PRESENCE AND RISKS BY MYCOTOXINS IN ANIMAL NUTRITION

B. Veldman
Schothorst Feed Research, Lelystad, The Netherlands

A variety of crops are susceptible to fungal invasion and might be contaminated with mycotoxins, originating from the secondary metabolism of moulds. It is estimated that 25% of the world's crop production is contaminated to some extend with these mycotoxins. Contamination of food and feed commodities with mycotoxins can affect human and animal health. The following overview is mainly based on the result of two desk studies, initiated by the Dutch Product Board Animal Feed with the aim to implement control measurements for mycotoxins in the entire animal production chain (Dutch Product Board Animal Feed, 2003).

Presence of moulds and mycotoxins in feed components

The most frequently found toxigenic mould species in feed components belong to the genera *Aspergillus, Fusarium, Penicillium* and *Claviceps.* These moulds are able to grow over a wide temperature range, varying from 0°C for *Fusarium* species up to 48°C for *Aspergilli*. According to their prevalence, the above-mentioned fungal genera can be allocated to two categories. These categories are field moulds (*Fusarium* and *Claviceps spp*) invading plants prior to harvest resulting in pre-harvest mycotoxin contamination and storage moulds (*Aspergillus* and *Penicillium spp*), invading stored feed commodities, resulting in post-harvest mycotoxin formation.
The allocation into two groups indicates also the possibilities to apply preventive measures to avoid or reduce mycotoxin contamination. Under field conditions, mycotoxin formation occurs in response to stress situations such as temperature challenges, draught or water stress, reduced plant resistance due to phytopathogens, improper use of fertilisers, pesticides or fungicidal agents, time point of harvest and structural damage during harvest. This indicates the reasons why the formation of mycotoxins at the pre-harvest stage is variable and difficult to predict depending on local agricultural practice and geographical circumstances.
In contrast, proper crop management, including drying, cooling and facilitation of proper storage conditions, can largely avoid post-harvest contamination. Post-harvest storage of feed commodities and subsequent processing can be subjected to control measures following the general principles of a HACCP-protocol.
The design of a control programme for mycotoxins, should be based on the expected prevalence of toxinogenic moulds and mycotoxins in individual feed commodities.
Aflatoxins are present in tropical and subtropical products such as oil seeds, trichothecenes and zearalenone in (mainly) cereals and maize silage, fumonisins in maize and products thereof from mainly only EU imported commodities. *Penicillium roqueforti* toxins can be found in ensilaged feeds due to the preference of this mould for an acidic environment. However, P. roqueforti toxin production in naturally contaminated material has found to be time dependent (Müller and Amend, 1997). This production pattern hinders not only a successful P. roqueforti mycotoxin monitoring in ensilaged commodities, but also affects the evaluation of actual adverse health effects in animals. Ochratoxins (particularly ochratoxin A), can be expected in Northern Europe in grains, nuts, peas and sometimes in grass pellets. *Claviceps* sclerotia, which can be found in rye and grass, contain ergot alkaloids. Ergot alkaloids are also produced by endophytic moulds which are mainly found in grasses in tropical arid areas such as *Lolium perenne* L. (Perennial Ryegrass) and *Fescue arundinacea* Shreb. (Tall Fescue grass). Grass cultivars used in Europe for grasslands for cattle are endophyte-free.
Taking into consideration that all above-mentioned toxins are able to induce clinical signs of intoxication at high levels and are known to impair health and productivity of animals at lower levels, a monitoring programme for these most relevant mycotoxins (in Europe) should be considered.

Mycotoxin exposure assessment of farm animals

An indication of the exposure to mycotoxins for the different categories of farm animals can be made on the basis of the average and the maximum concentration of mycotoxins in raw feed materials. For ruminants, the exposure assessment is more complex as the diet may consist of three types of feed: concentrate, by-products and forages; the latter generally represent 50-80% of the diet. Therefore, in table 1, the average and maximum calculated mycotoxin concentrations in a regular feed for only poultry and pigs are given.
The outcome of these calculations allow the conclusions that the observed zearalenone concentrations in feeds are high enough to adversely affect health and reproduction of gilts and sows. The maximum safe limit (ML)-value for zearalenone in diets for sows, as formulated by the German authorities (Dänicke et al., 2001) is 250 µg/kg and for gilts even 50 µg/kg. Poultry is not very sensitive for zearalenone (> 25,000 µg/kg); even the maximum zearalenone concentrations in poultry feeds are far below the safe ML-value. The assessed deoxynivalenol concentrations are likely to reduce performance in pigs. The mean concentration is below the safe ML-value of 1,000 µg/kg for pig feeds and 5,000 µg/kg for poultry feeds (Dänicke et al., 2001), but the calculated maximum concentration is clearly higher, indicating that frequently negative health and performance effects may occur in pigs. Poultry and pigs are both sensitive to ochratoxin A. The Dutch Product Board Animal Feed has set a safe ML-value for ochratoxin A in feed of 50 µg/kg and 200 µg/kg for respectively pigs and poultry (pers. com.).
The mycotoxins aflatoxins, fumonisins and ergot alkaloids occur less frequently in feed commodities or at low concentrations (av. and max. conc. not shown) that adverse effects induced by these toxins seem to be less significant in poultry and pig feeds in Western Europe.

Table 1 Average and maximum calculated mycotoxin concentrations (µg/kg feed) in an average regular feed for poultry and pigs

Animal category	Deoxynivalenol		Zearalenone		Ochratoxin A	
	Average	Maximum	Average	Maximum	Average	Maximum
Broiler	18	198	5	50	0.2	4.6
Layer	30	404	7	32	0.1	5.0
Turkey	55	805	16	122	0.5	12.5
Fattening pig	335	5793	84	1150	3.4	91.4
Piglet	65	917	11	181	1.4	28.4
Gestating sow	182	3390	208	1346	2.9	65.6
Lactating sow	285	5834	84	1160	4.6	113.9

Forages generally represent 50-80% of the diet of dairy cattle, meaning that they have a significant impact on daily mycotoxin intake by dairy cattle. Grass and maize are the main forage crops in Europe. The average and maximum daily intake of deoxynivalenol and zearalenone by dairy cows showed that maize silage contributed approximately 80% of the daily deoxynivalenol intake and approximately 50% of the daily zearalenone intake, indicating that maize silage is a major source of mycotoxins in the diet of dairy cows (Driehuis and Te Giffel, 2003). However, there is no evidence that mycotoxins in rations for dairy cattle, *i.e*. concentrate with forage constitute a serious risk factor with respect to animal health.

Carry-over of mycotoxins into animal derived products

Farm animals can be substantially exposed to mycotoxins via the diet, but the transfer to animal products is usually much less. For dairy cows, the rumen act as an effective "filter" against mycotoxins, so the transfer of mycotoxins to milk is extremely low (0.03% or lower) except for the carry-over of aflatoxin B_1 to aflatoxin M_1 which varies between 1-6%. In order to prevent too high a concentration of aflatoxin M_1 in milk (> 0.05 µg/kg milk), European Community countries regulate the content of aflatoxin B_1 in feed: max. 5 µg/kg feed for dairy cows.

For pigs and poultry the carry-over of fumonisins, trichothecenes and zearalenone in edible tissues and eggs is very low due to poor absorption (fumonisins), rapid metabolisation (zearalenone) and rapid metabolisation plus excretion (trichothecenes). Ochratoxin A is an exception with carry-over rates of 5-20%, as it binds to plasma-proteins once absorbed, resulting in accumulation in the animal body. Accumulation of ochratoxin A in kidneys and to a lesser extend in liver and muscles has been reported which resulted in regulations for pig organs and meat in some EU member states. For the consumer however, the contribution from animal derived products to the total intake of ochratoxin A is small compared to plant derived products.

Conclusion

Feed components are often contaminated with mycotoxins, mostly at lower levels but the degree of contamination may change from year to year. A monitoring programme for the most relevant mycotoxins should be considered. Evaluation of mycotoxin exposure to farm animals revealed that negative health and performance effects of pigs may occur with deoxynivalenol or zearalenone contaminated feed. The risk for animal production losses is low for poultry and dairy cattle. Carry-over of mycotoxins to animal products should under modern agricultural practice not pose a human health hazard if proper control measures are in place, preferably based on HACCP principles.

References

1. Dänicke, S., M. Gareis and J. Bauer (2001). Orientation values for critical concentrations of deoxynivalenol and zearalenone in diets for pigs, ruminants and gallinaceous poultry. Proceedings of the Society of Nutritional Physiology 10, 171-174.
2. Driehuis, F. and M.C. te Giffel (2003). Mycotoxins in forage feeds for dairy cattle. Proceedings of the second World Mycotoxin Forum, 17-18 February, Noordwijkerhout.
3. Dutch Product Board Animal Feed (2003). Mycotoxine. Kwaliteitsreeks nr. 88 en 89. www.pdv.nl
4. Müller, H-M. and R. Amend (1997). Formation and disappearance of mycophenolic acid, patulin, penicillic acid and PR toxin in maize silage inoculated with *Penicillium roqueforti*, Archives of Animal Nutrition 50, 213-225.