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Reducing mycotoxins in animal feeds

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FOREWORD

Mycotoxins are chemicals produced by molds infecting crops both in the field, and during storage, mixing, and delivery of grain and animal feed. Mycotoxin contamination of grain products poses a serious threat to the economic viability of grain and farm animal producers as it not only reduces crop yields but also causes illness and poor performance of livestock and poultry. In addition, consumers are concerned about toxic residues in grain and animal food products. The mycotoxin problem knows no boundaries; outbreaks have occurred in many countries around the world. Scientists in the mycotoxin program at Agriculture Canada are committed to keep the agri-food industries informed about the latest advances in our understanding of mycotoxins.

In 1982, Drs. Trenholm, Friend, Hamilton, and Thompson wrote Agriculture Canada publication 1745 entitled *Vomitoxin and zearalenone in animal feeds*. Interest in the topic was reflected in the exceptionally high demand for this brochure. A total of 16 000 copies in English and French were reprinted during the past 5 years. In the interim Drs. Scott, Trenholm, and Sutton published a National Research Council of Canada monograph entitled *Mycotoxins: A Canadian perspective*[1] for distribution to the scientific and technical community. It also met with a very high demand.

Some information in this booklet was initially published in the *Proceedings of the 23rd Annual Nutrition Conference for Feed Manufacturers*, which was sponsored by the University of Guelph and Canadian Feed Industries Association and held in Toronto, Ontario, April 28 and 29, 1987. In light of the serious nature of mold infection and mycotoxin contamination of grain products, the authors have substantially revised the material in the conference proceedings to inform grain producers, handlers, and millers of current knowledge about mold infection and mycotoxin production, and of effective means of prevention and detoxification of mycotoxin-contaminated grain. Guidelines for the safe handling of mycotoxin-contaminated grain products are included. Comments and suggestions are welcomed.

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INTRODUCTION

Mycotoxins are toxic chemicals produced by molds. In Canada, the mycotoxins of primary importance are zearalenone, a group of related chemicals called trichothecenes (including vomitoxin, T-2 toxin, and HT-2 toxin), ochratoxin, and ergot alkaloids[1]. A brief description of the toxic effects of mycotoxins is presented in Table 1. Aflatoxin is not considered to be a problem in Canada, except in imported grains grown in southern climates.

Table 1 Toxic effects of mycotoxins

Mycotoxins	Clinical signs[a]
Zearalenone	Swollen red vulva, vaginal prolapse and sometimes rectal prolapse in swine; suckling piglets may show enlargement of vulvae; fertility problems
Vomitoxin (deoxynivalenol, DON)	Decreased feed intake and weight gain in pigs with DON at ≥2 mg/kg feed; vomiting and feed refusal at very high concentrations of DON (≥20 mg/kg feed)
Other trichothecenes: • T-2 toxin • HT-2 toxin • diacetoxyscirpenol	More toxic than DON; reduced feed intake; emesis; skin and gastro-intestinal irritation; neurotoxicity; abnormal offspring; increased sensitivity to disease; hemorrhaging
Ochratoxin	Mainly affects proximal tubules of the kidneys in swine and poultry; kidneys are grossly enlarged and pale; fatty livers in poultry
Ergot alkaloids	Nervous system disorders; tremors; convulsions; diarrhea; necrosis of the extremities (gangrene); reduced feed intake; abortion; stillbirth and agalactia (poor milk production); blackening of the comb, toes, and beak in poultry

[a] mg/kg = parts per million (ppm).

Species of *Fusarium* mold are of particular concern in eastern Canada. Deoxynivalenol (DON) and zearalenone contamination has been associated with many reports of poor growth, reproductive problems, and illness in farm animals, especially pigs. In addition, other unidentified toxic metabolites are strongly suspected as causes of poor performance and health of farm animals[2]. Although it is difficult to estimate costs accurately in terms of reduced financial returns to grain producers and of illness and death to livestock and poultry, the extent of mold infection and mycotoxin contamination certainly indicates that multimillion dollar losses are associated annually with mycotoxin-contaminated grain and animal feedstuffs[3].

LIFE CYCLE OF *FUSARIUM* MOLD

The fungus associated with maize ear rot in corn and Fusarium head blight in wheat is *F. graminearum*. The principal inoculum source of *F. graminearum* is host debris, such as old corn stalks, ears, and stubble, and debris of wheat and other small grain cereals left on top of the soil. Fungal disease problems may become more acute when minimum or no tillage is practiced. Plowing in plant debris and crop residue left on the field after harvesting promotes decomposition of the moldy plant material. Ears of corn left on the field by harvesting equipment are main sites for reproduction of picnic beetles. Corn borers survive the winter in corn stalks, ears, and stubble left on top of the soil. Corn grown in rotation will control root worms[4,5]. Infected quack grass, barnyard grass, and other weeds may also serve as sources of *Fusarium* infection. Infected wheat and corn seed may give rise to diseased seedlings. *Fusarium*-infected wheat and barley crops at the heading stage may be a source of inoculum for corn in nearby fields. Although widespread in nature, higher levels of mold inoculum are found in grain fields where crops such as corn and small grain cereals susceptible to *Fusarium* infection are grown in rotation year after year over wide areas. Intensive cereal production accelerates development of disease. Crop residues are the principal sources of *F. graminearum*, although soil, seeds, and various grasses are also sources of inoculum[6,7,8,9]. Spores are dispersed in the air or are carried by insects and birds.

Some spores are deposited directly on the host plants. In some areas of Ontario, red-winged blackbirds and starlings damage corn cobs when kernels are at the milk stage. Birds shred the husks and puncture and ingest the contents of kernels. Not only do birds spread fungal infections, but also insects, which are contaminated with fungal spores, seek out damaged kernels. Adult picnic beetles and root worms commonly occur among corn silks and tassels, under leaf sheaths, and on other parts of corn during August and September. Damage caused by birds and insects make it much easier for mold infection to occur.

Most varieties of wheat and corn are susceptible to mold infection. Spores deposited on wheat spikes germinate and grow initially on anthers, but later the mold grows on the spikelets, which become straw-colored. Under humid conditions, pink and white mold growth may appear on the spikes and later on the grain (Fig. 1). Wheat spikes are very receptive to *F. graminearum* infection in the period from flowering to the soft-dough stage. The degree of resistance at various stages of development varies with cultivars. Some cultivars are highly susceptible at the flowering stage, whereas others are very susceptible at the milk or soft-dough stages[10]. The mechanisms involved in plant resistance to fungal invasion require much more research before we can fully understand the processes involved.

In corn, *F. graminearum* grows initially on the silks, anthers, and floral bracts and later on the kernels and cobs. Ears are most susceptible to *F. graminearum* shortly after the silks emerge, and suceptibility declines thereafter. As a general rule a reddish-colored mold appears on the kernels (Fig. 2), however, some *F. graminearum* strains produce no red pigmentation. With corn, upright ears and those with tight husk coverage at harvest seem to be more susceptible than ears with loose husks that drop before harvest[11]. Plants with rudimentary ears and sterile eartips may be more susceptible[12].

For disease epidemics to occur, weather factors favorable for production and dispersion of spores, growth on the host surface, and infection must coincide with the time that wheat and corn are receptive to mold infection. Infection is favored by warmth and prolonged surface wetness. Temperatures of 15° to 35°C, splashing or wind-driven rain to aid in dispersal of spores, and persistent wetness (≥48–60 hours) of wheat spikes and corn ears favor mold infection[9]. After initial fungal infection and spread, weather is not important with respect to toxin production by *F. graminearum*[13].

Once plants become infected, mold growth continues and increasing levels of mycotoxins are produced. At some point during the season, concentrations of specific toxins may actually decrease[13]. Delayed harvesting in the autumn may aggravate the toxicity by allowing the growth of another toxin-producing mold called *Fusarium sporotrichioides*. This fungus produces T-2 toxin, HT-2 toxin, and diacetoxyscirpenol. The net result is that the moldy corn may contain complex mixtures of toxins from at least two species of *Fusarium*. Cool, wet weather conditions favor the growth of *F. sporotrichioides*. Adverse weather conditions may encourage growth of other molds as well.

After harvesting, mold growth and mycotoxin production may continue if the grain is not dried immediately or properly stored. For example, further growth may occur in corn cribs either without roofs or with poor air circulation, in improperly sealed silos for high-moisture corn, in dry corn storage bins that allow snow to enter, and in bins not regularly aerated to avoid condensation. The optimum temperature for mold growth is usually between 20° and 30°C, but fungi can grow at temperatures as low as 5°C. Moisture content greater than 14% allows mold growth at temperatures greater than 5° to 10°C. Mold infection and mycotoxin production can also occur during the preparation of feed, in the feed delivery system, and in improperly cleaned feeding troughs.

PREVENTION OF MYCOTOXIN CONTAMINATION

GRAIN PRODUCTION AND HANDLING

Prevention is the basis of any sound program to minimize mycotoxin contamination. The following measures should be seriously considered.

- Avoid crop rotations that favor fungal infection. Wheat and corn are very sensitive to *F. graminearum* infection. Repeated planting of corn, wheat, and other small grains on the same or in nearby fields is not recommended. In addition, certain areas within a field may be more prone to fungal infections than other areas. Rotations should include crops other than corn and cereals susceptible to *Fusarium* infection[7,14].
- Break the cycle of planting periodically to control insect infestation[7]. Continuous corn, year after year, will lead to greater mold infection as a result of increased insect populations that attack corn plants and spread mold inoculum[15].
- Plant early. Effective land preparation that allows early planting and effective weed control assist in the control of *Fusarium* disease[8]. Weed control is important to eliminate noncrop hosts of *Fusarium*, such as quack grass and barnyard grass[7].
- Plant several varieties of corn with different heat unit requirements and growing characteristics to reduce the possibility of widespread contamination when adverse environmental conditions favor *Fusarium* infection of certain varieties.
- Select seed for increased seedling vigor. High-quality seed and fungicide-treated seed may reduce inoculum and increase seedling vitality. Infected wheat and corn may produce diseased seedlings when used as seed. Consult local specialists for field crop recommendations[16].
- Apply urea fertilizer rather than ammonium nitrate to reduce the incidence of *F. graminearum* in wheat crops. Teich[17] found that wheat fertilized with urea had less scab caused by *F. graminearum* than wheat fertilized with ammonium nitrate at the same rate of nitrogen application (120 kg/ha). Similar results were seen in a follow-up study with wheat involving topdressing in April with urea or ammonium nitrate. Comparable studies have not yet been carried out with corn.

- Avoid a high plant density of corn, as it may not allow adequate aeration and sun exposure to prevent mold infection.
- Inspect fields carefully before harvesting to make certain mold infection has not occurred, even if there is no evidence of bird or insect damage or lodging in your corn fields. Walk the corn fields and peel the husks back on some of the ears to see if mold is present. If possible, harvest and store the least infected grain separate from that with more serious disease.
- Avoid using moldy corn for swine diets, if bird damage is excessive. Bird damage to ears of corn facilitates insect and mold invasion[9]. Cobs that remain upright provide a place for birds to land and they damage the protective husks.
- Avoid harvesting any infected cobs for swine diets. Lodged stalks with cobs touching the ground provide an opportunity for ear damage. Kernels on infected cobs may contain DON at 500–1000 mg/kg (see Fig. 2). At these mycotoxin concentrations, the presence of $>1.0\%$ infected kernels in the diet would affect swine performance.
- Adjust combine (screens and air-cleaning fan) to minimize the amount of fines, moldy or broken kernels, and ear tips in your harvested crop. Mechanical damage to the outer seed coat by harvesting equipment facilitates mold infection.
- Clean harvested corn with screens before drying and storage to remove some of the infected material[8].
- Harvest the crop when it is ready, to avoid undue exposure to poor autumn weather conditions favorable to mold growth and mycotoxin production. If harvest is seriously delayed for corn of any maturity rating, especially under adverse weather conditions, fungal growth and mycotoxin production may be promoted. This situation occurs more frequently with later-maturing hybrids.
- Reduce *Fusarium* inoculum. Plow crop debris into the soil as soon as possible after harvesting[7]. If trash is left on the field after harvesting, mold infection can be carried over to the next year's crop. The trash assists insects such as the corn borer to overwinter and to damage the crop the following year. Plowing buries the inoculum-bearing debris, subjects the trash to microbial degradation, and thus lowers the chance for inoculum dispersal[14]. However, to be effective, virtually all crop debris must be buried.
- Avoid overwintering crops in the field. Serious occurrences of mycotoxins have resulted from leaving crops in the field over winter.
- Store freshly harvested corn properly without delay. Mold can grow in harvested corn unless it is dried quickly to a moisture concentration of $\leq 13–15\%$ and then cooled by aeration. The amount of moisture in the grain can be a primary factor contributing to mold growth. Alternatively, quickly add harvested corn to an airtight silo to prevent mold growth.

- Use mold inhibitors, e.g., propionate[18], to reduce mold growth in stored feed; however, they are unnecessary in properly dried and stored feed. Proper storage will not reduce mycotoxin levels present in the grain at harvest, but will prevent further mold growth and additional toxin accumulation.
- Use properly designed corn cribs with roofs. Some producers have reported that when corn cribs are used, the crop can be harvested earlier to minimize exposure to continued mycotoxin production during adverse weather conditions in the late autumn while the crop is still in the field. Exercise caution in crib storage, as the slower drying of corn can facilitate additional mold growth and mycotoxin production. A roof on the crib protects stored corn from the rain.
- Avoid using mold-infected cobs. In heavily infected ears of corn, toxin concentrations can be higher in the cob than in the kernels. Mixing cob meal in diets is not recommended if mycotoxin contamination is suspected (K. Hough and P. Benoit, personal commun. 1988)[19].

These preventive measures are outlined to provide sound management approaches to minimize mold contamination. Complete elimination of mold infection and mycotoxin contamination will be impossible until resistant varieties become available through intensive research.

MILLING AND FEEDSTUFF PREPARATION

The cornerstones of a good prevention program by millers are quality control, good milling practices, and the use of chemical preservatives.

Quality Control

An effective quality control program for incoming grains and good milling practices are essential to prevent mycotoxin contamination. Careful examination for moldy or broken kernels and insect damage is necessary. Although "black light" (ultraviolet light) has been used in the United States as a crude measure of aflatoxin contamination, the light is not a good indicator of the extent of *Fusarium* contamination. In countries where aflatoxin is a problem, scanning corn (not wheat) suspected of being mold-contaminated for fluorescence with a "black light" may have merit, but not in Canada, unless you are dealing with imported corn. A representative sample should be taken for moisture determination to ensure that the grain was dried properly.

Simple, rapid screening methods are being developed for mycotoxins of particular concern in eastern Canada. However, assays of specific mycotoxins may indicate only part of the picture. Unfortunately, molds are capable of producing several toxins. Rapid biological assays, such as the chick embryo[20] and Hela cell[21] assays are more promising than chemical methods, because the assessment is not related to a specific toxin (or toxins) and gives a broader index of potential toxicity.

When mold contamination is suspected, a thorough cleaning of the grain with screens and blowers may remove moldy, fine particulate matter (dust), some small moldy kernels, and broken pieces of cobs. Moldy tips of cobs may be heavily contaminated with mycotoxins.

Milling Practices

Good milling practices should include:

- cleaning out feed bins and delivery vehicles after emptying and before refilling;
- keeping feed mill equipment in good working order and clean;
- preventing access by insects and rodents to storage facilities;
- eliminating sources of moisture contamination in grain storage facilities; and
- aerating regularly stored grain.

Chemical Preservatives

Chemical preservatives are used to prevent further mold activity and to extend the shelf life of stored grains and animal feeds. Acid-type inhibitors such as benzoic, sorbic, acetic, and propionic acids and salts are commonly used. Some formulations may improve feed intake as well as prevent further mold growth[18], however, mold inhibitors do not detoxify mycotoxin-contaminated feedstuffs[22].

COMPLEX MYCOTOXIN MIXTURES IN MOLDY GRAIN

Recent data confirm earlier suspicions that adverse reactions seen in farm animals fed moldy grain were not caused by single mycotoxins, but by combinations of toxins and other fungal metabolites[23]. *Fusarium* species produce many metabolites toxic to animals. During normal field and storage conditions, many mold species grow and produce toxins. The situation may be further complicated when several sources of grain containing different mycotoxin contaminants are blended in animal feed. It is known that DON is less toxic than other related mycotoxins, such as T-2 and HT-2 toxin. However, low feed concentrations of DON, e.g., 1 mg/kg (ppm) in the presence of lower µg/kg (ppb) concentrations of T-2, HT-2 as well as other unknown toxins may be sufficient to cause severe reactions in very sensitive species such as swine (Fig. 3)[2].

DETOXIFICATION

Development of a "magic" formula to detoxify mycotoxin-contaminated grain, although desirable, is difficult to achieve. Physical and chemical procedures that are effective against one or a few toxins may have little effect on other toxins present. Consequently, prevention of mold infection and mycotoxin production at all levels of production, storage, milling, and delivery must be the central focus to mycotoxin management.

Harvesting and milling

In naturally infected grain, mold- and mycotoxin-contaminated kernels may represent <1–5% of all the grain. Kernels may be broken or shrivelled. In wheat, kernels sometimes take the appearance of "tombstones." In corn, the tips of the cobs containing moldy, shrivelled kernels of corn may be highly infected. Grain dust may also contain high concentrations of mycotoxins. During harvesting and milling, physical screening and air blowing should be used to remove pieces of corn cob, reddog and small particulates, and withered, infected kernels. Mold-infected kernels may contain up to 500–1000 mg/kg DON. **Dust masks, coveralls, and gloves should be used to protect operators** (see section entitled "Guidelines for safe handling ...").

In 1981, it was reported that the wet milling of corn removed about two-thirds of the T-2 toxin present[24]. In more recent studies[25,26], milling had little effect on DON concentrations in hard spring wheat, as DON was distributed throughout the milled products. Baking the flour into bread did not decrease the DON concentration[25,27]. In a study with naturally contaminated, Ontario soft white winter wheat containing DON at 0.6–1.0 mg/kg, the greatest concentration of fungal infection was at or near the surface of the kernels[28]. The highest levels of DON were found in the outer kernel (e.g., bran) portions; levels decreased in the inner flour portions. At higher concentrations of DON (5 mg/kg) in naturally contaminated wheat, the mycotoxin was fairly uniformly distributed among the various mill portions[26]. In another study, two hard spring wheats (containing DON at 1.4 and 7.5 mg/kg, respectively) were subjected to cleaning, tempering, and milling[29]. Twofold increases in DON concentration were recorded in shorts and feed flour fractions. Slight increases in DON concentration were measured in the bran of the first wheat sample.

If mold infection is not too severe, physical and chemical treatments that clean the kernel surface and remove heavily infected particulate matter, e.g., washing and roasting processes, may significantly reduce toxin levels in contaminated grain. Much more research is needed in this area.

Chemical treatment

In the laboratory, moist ozone, ammonia, and microwave and convection heat treatment reduced DON concentrations in moldy grain[30]. Complete reduction of DON was achieved after the addition of aqueous sodium bisulfite and application of heat by autoclave or microwave. However, ammonium carbonate added to a steam-pelleted swine diet containing mold-contaminated wheat did not improve feed intake or weight gain[31].

When contaminated corn was mixed in a diet to contain DON at 7.2 mg/kg, reduced feed intake and weight gain in pigs were observed. However, when the same amount of contaminated corn was treated with sodium bisulfite and autoclaved, the DON concentration decreased tenfold; feed intake and weight gain improved and were similar to controls[32].

Addition of binding agents

Alfalfa may be beneficial in diets contaminated with zearalenone. Alfalfa fiber partially overcame the growth-depressing effect of zearalenone in rats[33]. However, dietary concentrations of 0–25% alfalfa did not overcome the estrogenic effects of zearalenone at 10–40 mg/kg in the diet of Yorkshire gilts weighing 8–11 kg[34].

The addition of bentonite, anion and cation resins, and vermiculite-hydrobiotite on the toxicity of dietary T-2 toxin fed to Wistar rats was also tested[35]. Ten percent bentonite was the most effective treatment to overcome feed refusal and growth depression associated with the toxin. Bentonite in the diet seemed to prevent T-2 toxicosis by reducing intestinal absorption and increasing fecal excretion of the toxin. Spent canola oil bleaching clays also were effective to overcome adverse effects of dietary T-2 toxin on feed intake and body weight gain in rats[36].

Another study evaluated a chemical binding agent, polyvinyl-pyrrolidone (Antitox Vana®) and ammonium carbonate on the adverse effects of DON for Yorkshire pigs[31]. Addition of the chemicals did not alleviate the toxicity of DON in the swine diets.

Blended feeds and diet density

Swine are very sensitive to *Fusarium* toxins such as DON and zearalenone. If mycotoxin contamination is suspected in animal feed, test this feed with six weanling gilts compared with a similar group of gilts offered clean feed for 2 weeks. If the feed intake of gilts on the contaminated grain is lower than that of controls eating clean feed, DON or related trichothecenes should be suspected as a contaminant. Diluting the feed with clean grain may improve feed intake and weight gains. Increasing the diet density (20% more energy, crude

Figure 1 Kernels from uncontaminated wheat (upper) and wheat containing DON at 7 mg/kg (lower). Notice the pink burgundy color on the kernels selected from the contaminated wheat source.

Figure 2 The corn cob was naturally infected with "pink ear mold." Concentrations of DON as high as 500–1000 mg/kg (ppm) may be present in infected kernels.

Figure 3 Swine are very sensitive to mycotoxins. These pigs are littermates: the one in the background was fed a clean diet, the one in the foreground was offered a diet containing DON at 5 mg/kg for 7 weeks after weaning. Note the white, rat-like hair and thin appearance of the pig on the DON-contaminated diet.

protein, minerals, and vitamins[37]) may improve weight gains if feed intake is only reduced 15–20%. If the vulvae in the prepubertal gilts appear swollen and red, do not offer the feed to the farrowing herd until the feed has been diluted. Zearalenone does not normally affect feed intake of swine.

Recent studies suggest that immunization for production of antibodies against zearalenone might be useful to prevent zearalenone mycotoxicosis in swine[38].

MYCOTOXIN RESIDUES IN ANIMAL FOOD PRODUCTS

Research data indicate that swine are very sensitive to DON and zearalenone, whereas ruminants and poultry seem to be more tolerant[39]. This general observation may not necessarily apply to young or stressed animals. Recent evidence suggests that low concentrations of *Fusarium* mycotoxins in dairy rations may be associated with decreased milk production[40].

If contaminated feed is given to the more tolerant species, the focus changes to the safety of toxic residues in animal food products. Dairy cattle offered a diet containing DON at 66 mg/kg for 5 days resulted in trace (low µg/kg or ppb) concentrations of the toxin in the milk. In ruminants even extremely high, single doses of the toxin (gram quantities per animal) produced only trace residue levels in milk – too low to be of practical concern[41]. With poultry, although no appreciable residues were measured in tissues of birds fed DON at 20 mg/kg over 12 days, some accumulation in eggs was reported. However, DON was rapidly eliminated from poultry once the contaminated source was removed[42]. Residue levels dropped rapidly in ensuing days once the birds were returned to clean feed[43]. In conclusion, evidence to date suggests that the carry-over of DON in animal-derived products does not appear to be a special problem. More research is necessary to evaluate the safety of zearalenone and other mycotoxin residues in animal food products.

GUIDELINES FOR THE SAFE HANDLING OF MOLDY GRAIN

Mycotoxins and the molds that produce them are health hazards. As outlined in this booklet, the toxic effects associated with *Fusarium* mold and mycotoxins includes allergies, skin irritation, poor appetite, headache, vomiting, gastric (stomach) and intestinal irritation, hemorrhaging, increased sensivity to disease, and reproductive problems[1]. Inhalation of dusts from *Fusarium*-contaminated grain, especially indoors, is certainly very hazardous and must be avoided.

Inhalation of *Aspergillus* spores and toxins is a well-recognized occupational hazard of corn and peanut farmers and processors in the United States. A wide variety of symptoms are possible after inhalation of dust from crops contaminated with molds that produce mycotoxins; excessive exposure may lead to serious illness or even to death[44]. Regular medical examinations of personnel routinely handling moldy grain are encouraged.

Everyone handling moldy grain has a personal responsibility to be aware of the health hazards associated with mold and mycotoxin contamination, to use appropriate means that emphasize prevention of exposure to moldy grain, and to minimize contamination of facilities, equipment, and personnel. Reasonable precautions must be taken to minimize mycotoxin contamination by any route, e.g., oral, inhalation, and skin. Procedures need to be in place for handling and disposal of mold-infected material. When screening dust, other small particulates, and cob material out of harvested moldy grain, be certain to bury the screenings in a remote area away from field crops to minimize later exposure or accidental ingestion by farm animals.

Readers are reminded to take proper safety precautions to prevent personal injury or loss of life when entering any grain storage area.

The following guidelines are recommended for the safe handling of mold- and mycotoxin-contaminated grain in animal feed by grain and animal producers.

RECOMMENDED ACTIONS FOR GRAIN AND ANIMAL PRODUCERS

Field examination of moldy cobs

CAUTION: *Mycotoxins in infected kernels can cause severe skin irritation.*

ACTION:
- Use protective gloves when handling infected material
- Do not touch infected kernels
- Wash hands well with soap and water after handling moldy grain

Harvesting, drying, grinding, mixing, and transporting moldy grain and animal feed

CAUTION: *Inhalation of mycotoxin-containing spores and dust can cause allergic reactions, lung irritation, and mycotoxin poisoning.*

ACTION:
- Use protective mask to prevent inhalation of dust from moldy grain
- Increase the fat content of animal diets to reduce dust formation in animal buildings

- Whenever possible keep upwind away from moldy dust generated by farm equipment

CAUTION: *Mycotoxin-containing spores and dust can cause skin and eye irritation.*

ACTION:
- Use clean protective clothing (and goggles in dusty areas)
- Shower to remove moldy dust from exposed areas of body
- Whenever possible keep upwind away from moldy dust generated by farm equipment
- For combines that have operator cabins with filtered air supply, change air filters frequently

CAUTION: *Avoid ingesting mycotoxin-containing spores and dust.*

ACTION:
- Remove coveralls before eating
- Wash hands, face, and other exposed areas of body before eating
- Eat in an area not exposed to moldy grain

Entering grain storage areas

CAUTION: *Inhalation of mycotoxin-containing spores and dust can cause allergic reactions, lung irritation, and mycotoxin poisoning.*

ACTION:
- Use protective mask to prevent inhalation of dust from moldy grain
- Extreme care should be exercised when entering a bin of grain infected with mold. The bin should be well ventilated. Prevent personal exposure to dust by using protective coveralls, air filter masks, or head gear that supplies filtered or fresh air to personnel. Never work alone in a bin

CAUTION: *Mycotoxin-containing spores and dust can cause skin or eye irritation.*

ACTION:
- Use clean protective clothing (and goggles in dusty areas)
- Shower to remove moldy dust from exposed areas of body
- Whenever possible keep upwind away from moldy dust generated by farm equipment

CAUTION: *Avoid ingesting mycotoxin-containing spores and dust.*

ACTION:
- Remove coveralls before eating
- Wash hands, face, and other exposed areas of body before eating
- Eat in an area not exposed to moldy grain

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