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Mycotoxins in Corn Distillers Grains A concern in ruminants?

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The main fungi that produce toxins during storage belong to three genera: *Aspergillus*, *Fusarium*, and *Penicillium*. When dealing with cattle diets, it is not easy to correlate the presence of mycotoxins to that of molds. The same types of molds can produce different types of toxins, and different types of molds can produce the same mycotoxin.

When addressing mycotoxicosis, the fact that multiple ingredients usually make up a dairy cattle diet can be viewed both positively and negatively. On the one hand, multiple feeds dilute the toxins from any given feed, resulting in a safer diet. On the other hand, because the effect of toxins can be additive, if there are multiple contaminated feeds, the toxic effect of the feeds will be compounded. The primary toxins of concern are aflatoxin, zearalenone, trichothecene, fumonisin, ochratoxin, and patulin.

Aflatoxins are produced by the fungi *Aspergillus flavus* and *A. parasiticus*. They produce four toxins, of which aflatoxin B1 is considered the most potent natural carcinogen. Rumen microorganisms can degrade up to 42% of aflatoxin B1 (Santin, 2005), but they are also capable of producing aflatoxicol. Another metabolite, aflatoxin M1, is produced from B1 in the liver and can end up in the rumen through rumino-hepatic circulation. The toxicity of aflatoxicol and M1 is similar to that of B1, and they are readily absorbed by the intestine. Therefore, even when B1 is degraded in the rumen to aflatoxicol and transformed in the liver to M1, the toxic end-result is similar. The metabolite M1 circulates from the liver into the blood and ends up in milk or urine.

Zearalenone is degraded by protozoa to α -zearalenol, a product with high estrogenic activity, and to β -zearalenol, a product toxic to the endometrium (Tiemann et al. 2003). The main effects of zearalenone in cattle are thus related to reproductive problems such as embryo survival,

infertility, hypertrophy of the genitalia, and feminization of young males (decreased testosterone).

Trichothecenes derive from the fusarium group of molds, which include diacetoxyscirpenol (DAS), T-2 toxin, and deoxinivalenol (DON); these molds have been associated with gastrointestinal lesions in dairy cows. Trichothecenes have been well known for their impact on the dairy cow's immune system.

Fumonisin seem to be better tolerated by cattle than by monogastrics, although feed intake and milk production can be negatively affected in dairy cows. **Ochratoxins**, which are rapidly degraded in the rumen, are considered of little consequence for ruminants. **Patulin** is commonly found in silages, and sudden exposure to patulin may result in reduced feed intake and milk production (Santin, 2005).

Depending on weather conditions during growing and harvest seasons, corn grain may contain high concentrations of molds that are detrimental to livestock. Contaminated grains decrease productivity and negatively affect the health of the animal. As greater amounts of corn are used for fuel ethanol production, livestock producers are feeding lesser amounts of corn and greater amounts of the coproducts (known as distillers grains) resulting from ethanol production—these coproducts are primarily distillers dried grains with solubles (DDGS) and wet distillers grains (WDG). When concentrations of molds and mycotoxins are elevated in corn grown in a given year or region, there is a concern that these undesirable inhabitants of the grain will be transferred to the distillers grains.

As cornstarch is fermented to ethanol, the non-starch nutrient content of distillers grains is concentrated three-fold. Molds are usually present in the grain's pericarp and can result in high levels of mycotoxins. Consequently, as

starch is fermented to ethanol, mycotoxins are also concentrated threefold. The quantity of mycotoxins in newly processed distillers grains is directly related to their presence in the original grains (before fermentation takes place).

Mold spores can be present on surfaces previously used to store distillers grains and can inoculate new batches. Depending on the conditions in which distillers grains are kept at the plant prior to shipping and/or on conditions during transport and storage, both the initial concentration of mycotoxins and their profile might change. Molds may grow if under normal storage conditions a temperature between 68 and 86°F can be maintained for several days or weeks.

Moisture also plays an important role in mold development, with ideal conditions for growth ranging from 13 to 18% moisture. Muschen and Frank (1994) suggested that in grains with high levels of oil, such as peanuts (20-60%), molds can grow at a moisture concentration as low as 7%. Traditional DDGS have an oil content that ranges from 10 to 15%. This suggests that even when DDGS is kept under recommended dry conditions, it might have an increased susceptibility to fungal growth.

Most fungi need oxygen present to grow (1 to 2% oxygen). In a normal fermentation process, enzymes that consume oxygen are inhibited by low pH (Woolford, 1974). It has been found that pH in WDG is commonly between 3.0 and 4.0 (Kalscheur and Garcia, 2005), which would be low enough to inhibit oxygen depletion by enzymatic activity. Intact corn kernels breathe and consume oxygen in any structure where they are stored. Distillers grains, on the other hand, undergo a heating process during the ethanol production process that basically transforms the once “breathing” grain into a collection of inert particles loaded with nutrients, and these particles can be a substrate for mold growth. In fact, high temperatures attained after ethanol processing can also denature the enzymes responsible for oxygen depletion by respiration (Puzzi, 1986).

During aerobic respiration, fungi utilize grain fat and carbohydrates (Dixon and Hamilton, 1981b). Although there is little starch left in distillers grains, there are still plenty of structural carbohydrates and fat, both of which are readily available for fungal growth. The use of the carbohydrates and fat for fungal growth reduces the energy content of the distillers grains.

DDGS and WDG are more exposed to mold growth than whole kernels because the pericarp that protects the grain has been completely disrupted. This disruption allows for an easier colonization of the remaining nutrients by mold spores. When whole kernels are stored, molds grow as a result of the moisture present. The amount of moisture present between kernels is determined by the equilibrium of the moisture both inside the grain and between the kernels. When warm and ground wet or dried distillers grains are confined in a container (e.g., bin, bulk grain wagon, silo-bag, etc.), free water vapor moves from the warm core towards the cooler area (the inner surface of the containment surface). There it condenses and increases the amount of free water, which thus allows further mold growth.

Table 1. Mycotoxin concentration of dried (DDGS) and wet (WDG) distillers grains

Toxin	DDGS					WDG				
	Samples	Avg.	Normal Range	SD		Samples	Avg.	Normal Range	SD	
aflatoxin, ppb	30	4.61	2.12	7.09	2.49	28	2.17	0.00	6.79	4.61
vomitoxin, ppm	54	3.62	0.00	7.74	4.12	44	1.91	0.00	4.26	2.35
zearalenone, ppm	16	0.24	0.00	0.51	0.27	14	0.37	0.00	0.87	0.50
T2, ppm	11	0.03	0.00	0.07	0.03	14	0.12	0.00	0.24	0.12
ochratoxin, ppm	4	0.01	0.01	0.01	0.00	3	0.02	0.02	0.02	0.00
fumonisin, ppm	20	0.74	0.00	1.96	1.22	27	0.69	0.00	1.73	1.04

Accumulated crop years: 05/01/2000 through 04/30/2007; Source: www.dairyone.com. 2007

Table 1 shows results published by the Dairy One forage laboratory (Ithaca, NY) comparing DDGS and WDG. The average value for aflatoxins was twice as high for DDGS than for WDG. Although the standard deviation (SD) for WDG was almost twice that of DDGS, it is possible that the low pH in WDG may result in less than ideal conditions for the growth of the aspergillus fungi. The maximum threshold for aflatoxins for dairy cattle is considered to be 20 ppb; at greater concentrations, M1 will appear in milk. According to results from the same laboratory, vomitoxin (deoxinivalenol, or DON) is the mycotoxin that should be of greatest concern in both dry and wet distillers grains.

According to field observations, when vomitoxin concentrations were higher than 500 ppb (0.5 ppm), milk yield was reduced by 25 pounds (Genter et al.). The authors thus recommended testing for vomitoxin (DON) as a marker for feeds that have been exposed to mycotoxin contamination. The results observed in Table 1 certainly warrant a closer look at the concentration of vomitoxin in both dried and wet distillers grains.

The FDA suggests that levels above 2 ppm in the total diet may pose a potential hazard for lactating dairy cattle. For individual feeds destined for all animal species except for beef cattle, the FDA suggests not more than 5 ppm of vomitoxin for grain and grain byproducts (for beef cattle,

the FDA suggests 10 ppm). If the 5 ppm concentration is found in commodities, those feedstuffs should not exceed 40 percent of the ration. A maximum of 7.7 ppm of vomitoxin was reported from 54 samples (Table 1) of DDGS tested between 2000 and 2007. This warrants caution and suggests the need to test either the diet or the individual feeds that may contribute to the total concentration of this mycotoxin.

Fumonisin does not appear to constitute a problem with distillers grains in ruminant diets, considering the FDA maximum tolerance level is set at 60 ppm of total fumonisins in commodities and at 30 ppm in the total feed (50% inclusion rate).

Another survey, this one conducted by BIOMIN (Rodrigues, 2008), indicated that out of 44 DDGS samples collected between October 2006 and September 2007, 14% tested positive for B1 aflatoxin, 77% tested positive for zearalenone, 80% were positive for vomitox-

in, 88% tested positive for fumonisin, and no samples were positive for T2.

CONCLUSION

Mycotoxins are not destroyed during either the ethanol fermentation process or the distillers grains production processes; instead, they increase their concentration in the original kernels by nearly threefold. Inadequate storage conditions may also increase the concentration of mycotoxins (due to inoculation by mold spores present in the environment). The use of mycotoxin-contaminated distillers grains in dairy cattle diets poses a risk to human health because M1, an aflatoxin metabolite, transfers to milk. Even when the toxin level is within acceptable standards for distillers grains, their additive nature does not preclude the potential for toxicity. In the presence of borderline acceptable levels of aflatoxin B1 in distillers grains, testing the TMR and/or individual feeds is recommended to ensure that milk will not be contaminated.

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