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**A**flatoxicosis affects both people and animals. In fact, it was first discovered in 1961 when more than 100,000 turkeys and other farm animals died from a mysterious disease in the United Kingdom. The cause was found to be aflatoxins in the feed.

#### Sources of mycotoxins in the diet of livestock

Aflatoxins occur in many animal feed concentrates including cereal grains, soybean products, oil cakes (from groundnuts, cottonseed, sunflower, palm, and copra), and fishmeal. Brewers grains (a byproduct from the production of cereal-based alcoholic drinks) can have high levels. Pasture, hay, straw, and silage are more prone to contamination with other types of mycotoxins that will not be considered in this brief.

In general, livestock in intensive systems are at higher risk of dietary exposure than animals in extensive systems. Worldwide, a high and increasing proportion of dairy cattle, poultry, and swine are kept in intensive systems; aflatoxins are thus likely to be an increasing problem.

In countries where regulation for aflatoxins in animal feeds exists, the total permissible aflatoxin levels in animal feeds range from 0 to 50 parts per billion (ppb) with an average of 20 ppb (FAO 2004). (Standards for individual feed components may be higher.) Studies find that in developing countries around 25–50 percent of samples have levels above 20 ppb and contamination of 100 to 1,000 ppb are not uncommon (Binder et al. 2007, Rodrigues and Naehrer 2012).

#### Susceptibility of livestock

The effects of aflatoxins depend on various factors: genetic (species and breed strain), physiological (age, nutrition, and exercise) and environmental (climatic and husbandry). Fetuses are very susceptible to even low levels, and young and fast-growing animals are more affected than adults. Males are more susceptible than females. There is considerable variation by species. A list of animals in order of decreasing sensitivity runs rabbits>ducks>turkeys>chicken>fish>swine>cattle>sheep. Rats are susceptible and mice are resistant. Ruminants, if old enough to have a functioning rumen, are relatively resistant.

#### Impacts of aflatoxins on animal health and production

Very high levels of aflatoxins cause acute toxicosis and death in livestock and fish. Chronic consumption of lower levels can cause liver damage, gastrointestinal dysfunction, decreased appetite, decreased reproductive function, decreased growth, and decreased production. In addition, immune-suppression results in greater susceptibility to other diseases. Adverse impacts are more severe when there is co-contamination with other mycotoxins.

#### Impacts of aflatoxins on the livestock sector

Chronic aflatoxicosis probably has greater economic impacts than acute disease. Numerous studies show a worsening in food

conversion ratios, a decrease in average daily gain, and a decrease in body weight for animals experimentally fed aflatoxins (Khlangwiset et al. 2011). Additional losses occur in the livestock sector if grain and feed do not meet standards for animal feed. Moreover, the nutritive value of grains and cereals is reduced by contamination with the mold that produces aflatoxins. Economic loss also occurs if livestock and fish products do not comply with the standards for aflatoxins in human foods.

#### Impacts of aflatoxins in animal-source foods

Aflatoxin B1 is metabolized to aflatoxin M1 (AFM1) in the liver and excreted in the milk of dairy cows. Because aflatoxins are degraded by flora in the cow's rumen, the amount of AFM1 excreted in milk is only around 1–7 percent of the total amount of aflatoxin B1 ingested. Higher-yielding animals consuming large amounts of concentrates typically have higher levels in their milk. The presence of mastitis may increase the secretion of aflatoxins.

While levels of mycotoxins in cereals may reach thousands of ppb, levels in milk are generally less than 100 ppb. However, aflatoxins in milk are of concern because milk consumption is often higher among infants and children, who are likely to be more vulnerable. Accordingly, many countries set a lower threshold for aflatoxins in milk. AFM1 ranges are between 0.02 and 5 ppb, with 0.05 ppb the most common (Mohammadi 2011).

Aflatoxin levels are around three times higher in soft cheese and five times higher in hard cheese than the milk of origin. But because cheese is more concentrated, using aflatoxin-contaminated milk for cheese production is risk mitigating (for example, if ten liters of milk makes one kilogram of cheese and aflatoxins are five times higher in hard cheese, then the exposure of humans from consuming one kilogram of cheese is half as much as the exposure from consuming ten liters of milk). Aflatoxins may also be present in yogurt and other dairy products. Recent studies have suggested that a related toxin called aflatoxicol may also be excreted in significant amounts in milk, a subject that requires further research.

Trace levels of aflatoxins and their metabolites may also carry over into the edible tissue of meat-producing animals. Poultry feed contaminated at the level of 3,000 ppb may result in levels of 3 ppb in poultry meat. Aflatoxins may be carried over from feed to eggs at ratios ranging from 5,000–125,000 to 1 (Zaghini et al. 2005). These transfer rates are much lower than for milk, and surveys in developing countries typically find levels of less than 10 ppb in meat and offal. Given the relatively low quantities of animal-source food consumed, this is not likely to present a major contribution to overall consumption of aflatoxins in the diet. However, processed fish has been found to be significantly contaminated with aflatoxins (Adebayo-Tayo et al. 2008) and may represent a risk. Mold-fermented foods such as fermented meat may also contain aflatoxins, but there is very little information regarding the level of aflatoxins in traditionally processed foods.

## Control of aflatoxins in animal feeds

The general methods of aflatoxin management (plant breeding, biocontrol, pre- and postharvest practices, and nutritional strategies) are discussed in other briefs and here we focus on methods primarily applicable to animal feeds.

**Binders:** The addition of binding agents such as zeolite clays and aluminosilicates is effective in reducing toxicity. When binding agents are included in feed at a ratio of 200 parts feed to 1 part binding agent, they reduce most of the harmful effects of aflatoxins at levels of 1,000 ppb for pigs and 7,000 ppb for poultry. The cost is around \$0.25 per ton of feed.

**Blending:** One method of reducing moderate levels of aflatoxin contamination is to blend contaminated grain with clean grain (blending one kilograms of grain with aflatoxin contamination five times above the limit with nine kilograms of grain exhibiting no detectable aflatoxins would result in ten kilograms of grain with aflatoxins at 50 percent of the permissible amount).

**Decontamination:** Ammoniation is a safe and effective way to decontaminate aflatoxins; it has been used with success in many countries, yet is not legal in others. The average costs are 5–20 percent of the value of the commodity. Nixtamalization, the traditional alkaline treatment of maize in Latin America, can reduce toxicity and has potential for wider applications. Other chemical and biological agents have been effective in experiments but are not yet commercially developed.

## Feeding aflatoxin-contaminated cereals to livestock

Being fed to appropriate livestock may be the best use of most aflatoxin-contaminated corn. Although there are no currently established levels at which aflatoxins can be guaranteed safe for livestock, many animals, especially mature animals, can tolerate aflatoxins well. Many experimental studies do not show any statistically significant effects from low levels of aflatoxins, and there is a consistent pattern of fewer effects from aflatoxins at lower doses and increasing effects at higher doses. Moreover, there appear to be no scientific papers describing any toxic effects of mycotoxins when present at very low levels (AFSSA et al. 2009). Growth depression associated with aflatoxins is affected by factors other than species and age; for example, rats on high-protein diets with 500 ppb aflatoxins exhibited better growth than rats on low-protein diets without aflatoxins. Exercise and absence of other mycotoxins from the diet are also protective. Depending on species,

TABLE 1 Guidelines for acceptable aflatoxin levels in feed		
Animal	Feed	Aflatoxin level
Finishing beef cattle	Corn and peanut product	300 ppb
Beef cattle, swine, or poultry	Cottonseed meal	300 ppb
Finishing swine of 100 lbs. or greater	Corn and peanut products	200 ppb
Breeding beef cattle, breeding swine, or mature poultry	Corn and peanut products	100 ppb

Source: FDA. 1994. CPG Sec. 683.100 Action Levels for Aflatoxins in Animal Feeds, [www.fda.gov/ICECI/ComplianceManuals/CompliancePolicyGuidanceManual/ucm074703.htm](http://www.fda.gov/ICECI/ComplianceManuals/CompliancePolicyGuidanceManual/ucm074703.htm).

age, and length of trial, experiments have found no effects from aflatoxins at levels from 200 to 5,000 ppb and significant effects at levels from 20 to 10,000 ppb. Table 1 demonstrates the appropriate levels of contaminated foods that may be fed to livestock.

## Conclusion

Aflatoxins, like other mycotoxins, can seriously reduce livestock productivity. In poor countries, livestock are often fed highly contaminated grains considered unfit for human consumption and are thus at risk of acute toxicosis. Chronic aflatoxicosis is probably a major cause of economic loss, especially for farmers raising pigs and poultry in intensifying systems. Aflatoxins can transfer from feed to animal-source products, but there is minimal information about or testing of these products in developing countries. Risks are likely to be highest in the case of milk, processed fish, and indigenous fermented meat, fish, and dairy products.

Important information gaps requiring urgent research include the prevalence of aflatoxins in animal feeds, serum, and animal-source foods; the current economic impacts of aflatoxins in animal feed in developing countries; the most cost-effective means of managing aflatoxins in animal feed; and the impacts of aflatoxins in animal source food on human health especially in high-risk communities (such as those with very high consumption or risk-increasing practices such as smoking fish).

## FOR FURTHER READING

Pitt, J. I., C. P. Wild, R. Baan, W. Gelderblom, J. D. Miller, R. T. Riley, and F. Wu. 2012. *Improving Public Health through Mycotoxin Control*. IARC Scientific Publication 158. Geneva: WHO Press.

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