Minimizing the Impact of Corn Aflatoxin

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Our understanding of the occurrence and development of aflatoxin in corn has changed a great deal during the last decade, and methods of coping with the situation are beginning to emerge. The underlying strategy of dealing with aflatoxin in corn can be simply stated as an attempt to limit the impact and amount of aflatoxin entering the food chain. Tactics that have evolved can be roughly divided as: 1) reducing the potential for aflatoxin production in corn before harvest, 2) reducing the harvest and sale of contaminated corn, 3) utilizing contaminated corn, and 4) educating producers, buyers and consumers regarding aflatoxin.

Reducing aflatoxin in the field

Seasonal climatic and biotic factors play important roles in the development of aflatoxin in the field. High temperatures (>30 C) during the silking to late dough stage of kernel development are extremely important to the infection process (3), and water stress during this period greatly enhances aflatoxin concentrations in infected kernels. Regional manipulations of planting dates and the use of supplemental irrigation to alleviate moisture stress during the reproductive period significantly reduce the incidence and level of aflatoxin contamination in corn (2). Reduced fertilization or excessive plant populations that result in plant stress can contribute to aflatoxin at harvest. In general, producers should select regionally adapted varieties with proven high yield potentials and should utilize production practices that allow them to realize as much of that yield potential as possible.

To date, corn inbreds or hybrids immune to infection or aflatoxin production by *Aspergillus flavus* have not been identified. Varietal differences relative to aflatoxin content at harvest have been observed in several state and national variety tests, but such differences may reflect the relationship between a period of moisture stress and the silking and grain fill period of a given variety in the year tested. Significant differences one year are often reversed the next. It is unlikely that monogenic resistance providing immunity to aflatoxin production in corn will be identified. Current breeding efforts in the United States center around the identification of germ plasm that results in less aflatoxin accumulation in corn, given uniform inoculation and infection (4). Some states have attempted to take advantage of varietal differences in susceptibility to damage by ear-inhabiting insects as a means of lowering aflatoxin content.

The potential for chemical control of aflatoxin in corn has been examined by investigators in Georgia, North Carolina, and Texas. Benomyl applications to exposed silks reduced the aflatoxin concentrations in some studies in some years, but results are inconsistent. Work on the use of fungicides needs to continue.

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Reducing harvest and sale of contaminated corn

Modifications in harvesting procedures are some of the most sound tactics employed by producers to reduce the risk of marketing contaminated grain. Producers who suspect aflatoxins as a potential problem can examine fields and collect ears for analysis 2 or 3 weeks before harvest. If *A. flavus* is visible on a high percentage (>10%) of ears sampled, a grower may harvest the corn at high moisture (26–28%) and artificially dry it to a moisture content below 13%, which effectively halts aflatoxin buildup. This practice has been adopted in some areas where the natural dry-down of corn is slow but has limited utility in regions with little late-season rainfall or corn maturation during hot and dry times of the year. The risk of further aflatoxin contamination must exceed the expense of early harvest and artificial drying for this practice to become adopted in a given region.

During the actual harvest operation, reducing the combine header speed to minimize the harvest of fines and trash can lower aflatoxin contents in corn. Kernels infected by *A. flavus* are extremely friable. In addition, insect-damaged kernels and kernel fragments can contain a high percentage of the aflatoxin in a given load. Combines that collect and harvest ears from fallen stalks should not be used in regions where aflatoxins are a problem. Ears in contact with the soil are often heavily infected with *A. flavus*.

The incidence of aflatoxin contamination varies widely from field to field and within fields. Producers have found some utility in separating the corn from their best fields (fields with a history of high yields) from corn produced in traditionally low-yielding fields. Corn from irrigated fields or high-yielding fields should be kept in tanks or truckloads separate from corn produced on late-planted fields or fields where irrigation problems developed during the season. Marginal areas within a field may also be harvested separately to reduce the risk of aflatoxin contamination of clean corn.

After harvest, particularly of suspect, high-moisture corn, transit delays to the buying point or storage bin should be minimal. Aflatoxins have been shown to increase in truckloads of contaminated corn by as much as 6% per hour of delay.

Increased aflatoxin production in storage by grain already contaminated can have serious consequences for the producer. To minimize this risk, speed is of the essence. The faster the corn can be dried to a moisture content below 13%, the less aflatoxin can be produced by contaminated kernels within the stored lot. Once corn is dried to a safe storage moisture content, aflatoxin contamination will cease as long as the storage atmosphere maintains the moisture content below 13%. Recommendations for the safe handling of contaminated grain are regionally available.

Utilizing contaminated corn

The development of reliable and effective means for detecting aflatoxin was instrumental to implementing tactics for utilizing and marketing contaminated corn. Historically, aflatoxins have been detected at the buying point by using the bright greenish yellow fluorescence of kojic acid to arrive at a buy/no buy decision. While such methods can identify corn loads that need further testing, fluorescence is inadequate for quantifying aflatoxin levels in corn. The Association of Official Analytical Chemists (AOAC) provides buyers and producers with satisfactory techniques for rapidly determining aflatoxin content in loads (1). Once the aflatoxin concentration of a bin, truck, or boxcar is known, decisions about marketing the product can be made rationally.

Divergent tactics for utilizing grain have developed within the feed corn and the food corn industries. Food-grade corn is manufactured into a wide variety of products, including tortillas, corn chips, breakfast cereals, and grits. In southwest Texas, 60,000 acres of food-grade corn are produced annually. While the levels of aflatoxin contamination in this region are quite low compared with those in the southeastern United States, the incidence of truckloads exceeding 20 ppb is significant to area producers (Table 1).

Table 1. Incidence and level of aflatoxin B_1 concentrations in food-grade corn during 1980–1982 (Corn Processors, Inc., Uvalde, TX)[a]

Aflatoxin B_1 range (μg/kg)	Number of loads[b]		
	1980	1981	1982
0–20	204	291	213
20–50	23	0	35
50–100	2	0	36
>100	0	0	2
Total	229	291	286

[a] Analysis based on official AOAC methods with visual reading of TLC plates.
[b] Each load represents about 25 t.

The implication of aflatoxin contamination in food-grade products demands high-quality control. To minimize the potential impact on area producers, buyers have established systems to clean corn intended for use in food products. The first step in making corn masa for tortillas or corn chips is removal of the kernel pericarp with a lye soak. To optimize the quality of the product, the corn must be free from broken and cracked kernels. Several commercial systems have been designed for this process. Before corn is screened, aspirators blow out fines and trash. Then, shakers pass corn through ½-in. screens and over ¼-in. screens, and specific gravity separators remove lightweight kernels. Each cleaning results in a 10–12% weight loss. In 1980, 23 lots (50,000 lb/lot) of food-grade corn containing aflatoxins in the range of 20–50 ppb were cleaned by this process. All but one were cleaned to below 20 ppb; three required two passes to get below the FDA guideline. Results in 1982 were similar.

Utilization tactics for aflatoxin-contaminated corn in the animal industry are based on feeding studies that elicit "safe" tolerances for individual animal groups. Poultry is particularly sensitive to aflatoxicosis. Consequently, large firms within the poultry industry have developed rapid screening facilities to make sure the corn and starter rations they purchase are below 20 ppb. Adult cattle tolerate higher levels of aflatoxin in feed, so corn loads identified as containing greater than 20 ppb but less than 100 ppb can be safely used at feedlots. Corn products fed to lactating animals should be within the 20-ppb guideline. Such selective feeding tactics allow for safe utilization of corn contaminated in the 20–100 ppb range and greatly reduce the financial impact of corn aflatoxin on southern producers. In 1980, the FDA approved state regulations in South Carolina to identify corn contaminated in the 20–100 ppb range and permit interstate movement of this material as long as it was clearly identified and targeted as mature animal feed.

While alternative marketing outlets are available for corn contaminated with aflatoxins in the range of 20–100 ppb, loads in epidemic years can exceed 100 μg/kg. In 1977, an estimated 32% of the harvest in eight southeastern states exceeded 100 ppb. Results from the 1980 harvest were similar, with 27.8% of the corn above 100 μg/kg. The approach to minimizing the impact of aflatoxin at these levels has been decontamination by detoxification or blending. Blending contaminated corn with clean corn to reduce the aflatoxin concentration is a high-risk practice and though being used in some areas for on-farm feeding programs, should be discouraged in marketing channels.

Detoxification was first examined on a large scale following the 1977 epidemic of aflatoxin in corn. Significant reductions in aflatoxin content were observed in corn treated with anhydrous or aqua ammonia. The treatment was inexpensive and successfully detoxified sample loads but awaits FDA approval. Detoxification may yet prove the most useful tactic for lots containing aflatoxin in the 100–1,000 μg/kg range.

Educating producers, buyers, and consumers

Factors contributing to the development of aflatoxin in corn are numerous and complex. Although associated with low yields, aflatoxin is generally not regarded as yield-reducing in and of itself. Consequently, producers have come to regard aflatoxin in corn as a price-manipulating tool of corn buyers.

Producers generally respond to quality incentives at the marketplace. If educational programs can be developed to help growers understand how aflatoxin develops in corn, they will adopt production measures that minimize the incidence of aflatoxin contamination on their farms. Basic to this positive attitude among growers is the need for buyers to develop rapid screening techniques that quantify actual aflatoxin content of a sample. Black lights are inadequate buying tools and serve to foster distrust.

A rational consumer approach to aflatoxins is necessary to implement the overall strategy of minimizing the impact of aflatoxin in corn. Overpublicizing the problem among those not in a position to contribute to the solution should be avoided. At the same time, information on safe levels of aflatoxin in feed and food, where established, needs to be conveyed to interested parties.

A call for further research generally accompanies the discussions of plant health strategies, and this is no exception. A great deal of information is still lacking relative to the biology of aflatoxin production and the epidemiology of *A. flavus* in corn. Continued efforts in breeding for resistance, sampling methodology at the screening level, and decontaminating corn loads exceeding 100 ppb are imperative. Epidemics of *A. flavus* and aflatoxin in corn occurred in 1977 and 1980. Many state legislatures responded positively to the need for further research in those years, but the development and adoption process will benefit most from consistent funding.

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