Dealing with Mycotoxin-Contaminated Forages

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Every ton of feed discarded from the farm has to be replaced with another one that may need to be purchased. Current farm finances make it difficult for livestock producers to be overly critical of forage quality. It is not unusual for tough economic times to be followed by higher incidence of nutritional problems, sometimes a result of borderline risky decisions. Moldy forages are sometimes blended with "clean" ones in an effort to dilute overall mycotoxin concentrations. Using multiple feeds generally dilutes the toxins of a given feed, resulting in a safer diet. On the other hand, because the effect of toxins can be additive, multiple contaminated feeds can compound the toxic effect of a diet.

Photo 1. *Round bales show extensive surface mold that occurred between adjacent bales. Bales should be covered even when piled in a pyramid.*

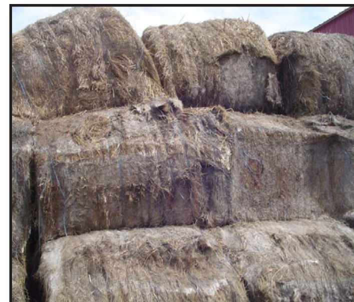


Photo 2. *Extensive mold growth in hay.*

Photo 3. *Corn silage with heat damage on surface, Mucor growth under it, and wedge-shaped mold infiltration immediately below.*

GROWTH CONDITIONS

Depending on weather conditions during growth and harvest, corn grain and forage may contain high concentrations of molds. Once on the feed, mold spores need four conditions to grow: air, moisture, temperature, and damaged kernels. All conditions are met in the exposed surface of corn silage. Disruption (damage) of the corn kernel cuticle encourages silage fermentation, improves silage digestibility, and increases its energy value. But this cuticle is also a protective barrier against molds and once disrupted, it is only a matter of having the remaining growing conditions for molds to develop. The moisture in the silage is more than adequate for mold growth. At the higher end of the moisture range (65-70%), it can be detrimental for their growth as it improves compaction and reduces air infiltration. If taking a chance due to weather or timely available machinery it is always preferable to be on the wet end as it improves compaction. Air and temperature are positively associated with air penetration in the silage, resulting in temperature increase as a result of carbohydrate oxidation. The last two conditions, air (most fungi need 1-2% oxygen to grow) and temperature (between 68-86ºF) are the culprits of silage deterioration. Producers should be concerned about airtight conditions by:

- chopping plants at right size
- devoting enough time and weight during silage compaction
- minimizing air exposure during preservation and feed-out

MOLDS & THEIR MYCOTOXINS

Three groups of molds are of main concern to livestock producers: *Aspergillus*, *Fusarium*, and *Penicillium*. The Aspergillus group of molds produces four Aflatoxins (B1, B2, G1 and G2), of which the most common and biologically active is Aflatoxin B1. Fusarium mycotoxins are: deoxynivalenol , zearalenone, trichotecenes, and fumonisin. *F. graminearum* or *roseum* produce Deoxynivalenol (DON or vomitoxin). The Penicillium group is most commonly observed in corn silages. According to the USDA, there are almost 100 Penicillium fungus species, but only 17 have been found to produce a mycotoxin of concern (USDA 2006). The main toxins are ochratoxin, patulin, PR toxin, mychophenolic acid, and roquefortine C.

MOLD IN FORAGES

There are four groups of molds prevalent in ensiled forages in the U.S.: *Mucor*, *Penicillium*, *Aspergillus*, and *Monillia*.

Aspergillus. Table 1 shows the concentration observed in corn silage samples analyzed in New York. The highest value of 18.4 ppb could be accepted even for lactating dairy cattle (upper level 20 ppb) and growing calves. Dry years/regions of the country are more prone to mycotoxicosis outbreaks due to aflatoxins. Gliotoxin, a strongly immunosuppressive mycotoxin, has been reported in mature corn silage associated with the presence of *A. fumigatus* (Richard et al. 2007).

Fusarium. The presence of pink kernels or ears in silage suggests the presence of this group of molds. Fusarium toxin occurrence in corn silage can be minimized by choosing varieties less susceptible to stem rot, harvesting at optimum maturity (65-70% moisture), and elevating the cutting height to at least 16" above ground. Deoxynivalenol can show up in corn silage but its concentration is usually low. Therefore, risk to the health and performance of ruminants is regarded as low. Whitlow (2008) reported that dairy heifers fed contaminated hay with ~500 ppb of Zearalenone had a reduction in pregnancy rates from 72 to 51%.

Penicillium. High Penicillium counts are a frequent occurrence in corn silage. Toxins from this group such as Roquefortine C, Mycophenolic acid, and Patulin have been reported in freshly harvested corn silage, which shows Penicillium toxin formation also occurs before storage. Weather conditions at specific growth stages of the crop have been reported to affect the final concentration of toxins in recently harvested corn silage (Mansfield et al. 2008); of 120 fresh cut forage and silage samples 15% had no toxins, 25% had one, 32% two, 18% three, and 10% all four toxins. Mycophenolic acid was reported in 38 of 135 samples of corn silage and in some samples, its concentration was equivalent to 10% of the dose given to patients undergoing immunosuppressive therapy (Schneweis et al. 2000).

MOLD EFFECTS ON CATTLE

Healthy ruminants can tolerate relatively moderate levels of molds in feeds unless they are immune-suppressed. Stresses that impair the immune function increase susceptibility to mycotoxicosis. Both aflatoxins and trychotecenes have demonstrated effect on immune-suppression. The effects that have been described are reductions in: cellular protein synthesis, cell mediated immunity, and antibody production. Therefore, it is very important to boost the immune system, aside from any actions taken to decrease mycotoxin concentration. Reducing overall stress and supplementing the diet with antioxidant compounds (e.g., selenium, vitamins A and E, beta carotenes, etc.) can be very effective as these fat-soluble vitamins act as superoxide anion scavengers (Galvano et al. 2001).

Aflatoxins. Once Aflatoxin B1 is ingested, 42% can be degraded or transformed in the rumen to aflatoxicol (also toxic), or absorbed and transformed in the liver to aflatoxin M1, which can show up in milk. Aflatoxin B1 and Aflatoxin M1 are both of concern to humans as they are potent carcinogens. (Santin, 2005). Aflatoxin in the diets of growing cattle and lactating dairy cows should not exceed 20 ppb.

Table 1. *Corn silage samples 2000-2009 (Source: Dairy One. 2009).*

	Samples	Average	Normal Range		Std. Deviation
Aflatoxin, ppb	2,500	10.212	2.023	18.401	8.189
Vomitoxin, ppm	4,517	1.738	0.470	3.006	1.268
Zearalenone, ppm	1,998	0.599	0	1.201	0.603
T2, ppm	872	0.183	0	0.603	0.420
Ochratoxin, ppm	267	0.012	0	0.041	0.029
Fumonisin, ppm	539	0.892	0	2.622	1.730

Fusarium. Symptoms are sometimes confused with other digestive upsets as animals might have erratic feeding behavior, diarrhea, and weight loss. Research has shown (Danicke et al. 2005) that in cows on a diet with 3.1 ppm DON, the flow of microbial protein and rumen protein utilization were reduced. Zearalenone competes with estrogen for binding sites, and has thus estrogenic effects (i.e., reduced conception rates, irregular estrus, and increases udder edema in heifers). Whitlow (2008) reported that pregnancy rates in dairy heifers fed hay contaminated with ~500 ppb of Zearalenone was reduced from 72 to 51%. Diets for dairy cows should not have more than 0.5 ppm of T-2 toxin; symptoms of its toxicity include intestinal hemorrhage, hemorrhagic diarrhea, abortions, and finally death. Fumonisins can produce liver damage and reduce feed intake and milk production. Fumonisin concentration in the diet of breeding ruminants should not exceed 15 ppm and 30 ppm in those older than 3 months. Deoxynivalenol should not exceed 5 ppm in the overall diet, whereas the maximum tolerated for Zearalenone is 25 ppm.

Penicillium. Their effect depends on the animal stress level and/or the presence of other mycotoxins that may challenge the immune system. Although not usually of direct consequence, high Penicillium counts may result in damage to liver and/or kidneys when combined with other mycotoxins. High levels of contamination may cause other non-metabolic related problems. Odd smells, for example, can result in feed sorting, acidosis, and displaced abomasums in ruminants. It is advisable to use high Penicillium counts as an "alert system" and then test for the presence of other toxins. For example, Ochratoxin produced by Penicillium can pose problems for certain age groups in the dairy herd. With heavy grain supplementation, this toxin can remain in the rumen undegraded and appear in the blood. Ochratoxin affects the kidney of young calves that have not yet developed a fully functional rumen. Avoid feedstuffs with high Penicillium molds in young stock and use it in mature animals after testing for other toxins of concern. Other Penicillium associated toxins are PR toxin, Roquefortine C, Mycophenolic acid, and Patulin. Mycophenolic acid negatively impacts the immune system.

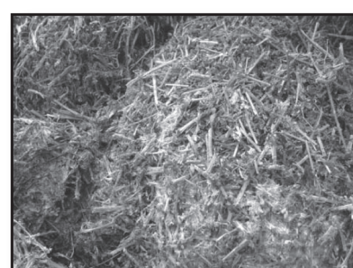
Photo 4. *Extreme heat damage in bagged corn silage did not even allow mold growth.*

PREVENTING MYCOTOXIN TOXICOSIS

Once the presence and concentration of mycotoxins has been determined, different practical approaches can be used to reduce deleterious effects. The most common include: mold inhibitors (precautionary, before mold develops), fermentation enhancers (high-moisture, fermented feeds), physical separation (discard grain fines), adsorbent agents (feeding time), blending down with clean feedstuffs to get below problem level, and strategically feeding to certain production phases.

Mold inhibitors (e.g., propionic acid) and fermentation enhancers (e.g., bacterial inoculants) are effective and recommended at storage time. However, there is no point in adding agents once grain or corn silage has been stored for some time and molds and mycotoxins have already developed. Hoffman and Combs (2009) suggest adding 10-20 lbs of actual propionic acid/ton of high-moisture corn, such as corn with 25% moisture or higher. Also, mold inhibitors will do nothing against mycotoxins that are already present. It is crucial to avoid unnecessary exposure of grain and silage to air during storage and feedout.

Photo 5. *Alfalfa haylage spoilage as a result of aerobic deterioration.*



If aflatoxins become a problem, absorption of the toxin can be reduced by adding anti-caking agents to the diet such as sodium bentonite, hydrated sodium calcium aluminosilicates, or a modified yeast-cell-culture-based product to the grain.

Despite research demonstrating use/effectiveness, adsorbent agents are not currently approved by the FDA to be used for that purpose.

DEALING WITH MYCOTOXIN-CONTAMINATED FORAGE

1. Prevention is key. Use forage inoculants when warranted.
2. Use best management practices (i.e., adequate moisture at harvest, increase compaction, minimize air exposure) when harvesting, storing, and feeding-out forages.
3. Test to determine which molds and mycotoxins are present and, for mycotoxins, at what concentration.
4. Choose an approach that is feasible and economically sound.
5. Reduce overall animal stress levels by adequate management and comfort.
6. Include antioxidants like vitamin E and selenium in the diet.
7. Improve overall nutrition programs, focusing on protein, energy, and effective fiber, and use proven rumen fermentation enhancers.
8. "Dilution may be the solution" - blend affected feeds with "clean" feedstuffs to achieve concentrations of mycotoxins below what are considered to be maximal safe concentrations.
9. Consider using anti-caking agents at feeding time.

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