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Mycotoxins in Feed and Food Crops

Texas Agricultural Extension Service • The Texas A&M University System
Daniel C. Pfannstiel, Director • College Station, Texas

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MYCOTOXINS IN FEED AND FOOD CROPS

Prepared by

James M. Armstrong, Extension Project Leader in Veterinary Medicine and Veterinarian (Livestock Health)

John E. Bremer, Extension Agronomist

Dennis B. Herd, Extension Beef Cattle Specialist - Nutrition

C. Wendell Horne, Extension Project Leader in Plant Sciences and Plant Pathologist and Coordinator of this Publication

William B. Thomas, Extension Swine Specialist

Fred D. Thornberry, Extension Project Leader in Poultry

Leland D. Tripp, Extension Agronomist - Peanuts, Sunflowers & Other Oil Seed Crops

Thomas H. White, Jr., Extension Area Dairy Specialist

Richard E. Withers, Jr., Extension Agricultural Engineer

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MYCOTOXINS IN FEED AND FOOD CROPS

INTRODUCTION

Mycotoxins are chemical compounds produced by fungi growing on organic substances such as corn and peanuts, which, when consumed, have some undesirable effects on the animal consuming them. More than 100 toxic compounds produced by fungi have been identified and about 45 of these occur in grain crops. The most common and widely known of the toxins is aflatoxin which is produced by some isolates of the fungi *Aspergillus flavus* and *Aspergillus parasiticus*. When feed containing high levels of this toxin is fed to test animals a series of predictable and undesirable side effects occur. This has resulted in its being labeled as a "carcinogen," which means "cancer-causing."

Even though the effects of feeding moldy grain have been known for many years it was not until 1961 that the cause was properly identified. In 1960, 100,000 turkey poults died in the British Isles from eating contaminated feed. The next year British scientists found the cause of the mysterious "Turkey X Disease." Since that time much research has been done to improve our understanding of the whole mycotoxin problem.

Mycotoxins have probably been present in man's food supply since the beginning of civilization. The ancient Greeks, for example, cooked with mushrooms. This resulted in some people getting sick and others dying from the poisonous species of the mushrooms or fleshy fungi. The development of the science of mycology (study of fungi) has permitted scientists to distinguish between the poisonous and nonpoisonous types. Only recently have we been able to identify and measure these toxins in food and feed substances. More recent developments have permitted scientists to measure these compounds in minute quantities such as parts per billion (ppb).

SERIOUSNESS OF THE MYCOTOXIN PROBLEM

The seriousness of the mycotoxin problem varies with the year, the crop being grown and the intended use of the crop product. Those who stand to lose economically from an occurrence of the problem should be constantly aware of its possibility. Failure to anticipate the possibility and have alternatives available when needed can result in unusually high losses.

This publication was developed to help those who might experience financial loss to better understand the problem and its control. Unfortunately one cannot always manage *all* the factors that may contribute to development of the problem. This makes it doubly important that as much control as possible be exercised.

Aflatoxin, the most commonly detected mycotoxin, does not frequently occur in wheat, oats, sorghum, rice and soybeans. It has been found with regularity, however, in peanuts and corn produced or stored under conditions that favored development of the toxin-producing mold. Aflatoxin is found less frequently in cottonseed and its products. Those commodities intended for human consumption are checked very closely for presence of toxins. Therefore, the consuming public has no reason to be overly concerned about the wholesomeness of processed foods containing these commodities.

WHO STANDS TO LOSE ECONOMICALLY FROM MYCOTOXIN CONTAMINATION?

The *producer* of agricultural commodities stands to lose most from contamination of his product. He produces in an environment where microorganisms abound and his crop must endure weather conditions over which he has no control. Experience shows that mycotoxin problems are more likely to occur when crops are produced under drought stress conditions or when the wheather at harvest time is not favorable for proper drying and curing.

When the producer finds himself a victim of unfavorable production conditions and has a quantity of contaminated grain on hand his options become severely limited. This is why every producer should learn as much about the problem as possible and do everything within his power to avoid mycotoxin development.

Livestock and poultry producers stand next in line for experiencing economic loss. Various poultry and livestock health problems may develop depending on the contamination level in feed being used and the susceptibility of the species being fed. Those engaged in commercial livestock feeding operations will no doubt become more concerned in the future with evaluating the quality of feed before purchase and handling it properly thereafter.

Buyers and handlers of certain agricultural commodities also stand to lose substantial sums of money if contamination is discovered while they possess the crop products. Testing to avoid such occurrences will likely increase substantially in the future.

DETECTION AND ANALYSIS OF MYCOTOXINS IN FEED GRAINS AND RELATED PRODUCTS

The science of mycotoxin isolation and identification has developed to the point where extremely low levels can be detected. The present knowledge of this problem is due mainly to the development of sensitive and accurate detection equipment. Certainly there was previous knowledge of injurious effects of feeding moldy grain, but this usually was considered only after damage occurred. Routine feed grain analysis to prevent damage is a recent development.

Detection methods range from procedures as simple as visual observation of the toxin-producing molds to complicated chemical analyses of the toxins themselves. Peanuts are inspected visually at buying points under a low power microscope for presence of the fungi that produce aflatoxin (*Aspergillus flavus* and *A. parasiticus*). If these fungi are detected on any part of a kernel in the selected sample, that entire load is condemned for feed or food use. This procedure is indirect and does not give an indication of actual presence of the toxin.

Another simple and quick method is the use of "black light." This specially designed light causes corn or other grain to fluoresce or "glow" in the dark. Again, this method is not always reliable for detecting the presence of aflatoxin. Some investigators have found that the reliability of this method may be more than 50 percent. Varying degrees of accuracy are obtained, depending on the samples being checked and the procedure being used. One USDA publication states that "In spite of the frequent failure to associate BGYF (Bright Green Yellow Fluorescence) with aflatoxin in corn, it is believed positive results are frequent enough and the need for a screening system is great enough to justify its careful use."

Mini-column analysis is the simplest procedure for actually detecting and measuring toxin. It requires chemical extraction from the product with solvents and takes about 30 minutes to run after the procedure is operational. To be accurate it must be run carefully and with precision. It is a test that can be used at buying points when adequate facilities are available and a trained person is running the test. Its major advantage is its ability to directly detect the chemical toxin rather the presence of the mold.

Thin-layer chromotography is another direct method used to detect toxins under laboratory conditions. It is considered the most accurate method available and is a research technique only. It takes much more time than the mini-column system and must be done by people that are well trained in its use. It is considered impractical for use as buying points.

Usually two or more parties are involved in the change of ownership of an agricultural commodity such as feed grain. If toxin content is a consideration in the transaction either one of these parties can be hurt financially by inadequate or inaccurate testing. Sampling must be representative of the entire lot and a system for analysis must be capable of giving reliable information.

If grain is stored improperly the toxin level may increase after initial sampling, providing conditions are favorable for growth and development of mycotoxin-producing fungi. It is imperative that recommended storage procedures be used to avoid a buildup of mycotoxins at that time.

It is to the buyer and seller's advantage that tests for mycotoxin presence be accurate. Certain private laboratories can do this testing, or testing equipment can be set up at buying points. Such testing is likely to become more routine in the future especially if interstate grain shipment is anticipated.

COMMON MYCOTOXINS AND FUNGI
THAT PRODUCE THEM

Mycotoxins	Fungi which produce toxin	Principal crop(s) Affected
Aflatoxin	*Aspergillus flavus* and *Aspergillus parasiticus*	Corn, peanuts, cotton seed
Patulin	*Penicillium expansum*	Apples, malt feed
Ochratoxin	*Aspergillus ochraceus* and other *Aspergillus* spp.	Corn, peanuts
Zearalenone	*Gibberella zeae, Fusarium* spp.	Corn
Trichothecenes	*Fusarium tricinctum,*	Corn
	Fusarium roseum	Corn
	Others	
Ergot alkaloids	*Claviceps paspali*	Dallisgrass
	Claviceps purpurea	Rye
Sporidesmins	*Pithomyces chartarum*	Range grasses

CONDITIONS FAVORING FUNGAL
INFECTION AND TOXIN FORMATION

Temperature and Moisture

Both temperature and moisture play a vital role in the potential for mycotoxin development on crops in the field and commodities in storage. Factors necessary for fungus development include a susceptible host, presence of the fungus and favorable environmental conditions.

At one time it was generally thought that mycotoxin development occurred only in harvested commodities when they were handled and stored improperly. While they can certainly occur under such conditions, later work shows that they often develop while the crop is in the field.

Conditions favoring the aflatoxin-producing fungus, *Aspergillus flavus*, are listed as follows:

Factor	Optimum	Range
Temperature	86° F plus	80 to 100° F
Relative humidity	85 percent plus	62 to 99 percent
Kernel moisture	18 percent	13 to 20 percent

The figures listed above were taken from several sources and in some cases represent compromises among findings. Variables such as the type of medium that the fungus is growing on may alter responses. Development of the fungus usually stops when the temperature is below 55° F and grain moisture is 12 percent or below.

Problems with aflatoxin have been far more severe on corn and peanuts when drought stress prevailed during the latter part of the growing season. Under such conditions, factors favoring infestation are ideal because: temperatures are high, relative humidities around kernels are high and the kernel moisture is lowered enough for infestation to occur. High grain moisture (20 to 30 percent) is not conducive to the infection process for this fungus. The fungus that produces aflatoxin also has less competition from other organisms when drought stress conditions prevail.

Confusion often arises when one thinks of production and storage conditions at the same time. Those oriented toward considering the aflatoxin problem to be a harvesting and storage problem find it difficult to see how drought stress (low moisture) can cause a problem considered to be related to high moisture at harvest time. Corn for example is vulnerable after it reaches the dough stage at which time the moisture usually is too high for infection by the aflatoxin-producing fungus. If severe drought stress is present, however, kernel moisture is lowered to the point where infection can occur.

Cultural Factors and Insect Damage

Drought is now considered one of the major factors which predisposes certain crops to infection of mycotoxin-producing fungi. In 1977 drought-stressed corn in the southeastern states was plagued with the aflatoxin problem. Corn and peanuts especially are subject to aflatoxin problems when drought occurs.

Peanuts have been subjected to a rigid inspection program for several years and increases in occurrence have been related directly to drought stress. During the height of drought stress moisture is pulled out of developing fruit into the surrounding dry soil. This causes the kernel to pull away from the inner surface of the pod. When moisture becomes available again the kernel expands rapidly causing the pod to split. While splitting is not essential for infection to take place it is thought to be a major contributing factor to infection.

Mechanical injury of the peanut pods and kernels also is caused by the lesser corn stalk borer. Such insect damage has been thought by some to contribute to the aflatoxin problem.

Insect damage on field corn has been shown to increase the incidence of ears infected with the aflatoxin-producing fungi. Scientists working in southeast Missouri with high moisture corn found a significant association between aflatoxin contamination and corn ear worm damage. When 9,900 ears of corn were evaluated 6.3 percent of the insect-damaged kernels showed aflatoxin association as compared to 2.5 percent on nondamaged kernels. The fungus was isolated from 37 percent of the ears showing worm damage as opposed to 14 percent on nondamaged ears.

Other insects have been found to carry spores of mycotoxin-producing fungi. Damage that they do to grain and other commodities increases the possibility of mycotoxin development.

MANAGEMENT OF FEED GRAINS

Harvesting

Fungi that produce mycotoxins can readily invade grains that are cracked or have damaged seed coats. Foreign matter such as crop and weed fragments not screened out during the harvesting operation also can enhance mold growth. It is, therefore, very important to minimize combine damage and foreign material by proper combine adjustment and operation.

The combine operator's manual is an excellent guide to proper operation and adjustment. Refer to it frequently when problems are encountered. Some of the recommended general practices for good combining are as follows:

- -First, get the feel of the combine's ability to handle the crop by operating at a slow ground speed. Use a lower gear than normal, but do not reduce engine speed; if you do, the combine will not perform efficiently. Gradually increase ground speed and check results until problems are encountered, such as unacceptable losses or threshing damage. Under normal conditions, operate at ground speeds between 2½ to 3½ miles per hour.

- -Do not hesitate to make adjustments to the combine if they are necessary. Know why you must make the adjustment before doing it. Make only one adjustment at a time and check the results before making others.

- -Check frequently for proper threshing action and adjust the cylinder speed and concave spacing as necessary. Growers are encouraged to install filter plates between threshing cylinder bars and adjust cylinder to lowest speed and widest clearance that will give adequate shelling. Less cracking occurs at low cylinder speeds.

-Check for grain losses when checking threshing action. Make adjustments as necessary, such as reducing ground speed, and changing cylinder-concave, fan, chaffer and sieve settings.

-When using a cutting platform in a standing crop, cut as high as possible without missing too many low grain heads. In tangled crops, use lifting guards and keep the header low and the ground speed slow.

-Keep the reel height and speed adjusted for changes in crop height and ground speed.

-When using a corn head, keep the header low to get low ears. Keep the corn head centered in the rows to prevent stalks from bending and losing ears.

-Adjust the cleaning units when losses over the show or excessive tailings occur.

-Do not overload the combine by operating at faster ground speeds; losses will increase tremendously.

-When operating in poor conditions, such as a weedy crop or a hard-to-thresh crop, slow down and make frequent checks for combine performance.

Best harvesting times vary with the crop and weather. The proper stage for harvesting is when the grain will give the biggest yields at the highest quality. Usually corn gives its highest yields when the moisture content is between 20 and 30 percent. Most researchers agree that the optimum moisture content is 26 percent. Weigh the yield factor against the cost of drying the crop and the availability of crop dryers to make sound economic decisions on harvest moisture content.

<u>Handling</u>

Improper holding of high moisture grain can lead to *Aspergillus flavus* and other mold growth before storage. Aflatoxins can be produced after about 24 hours when conditions are favorable for mold growth in wagons and other temporary storage containers. Do not hold high-moisture corn in wagons or similar heading areas more than 6 hours. Place high moisture corn awaiting drying in a "holding bin" or "wet bin" and force air through it to keep it cool. Use peanuts wagons to cool and dry corn while holding it for the dryer.

Research shows that corn which collects in auger wells and pits around dump stations frequently contains the fungus *Aspergillus flavus*. This can be a ready source of fungal contamination to corn as it is put into storage. Thoroughly clean all areas before and after use. Experiences with peanut handling in Texas as it relates to the aflatoxin problem, clearly substantiates the need for removing left-over grain from trucks, trailers, holding bins, drying facilities, storage bins and handling equipment before beginning a new lot of grain.

Storage

The major influences on growth and reproduction of microorganisms in grains are:

- -Moisture content of the grain
- -Temperature
- -Oxygen supply
- -pH
- -Condition or soundness of the grain

PREVENTING MYCOTOXIN DEVELOPMENT DURING FEED UTILIZATION AND STORAGE

Mycotoxins can accumulate when feed is held in storage even though the initial ingredients may have been free of them. The following suggestions are made to help producers avoid losses from mycotoxins.

- -Don't buy poor quality feed or feed ingredients.
- -Don't store under high moisture conditions.
- -Develop a systematic inspection and clean up program to keep bins, delivery trucks and other equipment free of adhering or caked feed ingredients.
- -Minimize dust accumulation in milling areas.
- -Cool pelleted feed before storage or delivery.
- -Keep all feed equipment free of caked feed.
- -Don't store finished feed for lengthy periods.
- -Have designated personnel check and report leaks or damage to feed bins and equipment on a regular basis.
- -Check with a professional nutritionist, veterinarian or plant pathologist if mycotoxin problems are suspected.

Recommended practices for controlling or preventing mycotoxins in stored grain, therefore, include proper management of one or more of these five influences.

Moisture content is by far the most important factor affecting the growth of microorganisms in stored grains. If moisture is maintained at a low enough level, other factors which influence storage will not greatly affect grain spoilage. The long-term, safe storage moisture content for corn in Texas is generally accepted to be 13 percent. However, high moisture grain must be cared for very soon after harvest to prevent or control mold development. Cool grain as soon as possible and dry down to 15 percent within a short period of time depending on the kernel moisture content and temperature. Usually, this short period is in terms of days, but it could be in hours for grain at 30 percent moisture and 80 or 90^{o} F temperature.

Artificially dry grain that is harvested above 13 percent moisture unless it is to be ensiled or stored wet with grain preservatives. Use approved drying methods as long as they accomplish the moisture reduction in the allowable period of time. Do not dry corn too fast. Research shows that drying with excessively high temperatures, drying too fast and cooling too rapidly may cause unacceptable quality losses. Recommended maximum kernel temperatures are as follows:

- Feeding - 180^{o} F
- Milling - 140^{o} F
- Seeding - 110^{o} F

Drying speed should not exceed eight points per hour; use slower drying speeds for moisture ranging from 19 to 14 percent. Finally, it is recommended that dried corn be allowed to temper before the cooling process and then be cooled slowly to achieve best quality results.

Temperature reduction also enhances preservation of grain quality in storage. Common storage fungi grow most rapidly at temperatures of 85^{o} and 90^{o} F. Below these temperatures, growth rates decrease, and growth is very slow at 35^{o} and 40^{o} F. Aerate stored grain with fans at the airflow rate of 1/10 cfm per bushel to achieve cooling and temperature equalization. Temperature equalization helps control moisture migration--the phenomenon which results in condensation and subsequent spoilage within storage bins.

Aerate as often as possible when the outside air temperature is 10^{o} F cooler than the grain temperature until the grain temperature is comparable to the outside air temperature. After that operate the fans 2 to 3 hours each week unless heating occurs which requires additional aeration.

The condition or soundness of the grain is another very important influence on grain quality in storage.

Foreign material, pieces of cracked grain and trash provide an excellent breeding ground for microorganisms and some kinds of insects and mites. Insects and mites produce water as a by-product of their growth and break the fruit coat of the grain (the natural protective layer). By doing this they indirectly provide moisture which is required for microbial growth and provide easy access for microbes to the nutrients contained inside the fruit coat. For long term storage, the less foreign material in the grain, the safer the storage conditions. Clean grain before storage.

Other recommended practices for the safe storage of grain are as follows:

- Clean and put storage bins in proper repair to prevent moisture leaks from faulty joints, holes, etc., and remove all debris in and around the storage areas. The latter aids in preventing insect buildup. Use a recommended bin insecticidal spray before grain is put into bins.

-Inspect stored grain frequently to determine the extent of insect infestation, and use approved control measures when necessary.

-Begin an effective rodent control program around storage bins since rodents not only feed on the grain but carry fungi and other microorganisms into the grain.

-Use one of several registered organic acids to store high moisture grain. Examples of these are propionic acid, isobutyric acid, mixtures of these and ammonium isobutyrate. These are sold under various trade names. Organic acids prevent *Aspergillus flavus* growth if applied properly to the grain as it is augured into the bins. However, these acids will not remove any aflatoxins that have formed within the grain before the fungus is killed. *Grains treated with acids can be used only for livestock and poultry feed. They cannot be used for human food or kept for seed use. They cannot be used in a brewery because the yeast will be inhibited.* These acids are very corrosive to metals and should not be used in metal storage bins unless the metal is amply protected. Distributors of these products have recommendations for protecting metal bins and other storage equipment.

Detoxification of Contaminated Feeds

Several compounds are under investigation for *removal* of aflatoxins from feed grains and other products; however, there are no compounds registered by EPA for this purpose.

One investigation being conducted in the southeastern states is the treatment of aflatoxin-contaminated corn with ammonia. Treatment methods are being studied as well as the feedability of ammonia-treated corn. Initial results indicate that the treatment of aflatoxin-contaminated corn with ammonia has potential and merits further study.

Safety and feedability are the primary concerns at this point. Ammonia contact with the eyes or skin could be very harmful, and a spark or flame generated from a fan motor in the presence of gaseous ammonia could cause an explosion. Also, some question still exists as to the possible side effects of ammoniation, although no problems have emerged in feeding trials so for.

CLINICAL EFFECTS OF MYCOTOXICOSIS

Mycotoxins cause diseases in a broad range of animal species that are described individually. Some mycotoxins result in severe inflammation of the liver or kidneys, massive hemorrhages and sometimes ulceration of the mouth and digestive tract. At other times the effects are not easily recognized. These effects are dependent on the species of animal, amount consumed and length of exposure. Moderate or high dosage to a sensitive animal or bird may lead to death within a short time. Growing poultry, young swine, pregnant sows, calves and dogs are highly susceptible. Adult cattle, sheep and goats also are susceptible when fed toxic diets over long periods of time. Tables 1 and 2 in the Appendix review the effects of different mycotoxins and dosage range on several animal species.

Beef Cattle

Aflatoxin is the most common mycotoxin known to affect beef cattle. Calves are more susceptible than adults as noted in the chart entitled "Effects of Aflatoxin on Dairy Cattle." Since aflatoxins pass through in milk and young calves are more susceptible, do not feed contaminated feeds to young calves or lactating cows. It is not advisable to feed suspect feeds to pregnant animals. Older nonpregnant animals can tolerate contaminated feeds better.

Chronic symptoms of liver damage, reduced growth and decreased feed efficiency can result from the continued intake of 700 to 1,000 ppb of aflatoxin in feed of 450-pound cattle. Kidney damage, anemia, interference with the body's immune system, greater susceptibility to bruising and interference with normal protein and fat metabolism have all been reported with varying levels of intake. In acute cases, those below the level that lead to sudden death in cattle, the following signs may occur: depression, including lack of appetite; nervousness, abdominal pain (animals may stretch or kick at their abdomen); diarrhea and rectal prolapse. Death of steers has been reported from an intake of 1,000 ppb of aflatoxin in feed during a 59-day trial.

Prevention is best; however, there are several dietary modifications that help animals recover from mycotoxicoses. A broad-spectrum antibiotic at treatment levels help prevent secondary invaders. A medium to high energy, high proten diet also improves growth rate. Other types of stress should also be avoided.

Dairy Cattle

Mycotoxins, in general, and aflatoxins, specifically, are quite frequently toxic to dairy cattle, particularly calves. The long-range effect of aflatoxin intake on dairy cattle is unknown at this time.

Recent data indicate that aflatoxin is secreted in milk when the cow consumes as much as 19 ppb per day. There are no official tolerances for aflatoxins since the *Delaney Amendment* prohibits the presence of *any* cancer-causing substances in food. Aflatoxin has been shown to be a cancer-causing agent. The Food and Drug Administration (FDA) allows grain to be marketed with 20 ppb or less aflatoxin.

Aflatoxins cause a catabolic loss of nitrogen through feces and urine, loss of appetite, reduced growth rate and kidney damage in calves. In older cows, it is detrimental to liver function and impairs protein and RNA synthesis.

Since aflatoxins are secreted in milk, do not feed certain feeds containing it to lactating cows where consumption is greater than .23 mg of aflatoxin per day or the ration contains more than 15 ppb. Suckling calves should not nurse cows consuming feed containing aflatoxins. Milk containing aflatoxins in levels of 0.2 mg/kg has been fatal to calves.

Usually, aflatoxins disappear from milk within 1 week when contaminated feed is removed from the cow's ration. Table 3 summarizes the effects of aflatoxins on dairy cattle.

Horses

Acute intoxications from ingestion of feed contaminated with certain fungi or molds have been reported in Texas. The Texas Veterinary Medical Diagnostic Laboratory receives 10 to 15 cases annually. Some others are likely not reported or not recognized.

In earlier years when horses and mules were used as a source of power for agricultural production many incidents of damage were reported to the Texas A&M Large Animal Clinic. These cases occurred mostly in the humid areas of Texas where corn was produced and stored on the farm. With the advent of feeding commercially stored and prepared mixed feeds this type of toxicity has decreased gradually.

Reports from the literature indicate that horses can be affected by moldy straw, ergot on seed heads of certain grasses and moldy corn. The most serious cases have been those from moldy corn which cause brain changes leading to lack of muscle control, circling and death.

Poultry

Mycotoxins in feed have been implicated in health and performance problems with poultry. Such incidences have been few in Texas, however. Since the potential problem exists Texas poultrymen should be aware of the danger from certain toxins and implement procedures to minimize changes of mycotoxin contamination or damage.

Symptoms of mycotoxin damage are broad and resemble those of many disease and nutrition problems. Those attributed to mycotoxins include liver and kidney damage; leg, bone and heart abnormalities; coccidiosis breaks; enterities; hemorrhages and bruises. A reduction in the resistance to diseases has been demonstrated in young chicks. The effectiveness of vaccines has been reduced. Less resistance to stress, reduced growth, reduced egg production and hatchability are primary symptoms. Other effects include increased morbidity and mortality.

Information on Aflatoxins, Cooperative Extension Work in Agriculture and Home Economics, South Carolina, Information Note 1, 1975.

Studies show that the incidence of mycotoxin (aflatoxin) concentration increases with each step in the feed handling process. Potential contamination sites include grain in the field, storage, transit, handling and feeding equipment.

Swine

Pigs of various ages are affected differently by mycotoxins. For example, young pigs are more susceptible to harmful effects of being fed moldy corn than any other animal. Do not feed moldy grain to breeding animals because some molds produce mycotoxins that have the same effect as female hormones. Unbred gilts, for example, will have swollen external reproductive organs and enlarged mammary glands. Pregnant sows may abort and be infertile. Market animals may refuse to eat moldy feed or vomit when they eat. Reduced growth rate, stunting, lose of appetite, nervous symptoms and death are signs of poisoning my mold toxins. Hungry animals may ignore poor, faulty grain and consume large quantities of it.

Two primary conditions found in swine that have eaten moldy feed are vulvovaginitis and aflatoxicosis. Vulvovaginitis is caused by a toxin produced by *Fusarium graminearum*. The first change noted in pigs consuming this toxin is a gradual enlargement or swelling of the vulva. It seemingly differs in no way from enlargement of the vulva due to the heat period, but the swelling continues until the vulva is smooth, very firm, tense and elevated or swollen out of the body. In some instances, there is vaginal prolapse. Gilts from 6 weeks old up to 100 to 150 pounds in weight are most often affected. Older animals appear resistant. Death may result from hemorrhage, infection, uremia or infection of the urinary tract.

Aflatoxicosis is primarily a liver disease, although other organs and systems may be involved secondarily. Aflatoxin is often the cause of diseases referred to as moldy corn poisoning or peanut meal poisoning in swine. These toxins are produced by *Aspergillus flavus*. Symptoms shown by field cases of aflatoxicosis include reduce growth, weight loss, appetite loss and general unthriftiness. As the disease progresses to the terminal stages, there often is muscular incoordination, convulsions and jaundice.

Aflatoxin affects many traits in swine and while definite tolerence levels have not been established, some guidelines are available. Effects of the same level of aflatoxins can vary because of the condition and total daily intake of aflatoxins. The following guidelines may be used and are generally the lowest levels that various research reports have shown to affect the trial concerned.

EFFECTS OF AFLATOXIN LEVELS ON SWINE

Trait	Parts per billion (ppb)
Decreased growth rate	150 to 300
Reduced feed efficiency	200

EFFECTS OF AFLATOXIN LEVELS ON SWINE (continued)

Trait	Parts per billion (ppb)
Serum protein alterations	400 to 500
Organ change or damage	400 to 500
Death loss - gradual	810
Death loss - 1 to 3 days	2,000
Abortions, dead pigs at birth	450 to 1,500

APPENDIX A

TABLES

Table 1. Mycotoxicoses associated with acute primary diseases of livestock and poultry*

Mycotoxicosis	Animal species	Primary effects
Aflatoxicosis	Poultry, swine, cattle	Liver inflammation, hemorragic disease, death
Ergotism	Cattle, sheep, chicken, swine	Tissue death, nervous seizures, reproductive failure
Facial eczema	Sheep, cattle	Inflammation of liver, increased sensitivity to light
Fusariotoxicoses		
Vomitoxicosis	Swine	Inflammation of intestines, vomiting
T-2 Toxicosis	Swine, cattle, poultry	Skin destruction, inflammation of intestinal tissue
Leucoencephalomalacia	Horse	Nervous depression
F-2 Toxicosis (Zearalenone)	Swine	Vulvur swelling
Orchratoxicosis	Swine, Turkeys	Kidney degeneration
Paspalum staggers	Cattle, sheep, horses	Loss of balance
Slaframine toxicosis	Cattle, sheep	Salivation, diarrhea, increased urine
Stachybotryotoxicosis	Horse	Skin destruction, inflammation of intestines, reduction in bone marrow function

*Academy of Veterinary Consultants Seminar, December 8, 1976, "Bovine Mycotoxicoses"

Table 2. Acute and chronic dose-response relationships of selected mycotoxins in cattle*

Mycotoxin	Level	Duration	Effect
Aflatoxin	0.08 mg/kg**	2 + weeks	Reduced weight gain (calves)
	0.02 mg/kg (B_1)	2 to 4 weeks	Reduced weight gain (calves)
	0.7 ppm (B_1)***	19 weeks	Reduced weight gain (steers)
	2 ppm		Reduced milk production
	0.5 mg/cow/day		Detectable milk residue
	0.5 mg/kg	14 days	Death (calf) jaundice hemorrhage, liver disorder
	1.0 ppm	59 days	Death (steer)
Ochratoxin A	1.0 mg/kg	14 days	Depression, reduced weight gain, inflammation of kidney and intestine
	2.0 mg/kg	14 days	Clotting disorder
T-2 toxin	0.16 mg/kg	12 days	Inflammation of intestines, abnormal ulcers
	0.64 mg/kg	20 days	Death (calf), bloody feces, abomasal and reminal ulcers

*Academy of Veterinary Consultants Seminar, December 8, 1976, "Bovine Mycotoxicoses"
**Daily intake per kg body weight (total toxin).
***Feed level (aflatoxin B_1).

Table 3. Effects of aflatoxin on cattle*

Aflatoxin level		Effects on		
mg/kg of body weight per day	Approximate parts per billion in total diet	Calves 100 to 300 pounds	Heifers and Steers 300 to 800 pounds	Cows 800 to 1400 pounds
.006	(19 to 23)			Appears in milk
.0012	(38 to 48)			Appears in milk
.0024	(75 to 96)		No effect during a 20-week trial	Appears in milk
.0048	(150 to 192)	Produced liver lesion and reduced feed intake when fed for 16 weeks	No effect during a 19-and a 20-week trial	Appears in milk and at all higher dosages below
.0096	(300 to 380)	Can reduce feed intake after 12 to 16 weeks	No effect during a 19-and 20-week trial	No adverse health effect when fed for 8 to 13 months
.0192	(600 to 770)	Death after 16 to 25 weeks. Very young calves had reduced feed intake by 4 weeks	Decreased feed intake during a 19-week trial with two out of 10 dying	Reduced milk yield during 7-week test
.0384	(1,200 to 1,500)			
.0768	(2,400 to 3,100)	Intake severely depressed within 2 weeks. Liver damage by 3 weeks. No death during 6 week test		Intake reduced and milk production dropped 50 percent in 6 weeks
.1536	(4,800 to 6,100)			Intake drastically reduced. Milk production stopped at 4 weeks
.3072	(9,600 to 12,300)			Dramatic drop in intake and milk production within 1 day

*Adapted from: Mertens, D. R., 1977, Current Mycotoxin Research in Dairy Science, Proceedings and Recommendations Resulting from the Corn Mycotoxin In-Service Training Meeting held in Atlanta, Georgia, October 18-19, 1977. p. 45-57.

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Assistance in diagnosis of animal problems associated with mycotoxins can be obtained from your local veternarian or the:

Texas Veterinary Medical Diagnostic Laboratory
Drawer 3040
College Station, Texas 77840

or

Texas Veterinary Medical Diagnostic Laboratory
6610 Amarillo Blvd. West
Box 3200
Amarillo, Texas 79106

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