to different types of poultry. This was done in an effort to mimic conditions seen in commercial poultry production where diets contain multiple vectors of mycotoxin contamination. The mycotoxins in such diets were determined to be mainly DON with lesser amounts of zearalenone and 15-acetyl DON in addition to fusaric acid. Three different modes of action of the mycotoxins fed were identified: reductions in cellular protein synthesis; reduced immunity; and alterations in brain neurochemistry.

Reductions in cellular protein synthesis

result in lesions of the gastrointestinal tract, including necrosis, gizzard erosion, haemorrhaging, and malabsorption of nutrients. Reduced hepatic protein synthesis can decrease utilisation of dietary amino acids resulting in increased uric acid synthesis as amino acids are oxidised for energy purposes.

Many *Fusarium* mycotoxins, as well as aflatoxin and ochratoxin, have been shown to be immunosuppressive. This results in increased susceptibility to disease, lingering health problems in the flock and possible failure of vaccination programmes. The disease symptoms arising from immunosuppression, moreover, are not symptoms characteristic of mycotoxins. They are only indirectly caused by mycotoxins and this makes certain identification of mycotoxins as the causative agent of reduced flock health very difficult.

Combinations of feed-borne *Fusarium* mycotoxins are pharmacologically active. This means they have drug-like properties due to their effects on brain neurochemistry. The most reproducible effects observed are elevations in brain regional concentrations of serotonin. Such changes alter behaviour, including reductions in feed intake, loss of muscle coordination and increased lethargy. The effects on various types of poultry were as follows:

Broilers

The feeding of a blend of ingredients naturally-contaminated with a combination of *Fusarium* mycotoxins resulted in reduced growth in the grower phase, elevations in blood uric acid levels, discoloration of breast meat and immunosuppression. Other research also showed changes in brain neurochemistry.

Broiler breeders

The feeding of a similar combination of *Fusarium* mycotoxin contaminated materials to broiler breeders significantly reduced hatchability due to reduced shell thickness of fertile eggs. Changes in brain neurochemistry were also observed. There were no effects of diet on sperm quality. In a parallel study with broiler breeder pullets, Girgis and co-workers observed immunosuppression.

Laying hens

Laying hens were very sensitive to the feeding of combinations of *Fusarium* mycotoxins. Egg production and feed efficiency were reduced while major increases in blood uric acid concentrations were seen. The elevations in blood uric acid levels were likely due to a reduction in hepatic fractional protein synthesis rates. Immunosuppression was also observed.

Turkeys

Turkeys were very sensitive to the feeding of high levels of *Fusarium* mycotoxin-contaminated feeds. Growth rates were significantly reduced even in the starter

Table 1 - Impact of fusarium mycotoxins on growth performance of turkeys (Chowdhury and Smith, 2007)

Phase	Control	Contaminated
Starter	632a	573b
Grower	1845a	1676b
Developer	2446a	2220b
Finisher	2747a	2484b
Overall	7670a	6953b

phase (Table 1) and some indices of immunosuppression were seen. The feeding of lower concentrations of *Fusarium* mycotoxins also reduced growth rates, elevated blood uric acid levels and caused immunosuppression. This was coupled with morphological changes in the small intestine and changes in brain neurochemistry.

Ducks

Ducks were quite resistant to the feeding of combinations of grains naturally-contaminated with *Fusarium* mycotoxins. Indices of immunosuppression, however, were observed.

Minimise contamination

It can be concluded that poultry are sensitive to combinations of feed-borne *Fusarium* mycotoxins and that the feeding of contaminated materials should be minimised. It appears that the frequency of mycotoxin contamination of poultry feeds is increasing. This may be due in part to adverse weather conditions pre-harvest in many parts of the world arising from global climate change. The complex nature of modern poultry rations including the increasing use of potentially contaminated by-products such as distillers' dried grains adds to the possibility of toxicological synergy between combinations of mycotoxins, thereby increasing the severity of the response of poultry to contaminated feeds. Many of the adverse effects seen in the studies reviewed above could be prevented by the simultaneous feeding of a polymeric glucomannan mycotoxin adsorbent (Alltech Inc.). The use of an appropriate mycotoxin adsorbent is likely the best short-term strategy available for minimising the adverse effects of feed-borne mycotoxins in poultry feeds. It is hoped that long-term strategies such as improved quality control measures arising from advances in analytical methodology and plant breeding strategies to reduce the susceptibility of plants to fungal invasion will help to minimise mycotoxin challenges to the poultry industries in the future. ■

References available upon request

* This is the first in a series of 5 articles on mycotoxins in poultry nutrition. The following articles will all give in-depth information on the occurrence in poultry rations and possible solutions for prevention and treatment.