The fungi *Aspergillus flavus* and *A. parasiticus* are common in most soils and are usually involved in decay of plant materials. They commonly cause stored grains to heat and decay and commonly invade corn, peanuts and cottonseed in the field before harvest. The problem is serious in subtropical and tropical regions of the world where cereals, peanuts, corn, and copra are important in the human diet. Aflatoxin B₁ is one of the most potent naturally occurring animal carcinogens and is formed in corn, corn silage, all cereal grains, sorghum, peanuts, and other oilseeds. All animal species appear to be susceptible to aflatoxins and susceptibility varies from species to species. Aflatoxins were identified as the cause of epidemic liver cancer (hepatoma) in rainbow trout. It was found 4 μg/kg (ppb) of diet fed for ~16 months causes liver cancer. Aflatoxins are classified as a confirmed potential human carcinogens. Young animals are more sensitive to aflatoxins. Cows are less sensitive to aflatoxins than calves. Monogastric animals including horses are more sensitive to aflatoxins than mature ruminants. Animals and humans on a protein-deficient diet are more sensitive to aflatoxins than animals on a protein adequate ration.

Naturally occurring mixtures of aflatoxins are classified as carcinogenic to humans by the International Agency for Research on Cancer and have been implicated in primary liver cancer. Outbreaks of human and animal aflatoxicosis have occurred in India and Africa. In the years 1977 and 1980, before harvest >60% of the corn grown in the southeastern United States contained >20 ppb aflatoxin B₁, and the majority of the pre-harvest corn exceeded the 20 ppb action level for human foods issued by the U.S. Food and Drug Administration (FDA). More recently, recurrent acute aflatoxicosis in Kenya in 2004 and 2005 caused more than 150 human deaths and were linked to inadequately stored, homegrown maize infected by *Aspergillus* spp.

Regulated Levels of Aflatoxins
All mycotoxins in human foods and animal feed are subject to regulation by the FDA. The FDA has issued advisory guidelines or action levels for aflatoxins (sum of B1, B2, G1 and G2) at 20 ppb for human foods. Some state agencies and foreign countries have established more restrictive limits (no more than 5 ppb) of permissible aflatoxin contamination in grains or other products in interstate/international commerce. Grains or other products with levels above 20 ppb but less than 100 ppb may be shipped under specific conditions within the USA for cattle feed. Grains over 100 ppb may be subject to confiscation. Mixing high and low aflatoxin-contaminated corn to achieve a blend which meets FDA standards constitutes adulteration, and is subject to severe FDA penalties. However, under some circumstances FDA and state Departments of Agriculture regulations have permitted the blending of aflatoxin-contaminated and clean grain to obtain mixes that can be fed to some nonlactating animals. Such feeds can be used on the farm where it is produced, but cannot be sold. The aflatoxin M1 metabolite is regulated at 0.5 ppb (0.5 μg/kg in fluid milk). Corn with 100 ppb of aflatoxin can be fed to breeding beef cattle, swine or mature poultry. Up to 300 ppb can be fed to finishing beef cattle and 200 ppb can be fed to finishing swine greater than 100 lb without residues of aflatoxins and their metabolites in edible portions of the animals.

Field Contamination

The potential seriousness of aflatoxins contaminating crops before harvest is illustrated by the years 1983 and 1988. In these two years, a general drought extended across the Corn Belt from Nebraska and Iowa to Illinois, Indiana and Ohio. Thousands of corn samples were taken from fields in these states and 5% to 10% of the samples contained >20 ppb of aflatoxin. In 1983, corn sampling at 118 elevators in Indiana showed none of the corn contained more than 100 ppb of aflatoxin, and only five samples contained more than 20 ppb.

It is essential that the growers and livestock producers be aware of the aflatoxin hazard locally and, if necessary, they should have the corn assayed for aflatoxins. If a producer is purchasing feed out of the local area, he should be aware of the aflatoxin situation in the area from which the grain is purchased and require aflatoxin analysis if
there is reason for concern. This also applies to the *Fusarium* spp. and their mycotoxins discussed in later sections.

**Risk Factors for Production of Aflatoxins**

Aflatoxins B₁, B₂, G₁, and G₂ are produced by *A. flavus* and *A. parasiticus* in grains or seeds before harvest and during storage. Infection is most common after the kernels have been damaged by insects, birds, mites, hail, early frost, heat and drought stress, windstorms, and other unfavorable weather. The presence of *A. flavus* or *A. parasiticus* in a given feed sample does not mean that aflatoxins are present, but the presence of the toxigenic fungi does increase the risk for aflatoxin production. Aflatoxins persist under the majority of environmental conditions, and aflatoxins are not destroyed during feed manufacturing processes. Pelletizing feeds may eliminate fungi present in the stock, but will not reduce or eliminate aflatoxin present in any of the ingredients. Food processing and baking does not destroy aflatoxins. Aflatoxins are not destroyed during alcohol production, and on a dry matter basis, aflatoxins are concentrated in stillage and distillers solubles.

**Decontamination and Binding of Aflatoxins**

Roasting, ammoniation at ambient temperatures and some microbial treatments may sharply reduce but not eliminate the aflatoxin content. Ammoniation has been shown to be most effective in reducing aflatoxin levels. Currently these treatments have limited application, with roasting being the least effective. The addition of binding agents such as hydrated sodium calcium aluminosilicate (HSCAS) and bentonite clays to corn has been shown to decrease the toxic effects of aflatoxin when fed to swine. These compounds probably work by nonspecific binding to the mycotoxin, and thereby reduce the absorption of aflatoxins in the intestine. Although not specifically approved for this purpose, various products which have this ability are approved as binding or anti-caking agents.

**Toxicology of Aflatoxins**
All animal species are susceptible to aflatoxicosis, and the sensitivity varies between species. For example, monogastric animals such as birds, fish, dogs, and swine appear to be more susceptible to aflatoxicosis than mature ruminants. In poultry, liver and kidney disorders, leg and bone problems and increased occurrences of bruising can develop as well as outbreaks of diseases such as coccidiosis. Aflatoxins decrease native resistance to disease and this phenomenon may cause vaccines to fail. Immunosuppression is manifested by increased susceptibility to and occurrence of disease, especially diseases that would normally not be fatal. Liver disease causes a decrease in blood clotting factors and an increase in trimming and condemnation of the birds occurs because of massive bleeding and bruises. Less carcass pigmentation is exhibited and egg yolks are paler. The hatchability of eggs can decrease, and reduced indices of production in the birds may be noted. Growth is reduced and mortality rate increased, especially during the growing period.

Regular or occasional consumption by livestock of feedstuffs contaminated with aflatoxins within the range of <100 ppb to a few hundred parts per billion (ppb) may result in decreased feed consumption, decreased feed conversion, stunting, and decreased weight gains, wasting of body condition and death. Decreased productivity is accompanied by damage to the liver and additional pathology such as hemorrhaging into the gastrointestinal tract, muscles and body cavities may be observed. As with poultry, suppressed natural immunity, decreased effectiveness of vaccines and increased diseases associated with animal production can occur. Signs of neurologic dysfunction may also be observed. Once the damage has occurred, the animals may not fully recover even if returned to a toxin-free ration.

**Aflatoxins in Milk**

Aflatoxins M₁ and M₂ are metabolites of aflatoxins B₁ and B₂ that are excreted in milk from dairy cows fed aflatoxin-contaminated feeds. Lactating cows consuming feed containing 20 ppb or less of aflatoxin will have less than 0.1 ppb of aflatoxin M₁ in milk. The dietary threshold for cows to excrete aflatoxins in milk is ~15 ppb in the diet. Generally, the levels of the M₁ metabolite are 1% of the aflatoxin content of feed and range from 0.17% to 6.3% of the dietary aflatoxin. The percentage of dietary aflatoxins
excreted in milk increases with milk yields, and cows in early lactation excrete higher levels of aflatoxins in milk. For comparison, humans excrete 0.09% to 0.43% of the dietary aflatoxins in milk.

**Aflatoxins in Grain Dust**

Aflatoxins are present in the spores of *A. flavus*, and these spores can be produced in great abundance on the ears of fungus-infected corn. When corn is unloaded and mixed at elevators or other transfer points, considerable grain dust (fungal spores and mycelia plus broken grain) is formed and grain dust can contain aflatoxin. In 1980, dust collected in Georgia near a combine harvester contained from 2,030 to 41,200 ppb of aflatoxin. The aflatoxin content of the dust at the elevator receiving this corn ranged from 621 to 1,480 ppb. Aflatoxin produced in other stored cereal grains will also be present in “grain dust”. Dust masks must always be worn when handling obviously moldy grain. Inhaling aflatoxin-contaminated dust is a health hazard. Workplace exposures to aflatoxins have been associated with increased occurrences of cancer. Grain invaded by *Aspergillus* species is highly friable, therefore great care should be taken when feeding grain screenings. Broken grains often have very high levels of aflatoxin concentration.

Grain handlers have been shown to have more respiratory problems than the general population. Farmer's lung, a disease which afflicts grain handlers, is a pulmonary disease which occurs in farmers when they inhale large amounts of grain dust containing fungal hyphae and spores. Farmers' lung is a tissue-damaging allergic reaction (called extrinsic allergic alveolitis) to fungal spores and other material in grain dust. Mycotoxins in grain dust are frequently associated with skin irritation, fever, wheezing, breathlessness, cough and ulcers. This latter disease is due to the direct effect of the fungal toxins, not an allergic reaction.

Categories: Stored Grain, Fungi, Aflatoxins, Aflatoxicosis

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