Mycotoxin contamination in animal feed and forages

Better Returns Programme

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Key messages

- Mycotoxins are chemical compounds produced naturally by moulds. They can cause toxicity in a variety of species
- Mycotoxins can reduce farm profits through reduced crop yields, product rejection and lower animal productivity and health
- Feeds and forages can become contaminated with mycotoxins in the field, during harvest, drying and transport, as well as during storage
- There are around 400 known types of mycotoxins with Aflatoxins (AFL), Fumonisins (FUM), Ochratoxin A (OTA), Deoxynivalenol (DON), T-2/HT-2 and Zearalenone (ZEN) regarded as most significant
- Good agricultural and storage practices are the best ways to control and prevent mycotoxin contamination of feeds
- Mycotoxins can be found in cereal grain, straw and silage
- The key factors affecting likely risk of mycotoxins in grain are: preceding crop, crop debris, variety, agronomy and weather at flowering and harvest
- Currently Aflaxtoxin B1 is the only mycotoxin with legal limits for inclusion in animal feed
- Tests to detect the presence of mycotoxins can be run on forage and feed samples, as well as blood and tissue samples
- Mycotoxin binders are available that reduce the risks associated with continued feeding of the affected feed
- Where mouldy feed is present it should always be discarded, as not only does it pose a high risk of mycotoxin contamination, it can also be associated with other health risks
- If mycotoxin exposure is suspected in livestock, contact the vet for further advice

Keywords:

Mycotoxin contamination, symptoms of mycotoxin poisoning, avoid feeding livestock mycotoxin-affected feed, mycotoxin mitigation products

Contents

Introduction

Mycotoxins are chemical compounds produced naturally by moulds, which vary in size and structure and can cause toxicity in a variety of species including cattle and sheep.

Mycotoxins can reduce farm profits through reduced yields, product rejection and lower animal productivity and health.

Feeds can become contaminated with mycotoxins before harvest or during preservation or storage.

There are around 400 known types of mycotoxins, which are mostly produced by moulds of *Claviceps, Alternaria, Fusarium, Aspergillus* and *Penicillium genus*.

Aflatoxins (AFL), Fumonisins (FUM), Ochratoxin A (OTA), Trichothescenes (TRIC) and Zearalenone (ZEN) are regarded as the most significant mycotoxin groups affecting livestock production.

Regulations exist with legal and guidance limits for certain mycotoxins in animal feed, with the aim of protecting both human and animal health.

This BRP+ document aims to help the industry identify risk factors and appropriate management strategies to minimise the risk of mycotoxins in home-grown feedstuffs.

Occurrence and significance

Mycotoxins are chemical compounds produced naturally by moulds. They vary in size and structure and can cause toxicity in a variety of species.

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It has been shown some mycotoxins have a high carry over rate from feed to milk, possibly contributing to mycotoxin intake in human populations. There are different permitted levels in foodstuffs and feed.

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Mycotoxin production is influenced by environmental conditions including pre-and post-harvest temperature, agronomic practice, carbon dioxide and moisture levels.

Generally, mycotoxin contamination is most likely to occur in warm, wet conditions.

Health problems

Mycotoxins can cause a number of health problems in cattle and sheep, including reduced feed intake, reduced nutrient absorption, impaired metabolism, changes to hormone secretion and suppressed immune system, all with a negative impact on livestock performance.

The severity of symptoms can be affected by the type of mycotoxin, the amount consumed and the duration of exposure. Contaminated batches of feed can contain several types of mycotoxins. This, combined with the fact that mycotoxins are often unevenly distributed throughout the feed, can make it difficult to pinpoint the exact effect a particular mycotoxin will have on an animal, since they have more than likely been exposed to several mycotoxins at the same time.

It is thought ruminants are less susceptible to mycotoxins than other species, because the bacteria which make the rumen function can degrade certain mycotoxins into a less toxic form, providing some protection. However, some mycotoxins can resist breakdown and prolonged exposure to mixtures of mycotoxins can impair the function of the rumen microbes.

Main mycotoxins affecting livestock

There are around 400 known types of mycotoxins with Aflatoxins (AFL), Fumonisins (FUM), Ochratoxin A (OTA), Deoxynivalenol (DON), T-2/HT-2 and Zearalenone (ZEN) regarded as the most significant with regards to animal health.

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The number of recognised mycotoxins is increasing, with the European Food Safety Authority considering the risk of ergot alkaloids, alternia toxins and citrinin to human and animal health. However, further research is required until recommendations can be made surrounding these mycotoxins.

Table 1: Main mycotoxins affecting ruminant health and performance

Type of mycotoxin	Causative mould	Symptoms	Additional information
Aflatoxins (AFL)	*Aspergillus*	Jaundice Weight loss Depression Immunosuppression Reduced milk yield	Carcinogenic Partially broken down by the rumen and excreted in milk
Fumonisins (FUM)	*Fusarium*	Decreased feed intake Reduced milk yield	Incompletely degraded by the rumen
Ochratoxin A (OTA)	*Aspergillus* *Penicillium*	Ill thrift	Potential human carcinogen Metabolised by rumen Found in meat, milk and dairy products
Deoxynivalenol (DON)	*Fusarium*	Immunosuppression Decreased feed intake Decreased milk yield	Commonly detected in maize Contamination usually occurs during crop growth when *Fusarium* grows best
T-2/HT-2	*Fusarium*	Immunosuppression Reduced fertility	Members of the same family as DON and affect animals in a similar way Commonly detected in oats and oat feed Signs of exposure seen at lower levels of contamination than DON
Zearalenone (ZEN)	*Fusarium*	Reduced fertility	Rarely toxic to ruminants Can be detected alongside its metabolites in urine

Sources of mycotoxins

Good agricultural and storage practices are the best ways to control and prevent mycotoxin contamination of feeds.

Generally, mycotoxins are very stable compounds that can survive on the grain long after the initial mould has disappeared, so the absence of mould does not mean the crop is clean.

Good agricultural and storage practices are the best ways to control and prevent mycotoxin contamination of feedstuffs and subsequent exposure to livestock.

Mycotoxins can be found in grain, silage and straw.

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Cereal grains

Cereals are susceptible to mycotoxins produced while the crop is growing, eg *Fusarium* species and during storage, eg *Penicillium* species.

Field mycotoxins:
In the field, infection of ears by *Fusarium* species can result in mycotoxin development when the weather is warm and wet at flowering.

Fusarium mycotoxin occurrence may be greater when wet weather delays harvest. Crops infected at flowering may have individual bleached spikelets, or partially bleached ears, resulting at harvest in pink or chalky white shrivelled grains. However, there is little correlation between *Fusarium*-damaged grains and mycotoxin contamination.

Storage mycotoxins:
Storage fungi can grow on cereals from about 14.5% moisture content (7.5-8% in oilseed rape) upwards. They can cause heating and loss of germinative capacity and some produce mycotoxins.

Ochratoxin A (OTA) may be produced by the storage mould *Penicillium verrucosum* if grain exceeds 18% moisture content. The greatest risk occurs during harvest backlogs and during ambient air-drying, when grain may take weeks to dry. Incidence of this mycotoxin can be unpredictable. In the UK only some strains of *Penicillium verrucosum* produce OTA and even when present, those strains do not always produce toxins.

Cleaning of feed storage areas between batches is key to minimising mycotoxin contamination.

Straw

Straw can contain higher concentrations of *Fusarium* mycotoxins than harvested grain. It is therefore important the consumption of straw by livestock housed on straw bedding is taken into consideration within any investigation of presumed mycotoxicosis.

In the delayed harvest of 2008, nearly 50% of straw samples exceeded the feed guidance limits for the mycotoxins DON and ZEN.

Mycotoxin levels can vary greatly between bales harvested from the same field, which could result in intermittent mycotoxin issues when they are fed.

To reduce the risk of mycotoxin contamination, straw should be harvested and stored undercover as soon as possible to minimise exposure to rain.

Silage

Aspergillus, Penicillium and *Fusarium* are considered to be the most important moulds and producers of mycotoxins in silage.

To minimise mycotoxin content of silage it is crucial the crop is ensiled at the optimum moisture and is compacted quickly.

It is also important that silage is covered properly so that no oxygen can enter the silage, as the presence of oxygen can cause fungal growth and mycotoxin production.

When feeding clamped silage it is recommended that the silo front is systematically removed, so that no one area remains exposed for long periods of time.

For baled silage, ensure bales are correctly handled to avoid damage to the plastic wrapping.

Assessing mycotoxin risk in grain

Mycotoxin levels in grain vary from year to year and between regions. The key factors affecting likely risk in grain are:

- Preceding crop
- Crop debris
- Variety
- Agronomy
- Weather at flowering and harvest

The key factors affecting likely risk in grain are, preceding crop, crop debris, variety, agronomy, weather at flowering and harvest.

The same risk factors are generally relevant to contamination of forages and feeds, with wet weather at harvest or poor conservation being a particular risk for forages and warm, moist conditions during storage being a high risk in both situations.

Table 2: Risk factors for mycotoxin contamination of grain

Risk factors	Importance
Previous cropping and crop residues	
Crop residue on the soil surface is the major source of head blight inoculum, especially after (in descending order) grain maize, forage maize, wheat or potatoes. Rotation helps to reduce overwintering inoculum by lowering levels of infected crop debris on the soil surface. Cultivation should effectively bury infected crop debris. • Plan rotation to minimise wheat after maize • Remove straw to help reduce crop debris	**High risk** Grain or forage maize **Moderate risk** Wheat, potatoes **Low risk** Others
Cultivations	
The aim of cultivations is to effectively bury crop debris. • Ensure crop debris is buried by ploughing or • Cultivate to mix crop debris into the upper soil layer	**High risk** 'Min-till or 'no-till' **Low risk** Plough
Region	
In wheat, levels of DON and ZEN tend to be lower in Northern England; moderate in western England and highest in Southern and South-eastern England. Evidence suggests that higher humidity in coastal areas may increase risk.	**High risk** Southern and South-eastern England **Low risk** Northern England
Weather	
Early season conditions from sowing to around growth stage (GS) 31, influence the build-up of inoculum. Warm, dry weather poses the highest risk.	**High risk** Warm and dry **Low risk** Cold and wet
During flowering (GS59-69) crops are particularly susceptible to severe head blight infection. Further rainfall after infection, particularly after ripening, allows secondary infection. • Consider need for ear spray, especially if weather is forecast to be, or is, wet during flowering • Apply fungicide at the recommended rate as near to infection time as possible • Measure rainfall as accurately as possible during this period	**High risk** Warm and wet **Low risk** Cold and dry
At harvest *Fusarium* mycotoxins may increase if wet weather causes delays. • Prepare before harvest to minimise delays • Harvest grain as soon as possible once ripe • Harvest and store separately grain from localised patches of weathered or lodged crops • Measure rainfall as accurately as possible during this period	**Moderate risk** Rain-delayed harvest
Variety	
More resistant varieties have a lower risk of *Fusarium* mycotoxin contamination. Current UK wheat varieties have a limited range of resistance to head blight. • Consider head blight resistance in choice of winter wheat varieties from the AHDB Recommended Lists for cereals and oilseeds at cereals.ahdb.org.uk	**Moderate risk** Wheat varieties with rating 5 and below **Low risk** Wheat varieties with rating 6 and above
Lodging	
Lodging causes humid conditions conducive to mycotoxin production. • Consider a Plant Growth Regulator (PGR) application at the appropriate dose and timing	**Moderate risk** Lodged crops **Low risk** Standing crops
Harvest	
The highest concentrations are found in *Fusarium*-damaged grains and chaff. • Set combine, especially fan speed, to minimise retention of light *Fusarium*-damaged grains and chaff • Combine and store weathered or lodged crop areas separately	**Moderate risk** Damaged grain Delayed harvest
Other agronomic factors	
A range of broad-leaved and grass weeds, as well as some insects, can carry *Fusarium*, leading to infected weed and crop debris, as well as a carry-over of spores.	

Assess risk at:

Start of the season
Consider likely effects of rotation and agronomy.

Early flowering
Take account of recent and forecast rain in deciding need to spray against *Fusarium*.

Harvest
Review all factors to determine mycotoxin risk and potential end-use for grain.

Assessing level of risk

Table 3: The risk to a winter wheat crop.

Factor	Details	Risk	Score
Region	High	4	
	Moderate	2	
	Low	-2	
	Very low	-4	
Previous crop	Maize	6	
	Other	0	
Cultivation	Direct-drilled	4	
	Standard non-inversion tillage	3	
	Intensive non-inversion tillage	2	
	Plough (soil inversion)	0	
Wheat variety	RL resistance rating 1-5	1	
	RL resistance rating 6-9	0	
	RL resistance rating unknown	1	
Pre-flowering score			
T3 fungicide	<50% dose rate of approved fungicide	0	
	50-74% dose rate of approved fungicide	-2	
	75% or above dose rate of approved fungicide	-3	
Rainfall at flowering (GS 59-69)	More than 80mm	9	
	40-80mm	6	
	10-40mm	3	
	Less than 10mm	0	
Rainfall pre harvest (GS 87 to harvest)	More than 120mm	12	
	80-120mm	9	
	40-80mm	6	
	20-40mm	3	
	Less than 20mm	0	
		Total score	

RL = Recommended List

Risk	High	Medium	Low
Total score	Over 15	10-15	Under 10

This tool is available to download from cereals.ahdb.org.uk

Consider testing if there is a high *Fusarium* incidence in the crop, or evidence of chalky-white shrivelled or pink grains in harvested grain.

Legal limits

Currently Aflatoxin B1 is the only mycotoxin with legal limits for inclusion in animal feed.

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This is because this mycotoxin is carcinogenic and can contaminate milk if lactating animals are exposed to significant levels. The maximum permitted limits for Aflatoxin B1 are shown below (Table 4).

Additional guidance values have been recommended for a further five mycotoxins.

These mycotoxins pose a risk to animal health and can affect livestock production for several species, but the risk to public health is considered low. The guidance limits are shown below (Table 5).

Table 4: Legal limits for Aflatoxin B1 in animal feed

Feedstuff	Maximum content in mg/kg (ppm)
All feed materials	0.02
Complete feedstuffs for beef cattle and sheep	0.02
Complete feedstuffs for dairy cattle	0.005
Complete feedstuffs for calves and lambs	0.01

Note: Relative to a feedstuff with a moisture content of 12%

Table 5: EU guidance values for mycotoxins in feed

Mycotoxin	Feedstuff	Maximum content in mg/kg (ppm)
Deoxynivalenol (DON)	Feed materials: - Cereals and cereal products - Maize co-products Complete feedstuffs for: - Sheep, beef and dairy cattle - Calves and lambs	 8 12 5 2
Zearalenone (ZEN)	Feed materials: - Cereals and cereal products - Maize co-products Complete feedstuffs	 2 3 0.5
Ochratoxin A	Feed materials: - Cereals and cereal products	 0.25
Fumonisin B_1 and B_2	Feed materials: - Cereals and cereal products Complete feedstuffs for: - Sheep, dairy and beef cattle - Calves and lambs	 60 50 20

Note: Relative to a feedstuff with a moisture content of 12%

Testing

Methods

Tests to detect the presence of mycotoxins can be run on forage and feed samples as well as blood, urine and tissue samples.

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New methods of detecting mycotoxins are currently being developed to improve the accuracy and range of mycotoxins that can be tested for.

If mycotoxin contamination is suspected, it is important to consult a vet to ensure thorough investigation to make a diagnosis.

Testing feedstuffs

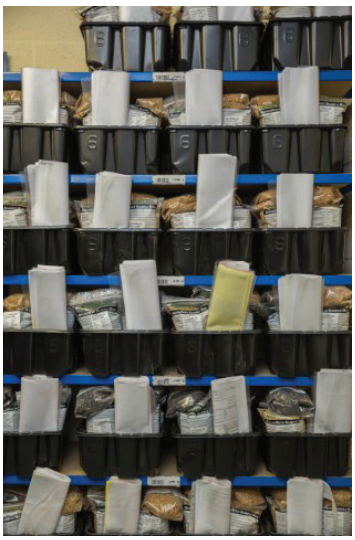
Methods range from simple on-farm tests indicating the presence/absence of specific mycotoxins, to officially recognised and validated methods of quantifying the levels present. For all methods, prior extraction from a ground sample of grain is needed.

Qualitative lateral flow dipstick methods indicate the presence or absence of a specific mycotoxin above a set threshold. Presence or absence of a test band is interpreted by reference to the manufacturer's instructions.

Quantitative assay methods measure the concentration of a specific mycotoxin. Test kits are available in two formats:

- **Quantitative lateral flow**, similar to the qualitative method, is suitable when a single determination is required, eg grain storage/intake (typically £15-£24 per test)
- **Micro-titer plate ELISA**, measures the intensity of colour produced by chemical reactions and is suitable for analysing multiple samples (typically £30 per test)

Confirmatory analysis uses sophisticated, costly instruments operated by highly skilled staff. Methods are validated according to (EC) No 401/2206 and conducted by laboratories with current UK Accreditation Service (UKAS) status (over £100/test).



Mycotoxin binders

Good agricultural and manufacturing practice is the best method of controlling mycotoxin contamination. However, where contamination has occurred, mycotoxin binders are available that reduce the risks associated with continued feeding of the affected material. These can help reduce the toxic capacity of mycotoxins and alleviate some of the detrimental health effects of toxin exposure. Care should be taken to ensure that the underlying nature of the intoxication is properly understood to make sure a suitable product is used.

Mycotoxin binders are available that reduce the risks associated with continued feeding of the affected feed.

Prevention of feed contamination is preferable to having to alleviate the problem. However, where mouldy feed is present it should always be discarded, as not only does it pose a high risk of mycotoxin contamination, it can also be associated with other health risks including abortion and mastitis.

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Feed additives available to mitigate mycotoxin contamination include:

- **Mineral and organic adsorbents**

The most commonly used mineral and organic adsorbents are the aluminosilicates and activated carbon, which work by holding toxins onto their surface. They are relatively inexpensive but require a high inclusion rate. Care must be taken when using activated carbon, as it is not selective to toxins and can lead to a reduction in available vitamins and minerals.

- **Biological adsorbents**

Biological adsorbents include yeasts, bacteria and lucerne fibre. Yeasts made from cell walls contain varying levels of sugars and cellulose, which allows them to bind to different mycotoxins.

Some strains of bacteria have been shown to have adsorbent properties. Lucerne fibre reduces mycotoxin absorption in the gut and improves excretion of the mycotoxins in the faeces.

- **Bio-transforming agents**

These include bacteria, yeasts and fungi that have the ability to convert toxins into less toxic forms.

Further information

If at any time mycotoxin exposure is suspected in livestock, contact the vet for further advice.

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References

AHDB Cereals and Oilseeds. Guidelines to minimise risk of *Fusarium* mycotoxins in cereals. Available at cereals.ahdb.org.uk

Commission Recommendation 2006/576/EC of 17 August 2006 on the presence of Deoxynivalenol, Zearalenone, Ochratoxin A, T-2 and HT-2 and fumonisins in products intended for animal feeding.

Commission Recommendation 2013/165/EU of 27 March 2013 on the presence of T-2 and HT-2 toxin in cereals and cereal products.

Directive 2002/32/EC of the European Parliament and of the Council of 7 May 2002 on undesirable substances in animal feed.

AHDB Recommended Lists - available at cereals.ahdb.org.uk

AHDB Cereals and Oilseeds Fusarium Risk Report available at cereals.ahdb.org.uk

AHDB Cereals and Oilseeds Risk Assessment Tool available at cereals.ahdb.org.uk

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