Moulds and Mycotoxin Problems Associated With Corn

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Mould and mycotoxin are common concerns regarding forage quality, especially (1) in regions where crops have suffered environmental or disease stress and/or (2) specific silage and high moisture grain storage situations that have compromised fermentation. There have been many excellent reviews of the more than 400 known mycotoxins, including one by L.W. Whitlow and W.M. Hagler Jr. in the 2008 Feedstuffs Reference Issue & Buyers Guide (Whitlow and Hagler, 2007). This paper will focus on the practical, applied aspects of mycotoxin testing, prevention and treatment drawn from recent discussions with some of the leading authorities in the industry.

In the field
Mould spores are virtually everywhere and easily survive over winter in soil and plant residues. Nature provides host plants with protection from invasion by mold spores. The pericarp of the corn kernel prevents entrance of foreign material. Mold spores gain entrance into grain and forage components in several ways.

- The primary avenue is pollination when fungal spores travel down the lumen of the corn silk to gain entrance into the kernel. The prevalence of mold growth depends on environmental conditions during silking time. For example, cool, humid summers allow Fusarium graminearum to prevail. Hot, droughty, and humid summers provide conditions for Aspergillus to prevail.
- The second way mold spores enter the corn plant is physically fracturing the kernel pericarp or stover wall due to trauma such as weather stress (drought, hail) or insect damage (e.g.: corn borer infestation).
- A third but minor mode of entry occurs during germination when soilborne mold spores from the rhizosphere enter into the seedling. Consequently, corn breeders have placed high importance on kernel texture in an attempt to help resist mold infestation and to be able to withstand the rigors of interstate shipment (Seglar & Mahanna 1995; Munkvold, 2003). Common field fungi (primarily Aspergillus and Fusarium spp.) are capable of producing recognizable toxins, including aflatoxin, vomitoxin (deoxynivalenol), fumonisin, zearalenone and T-2.

Estimates are that 70-90% of all mycotoxins are already in the corn ear prior to harvest and ensiling, although the presence of visible ear moulds does not
correlate well with mycotoxin contamination. Practical approaches to minimizing field-produced toxins are: (1) reduce fungi populations and access sites by planting hybrids with insect, stalk rot and ear mould resistance, (2) harvest in a timely manner with particular attention to proper moisture levels, (3) isolate silages from crops exposed to severe drought or hail damage and (4) consider traditional tillage methods to reduce fungal spore loads in crop residues. No silage acid or inoculant product is capable of degrading these preformed, field-produced toxins (Seglar, 2001).

In the grain bin
Grains stored at <15% moisture generally results in an environment that is not conducive to further mould growth during storage. Drying the grain in a “continuous-flo dryer” to a moisture level of 14% and then cooling to ambient air temperature as quickly as possible produces a stable grain environment. Plenum temperatures should range from 190-210 degrees F. for this crop to qualify as high quality grain without compromised nutrient availability.

Specific recommendations that corn growers should follow when storing corn grain in bins include:

- Begin the cool-down process as soon as the grain goes into storage.
- A 60,000 bushel bin with a 20 hp fan at 4” static pressure will provide 1/3 CFM of air.
- It takes 3 days of operation to reduce grain temperatures by 10 degrees.
- Ultimately grain should be cooled down to 30-35 degrees for safe storage. As outside air temperatures start to go down, the grain cooled down as quickly as possible to minimize chances of condensation on the inside bin walls.

Farmers need to monitor their stored grain on a weekly basis until sold. This is accomplished by having one person climb the bin ladder and access the manhole and have another person at the lower level start the fan letting it run 3-5 minutes. The man on the top level checks the air quality in the bin to make sure there is no condensation, and that the air is fresh and cool and that the static pressure gauge stays at the same reading as the previous week!

Weekly evaluations of grain stored in corn bins should be done utilizing Personal Protective Equipment (PPE) that involves use of an approved filter mask to avoid the potential inhalation of mold spores. See comments “In The Silo” section of this paper regarding information on organic dust toxic syndrome.

Once the crop that has experienced plant disease issues has been properly harvested and stored prospective buyers should be contacted to determine how they want to evaluate the marketability of the crop. During year of Gibb Ear Rot, this usually involves determining if mycotoxins are present, specifically vomitoxin (DON) and zearalenone. (Gnadke, 2010).
In the silo
Consultants and dairy producers observing moldy forages and grains should not inhale mold spores that may exist within ensiled feeds. A common agricultural health disease to humans known as organic dust toxic syndrome resulting in an acute cell mediated hypersensitivity inflammatory reaction that can create a lifelong chronic condition known as hypersensitivity pneumonitis. (Sorensen & Lewis, 1996)

The field fungi described above does not typically grow in the anaerobic, low-pH environment found in well-managed silages. However, it is possible for these fungi to produce additional toxins in the storage structure, but only in aerobically challenged silages resulting from low harvest moisture, poor initial compaction or improper feed-out techniques.

Crops heavily laden with Candida and Hansula yeast species are of particular concern because these lactate consumers can elevate silage pH. Conditions then become conducive for growth of field fungi in the storage structure should excess oxygen penetrate high-pH silages.

The most common moulds isolated from northern European silages include Penicillium rouqueforti, Aspergillus fumigatus, and Monascus ruber (Gremmels, 2005). A review of Pioneer silage samples shows these three moulds to be the most prevalent in North American samples as well. Storage fungi, such as Penicillium, Mucor and Monila, do not typically invade the crop prior to harvest, but their soilborne spores are on the forage crop when they are being ensiled. Penicillium Ear Rot is an ear mould that may exist in Canadian corn acres and therefore mycotoxins from some species of Penicillium can form while the crop is in the field and after ensiling, suggesting that preventative measures should begin prior to ensiling. However Penicillium rouqueforti usually is unique to silage environments since it prefers a low pH environment in contrast to the other molds that prefer higher pH environment. Most of the silage storage mycotoxins of concern are produced by Penicillium rouqueforti. (Mansfield et al., 2007).

Nutritionists may lack awareness of PR toxin because no laboratory, to date, has developed a screen to detect this Penicillium-produced toxin. However, Trilogy Analytical Laboratory is very close to commercializing a thin layer chromatography screen for PR toxin (Malone, 2007). Mucor and Monila are typically white to grayish in color and do not produce any known mycotoxins. Their primary concern is reducing silage nutritional quality, bunk life and palatability. Most experts agree that Penicillium (typically bluish-green in color) and their toxins (primarily PR toxin, but also patulin, citrinin, ochratoxin, mycophenolic acid and rouquefortine C) are of greatest concern in ensiled forages because they are very resistent to low pH (Whitlow, 2007;).
The only practical approach to preventing growth of storage fungi is implementing silage management practices that create and maintain anaerobic silage environments.

**Dairy production**

Nutritionists usually begin to suspect mycotoxin issues after linking observations of spoiled silage, digestive upsets and erratic intake with symptoms of opportunistic diseases that seem to be the result of compromised immune systems.

It is important not to rule out a toxin issue, even in normal-appearing silage, because it is well documented that toxins can be present in silages lacking visible spoilage or fungal growth (Whitlow, 2007). Conversely, mouldy silage may be completely free of detectable toxin loads.

It is often difficult to confirm mycotoxin as the culprit responsible for production and health problems. The first obstacle is obtaining a representative sample from the contaminated portion of the crop. One might consider analyzing mouldy samples for comparison with visibly clean areas. The best approach for estimating actual toxin intake from questionable forage or grain is to sample the feed after being blended in a total mixed ration mixer. This is a safer approach that provides a more homogeneous sample compared to traditional methods of sub-sampling composites, random samples taken from across the face of the storage structure.

As an industry, we may be severely underestimating the contribution of toxins to production problems because they can often exist in conjugated forms (primarily with sugars) that escape laboratory detection (Whitlow, 2007). These undetected toxins can then exert their toxic and immunosuppressive effects when disassociated in the digestive tract (Kendra, 2005).

Enzyme-linked immunosorbtant assay (ELISA) tests are designed as rapid and inexpensive toxin screens for grain, but they are prone to many false positives when used on forage samples (Malone, 2007). It is best to utilize a laboratory providing chromatography approaches such as high-pressure liquid chromatography (HPLC), gas chromatography (GC) or thin layer chromatography (TLC).

Since many of the mycotoxins produced by storage moulds are not identified by commercial laboratory services, consultants may contract with a mycology laboratory to have silage fungi isolated and identified. If the isolated fungi are from a mycotoxigenic species, then mycotoxins become a plausible causative agent.

Once toxins are detected, or are highly suspected from fungi identification nutritionists must decide on a practical approach to remediation. Unfortunately,
the options are few, other than segregating obviously spoiled feed and “shotgun” approaches to neutralizing toxins’ effects or stimulating the immune system by increasing ration energy, protein, vitamins (A, E, B1) and minerals (selenium, zinc, copper, manganese).

The most effective remedy may be the tried and true adage of “dilution is the solution.” This is much easier to accomplish on farms that have multiple storage options for isolating problem silages rather than ensiling all of the forage in one or two large bunkers. The concept of dilution has several implications regarding mycotoxicosis.

It has been proposed that there are no more feed toxins today than in the past. It may be that animals today are consuming significantly more dry matter coupled with increased detection capabilities. Dilution also becomes an important consideration as producers feed more and more of a single feedstuff that may be susceptible to toxin issues. A practical example might be the increase in corn silage inclusion rates in the U.S. the past two years to offset higher grain prices. It would be prudent for nutritionists to communicate with growers, custom harvesters and feeders to ensure that silage is harvested, ensiled and managed in a manner that minimizes the potential for storage-produced toxins.

It has also been shown that binding agents are capable of reducing toxin levels in feed. However, while many of these products have generally recognized as safe status, the U.S. Food & Drug Administration does not allow the addition of these products to the ration specifically for the purpose of mycotoxin reduction. Obviously, more public funding of research in this area is warranted, along with appropriate regulatory standards.

**Summary Comments**

There are field-produced toxins over which nutritionists have little control. Nutritionists can begin to exert influence by helping ensure proper harvest moisture, silage compaction and feed-out methods to reduce aerobic environments conducive to the growth of storage produced toxins.

Confirming toxin presence is challenging from a sampling perspective and because toxins often exist in a non-detectable, conjugated form. If a laboratory analysis is conducted, chromatography methods should be used to test forage samples. New laboratory screens are becoming available to detect the presence of some of the common storage-produced *Penicillium* toxins.
References


