

# 11. TOXIC SUBSTANCES IN FEEDS

While the main focus of animal nutrition is the need for - and supply of - nutrients, the feedstuffs which supply these nutrients may also carry with them certain toxins or antinutritional factors. Toxins are generally considered to be poisonous substances present in the feed, often produced by the host plant or by an organism living in the feed, which could adversely affect the health and wellbeing of animals; conversely, antinutritional factors are substances which impair normal feed digestion or nutrient utilization. A diet can be perfectly balanced but fail to support optimal growth if it contains anti-nutritional factors that adversely affect appetite, feed utilization or animal health.

Toxins may be substances that occur naturally in certain species of plants. Examples are tannins and phytates; their presence is readily predicted and appropriate adjustments can be made in the diet formulation. Toxins can also be the result of contamination by bacteria or fungi. The bacteria themselves may be toxic to the pig, or if the bacteria or fungi are not poisonous, they may produce substances which are. This is not a predictable occurrence and therefore, can be much more difficult to deal with. Listed adjacent are some of the toxins or toxin producers which may be found in feeds in Canada. It does not include weed seeds which may also contain noxious substances. Mycotoxins are metabolites (products of metabolism) of fungi, the most common in Canada being ergot alkaloids, ochratoxin A, zearalenone and the tricothecenes. These are discussed in detail later in the chapter.

## Toxicants Produced by Plants

Many common feed ingredients contain natural toxicants and/or toxins which may impair pig performance. For example, raw soybeans contain trypsin inhibitors and the enzyme urease. They are part of the normal plant or seed and are generally predictable in both quantity and impact on the pig. Although their presence is undesirable, our knowledge of anti-nutritional factors allows nutritionists

### Potential Toxins or Toxin Producers Which May be Present in Common Feed Ingredients

Endogenous	Exogenous
Phytates	<i>Fungi</i>
Saponins	Aspergillus
Estrogens	Fusarium
Trypsin Inhibitors	Penicillium
Tannins	Ergot
Glucosinolates	
Lectins	<i>Bacteria</i>
Thiaminase	Escherischia coli
Oxalates	Salmonella
Gossypol	Campylobacter
	Listeria
	Clostridia

to formulate rations around them. Research is underway to negate the effects of many of these toxic factors. The following is a discussion of some of the more common toxicants which may be encountered when formulating pig diets in Canada.

## Phytates

Phytic acid is present in many plant seeds, containing 6 phosphorus molecules linked to an organic compound called inositol. In the plant kingdom, it serves as an important storage form of phosphorus. Phytic acid may chelate or bind with a variety of minerals, including calcium, magnesium, iron and zinc to form phytate. In pig diets, phytate typically binds calcium and magnesium as well as phosphorus; destroying phytate through enzymatic or processing activity will therefore increase the utilization of all three mineral elements, not just phosphorus as normally assumed.

In mature cereal grains, 60% to 80% of the total phosphorus is so bound; in soybean meal, about half of the phosphorus exists as phytate phosphorus.

Table 11-1 provides information on the relative proportion of total phosphorus present in the form of phytate in common feedstuffs.

Phytate is of nutritional significance because phosphorus in phytic acid is poorly absorbed by the pig. In fact, the availability of total phosphorus from grain sources ranges from 20% in corn to 45% in wheat; barley and oats are intermediate at about 30% availability. These low availabilities are the result of poor utilization of phytate-bound phosphorus - essentially zero bioavailability in corn and oats, 10% in barley and 40% in wheat. In contrast, inorganic phosphorus supplements, such as dicalcium phosphate are about 80% available or better.

A number of factors will influence the availability of phytate phosphorus. Germination releases the naturally-occurring phytase in cereal grains; within one week of germination, the amount of phytate phosphate will be reduced by 50%. Some grains contain more natural phytase than others; wheat in particular, is known to be a relatively rich source of phytase and thus has a higher phosphorus availability (Table 11-2).

Phytase supplements can also be purchased for inclusion in pig diets; these are normally derived from a genetically-modified *Aspergillus* strain. Biological action will vary with the source, but as a rule, approximately 500 units of phytase per kg of mixed feed is equivalent to 0.1% supplemental phosphorus in the diet. Phytase supplements must be properly handled to obtain maximum benefit. Because phytase is an enzyme, it is susceptible to the effects of heat and moisture. Therefore, pelleting diets containing phytase must be carefully controlled to avoid die temperatures in excess of 70°C as losses in enzyme activity may exceed 25%; alternatively, phytase can be added as a liquid post-pelleting or used in mash diets.

Certain micronutrients, such as iron sulphate, copper sulphate or choline chloride will contribute to phytase breakdown. Therefore, phytase is best not added to premixes containing trace minerals or choline; because these ingredients are diluted in complete feed, their impact on phytase in mixed diets is greatly reduced.

**Table 11-1. Phytate Phosphorus Content of Common Feedstuffs.**

Feedstuff	Total Phosphorus, %	Phytate Phosphorus, % of total
Alfalfa meal	0.30	0
Barley	0.34	56
Corn	0.26	66
Cottonseed meal	1.07	70
Grain sorghum	0.31	68
Oats	0.34	56
Sesame meal	1.27	81
Soybean meal	0.61	61
Wheat	0.30	67
Wheat bran	1.37	70
Wheat middlings	0.47	74

Source: Ward, 1994.

**Table 11-2. Naturally-occurring Phytase in Common Feedstuffs.**

Feedstuff	Relative Phytase Activity
Wheat, rye	High
Barley	Medium
Oats, soybean meal	Low
Corn, sorghum	Very low
Cottonseed	Undetectable

Source: BASF Technical Bulletin No. 9201.

### Saponins

Saponins are a family of compounds found in many plants of economic importance, including canola, alfalfa, soybeans, peas, sugarbeets, sunflowers, oats, chickpeas and beans. They are characterized by a bitter taste, but are used commercially in such diverse consumer products as shampoo, soft drinks, soap and fire extinguishers. The type of saponin, the concentration present and the physiological effect on swine varies a great deal within and among plant species.

If injected, saponins are highly toxic, attacking and altering the structure and function of cell membranes. However, when administered orally, their effect is greatly reduced. Saponins impair pig performance, due to their bitter taste and irritating

effect on the lining of the mouth and gut. There is some suggestion that the absorption of certain nutrients, including vitamins and trace minerals is altered by saponins, presumably due to changes in the structure of the lining of the gut; for example, soybean saponins bind zinc and render it less available, while ginseng saponins actually increase the absorption of iron. Interestingly, saponins also lower blood cholesterol levels.

In animal nutrition, concern about impaired performance due to saponins is most often associated with alfalfa. The saponin content of alfalfa varies according to season, being highest in mid-summer and tapering off thereafter; not surprisingly, the saponin content of second cut alfalfa tends to be higher than that of first or third cuttings. Plant breeders are now developing low saponin alfalfa varieties.

### **Estrogens (Phytoestrogens)**

The estrogen content of feeds can occur from the plant directly or from contamination with molds which produce estrogenic mycotoxins. Alfalfa and soybeans can produce an estrogenic compound called coumestrol. The use of alfalfa pellets in sow diets has declined, due in part to the fear that possible estrogenic compounds may impair reproductive performance.

### **Protease Inhibitors (Trypsin Inhibitors)**

Most legume seeds (eg. soybeans, faba beans), some grains (eg. corn, rye, barley and triticale), alfalfa and potatoes contain protease inhibitors. These are protein molecules which bind to and inactivate trypsin or other digestive enzymes that help to break down protein molecules in the small intestine. Of the protease inhibitors, trypsin inhibitors are best known, but inhibitors of chymotrypsin also exist in nature. In practical terms, while protease inhibitors are widespread throughout the plant kingdom, the ones of greatest significance in pig nutrition are those found in soybeans, other beans and triticale.

In swine nutrition, protease inhibitors are most often discussed in the context of impaired performance due to reduced protein digestibility. However, trypsin inhibitors have been shown to impair per-

formance independent of their impact on protein digestion, at least in some species. In some species, but not the pig, the effect of trypsin inhibitors can be reduced by supplementation with sulphur amino acids; this occurs because such animals respond to trypsin inhibitors by producing more trypsin, a protein which is particularly rich in sulphur amino acids. In the pig, inhibition of protein utilization occurs because the quantity of trypsin inhibitor present exceeds the available supply of trypsin, and increased supply is either not possible or is inadequate.

Trypsin inhibitors are readily destroyed by heat; fifteen minutes at 100°C is sufficient to remove almost all negative effects. A simple, indirect test, called the urease test, is often employed to determine the level of trypsin inhibitor left after soybeans have been processed. The enzyme urease is also present in soybeans; it converts urea to ammonia and can be tested quite easily. It is assumed that the destruction of urease during soybean processing parallels that of trypsin inhibitor, so that if one is inactivated, the other will be similarly destroyed. If the urease test is negative, this serves as an indirect indication that trypsin inhibitor has also been destroyed.

Heating ingredients to destroy protease inhibitors must be carried out with great care; this is because excess heat may damage certain amino acids, especially lysine, rendering them unavailable to the pig.

### **Tannins**

The term "tannin" was originally used to describe a group of plant extracts used in tanning leather. They are found in many crops, including rapeseed, soybeans, fababeans, sunflower seeds, alfalfa and sorghum. More technically speaking, tannins are a group of compounds that bind to proteins, including dietary proteins, digestive enzymes and proteins which assist in nutrient absorption in the gut. It is not surprising, then, that tannins impair the ability of the pig to use dietary protein, carbohydrates and fats; however, the most significant impact is directly on protein utilization. Tannins also reduce palatability, due to a sour taste.

Tannins are divided into two broad categories: condensed and hydrolyzable. The latter are named due to their ability to be readily broken down while the condensed tannins are much more stable and complex in structure.

The tannin content of sorghum differs among varieties, with yellow sorghum having very low levels. Tannin content is directly related to bird resistance in the field; consequently, plant breeders are faced with the decision to select varieties for low tannin content, desirable in animal nutrition, or high resistance to predation by birds, which is desirable in regions where sorghum is a human food staple, but is vulnerable to attack by wild birds. Sorghum tannins are of the condensed kind.

The most effective means of addressing the issue of tannins in swine nutrition is to select crops and varieties of crops with little or no tannin content. Alternatively, affected crops can be treated with dilute alkali or polyethylene glycol to improve their feeding value. Heating is somewhat less effective because tannins are heat stable.

### **Glucosinolates**

Glucosinolates are common in plants in the *Brassica* family, including rapeseed, mustard, turnips, crambe and kale. They reduce palatability and impair the function of the thyroid gland. Since the thyroid gland is so important in regulating animal growth, this can be a serious problem.

Canadian plant breeders have developed low glucosinolate varieties of rapeseed; to distinguish these new varieties with highly different nutrition characteristics, the term "canola" was coined. Continued research on lowering the glucosinolate level to essentially zero is on-going; however, it is not yet known if these further improvements will affect animal performance. Meal from current varieties of canola can be fed at high levels to swine without any apparent effect due to glucosinolate activity.

### **Lectins**

Lectins are either protein or carbohydrate-protein compounds which share a common characteristic: the ability to selectively bind certain carbohydrates.

Lectins are known to impair growth, cause diarrhea and interfere with nutrient utilization.

Found in highest concentration in legumes, including soybeans, lectins were first associated with castor beans. The ability of the lectins to bind to cells along the intestinal tract is highly specific, such that certain lectins will bind and others will not. If binding occurs, the lectins may enter the cell and, if toxic, can initiate a range of adverse reactions, from greatly enlarged intestinal tissue to impaired nutrient absorption and depleted body muscle, fat and glycogen reserves.

### **Thiaminase**

Thiaminase is an enzyme which destroys the B vitamin thiamine. It is not found in any feedstuff common in pig diets, but is present in certain fish, including carp. If such fish are fed in uncooked form to swine, problems may occur. Since feeding raw fish to swine is unlikely, the risk of problems due to thiaminase is remote.

### **Oxalates**

Oxalic acid is a compound with the ability to bind calcium, rendering it less available for absorption by the pig. Oxalate poisoning, while common in grazing species exposed to certain plants, is rare in swine. However, some feedstuffs that may be included in swine diets, such as alfalfa, contain oxalate, lowering the bioavailability of calcium.

### **Gossypol**

Gossypol is a yellow pigment found throughout the cotton plant; in the seed, gossypol is found in the pigment glands. During processing, the glands are ruptured and gossypol released. A portion of the gossypol will bind to protein, primarily the amino acid lysine, rendering it less available to the pig. Thus, the higher the portion of bound as compared to free gossypol, the lower will be the biological value of the protein. The remaining, or free, gossypol is reactive and affects animals in a number of ways: depressed appetite, lower weight gains, impaired lung, heart and liver function, anemia and male infertility. Free gossypol levels should not exceed 100 ppm in pig diets.

The effects of gossypol can be reduced by adding ferrous sulphate to the diet; the generally accepted recommendation is 1 unit of iron as iron sulphate per unit of gossypol. Even with added iron, the maximum upper limit of free gossypol in swine diets is 400 ppm. Increasing dietary protein is helpful as well, but rarely economical.

## Exogenous Microbes and Toxin Producers

### Bacteria

Contamination of feed by pathogenic microbes such as certain strains of *Salmonella* may lead to infection of the herd and an outbreak of disease. In the case of *Salmonella*, there are more than 1,000 different serotypes, yet only a handful tend to be of significance in pork production, including *S. choleraesuis* and *S. typhisuis*. Some other *Salmonella* serotypes have a broad spectrum of hosts and could therefore infect swine if the conditions were right.

It is unclear how significant a threat feed represents to herd health. However, owners of herds with a minimum disease health status prefer to act conservatively and avoid any potential health problems; some therefore refrain from using feed ingredients which may be more prone to contamination. This is difficult in practice; although animal by-product meals are most commonly suspected, all feeds are at least potentially at risk.

Animal by-products manufactured in modern facilities are usually processed and handled in ways that eradicate initial contamination and prevent reinfection. Dealing with reputable suppliers will certainly help minimize risk with products such as meat meal, blood meal, feather meal and plasma proteins.

However, care in processing animal byproducts will not eliminate risk. Uncontaminated material, of animal or vegetable source, passed through a contaminated storage or transport facility will become infected. Contamination can also occur through exposure to wild birds, rodents, etc. which are often carriers of disease. Some producers only use mixed feeds that have been steam pelleted and

feed trucks that are regularly sanitized as a further safeguard against disease transmission. The data in Table 11-3, based on the results of a survey reported by the Veterinary Diagnostic Laboratory at the Pennsylvania State University, illustrates that removing ingredients of animal origin will not eliminate the risk of *Salmonella* contamination.

**Table 11-3. The Results of Salmonella Assays Reported by the Veterinary Diagnostic Laboratory at the Pennsylvania State University.**

Ingredient	No. Samples	% Positive
Animal Protein	62	63
Distillers Grains	51	0
Canola Meal	11	18
Oats	15	7
Soybean Meal	20	20

Adapted from John, R.E., 1990. Proc. Symp. Feed Quality Assurance, Centre for Veterinary Medicine, USDA, Arlington, VA.

These results compare to a survey of five feed compounders conducted by the United Kingdom Ministry of Agriculture, Food and Fisheries (Table 11-4).

**Table 11-4. Survey of Raw Materials Provided by Five Feed Compounders in the U.K.**

Ingredient	No. Samples	% Positive
Barley	42	0
Corn	18	6
Fats	31	3
Feather Meal	23	0
Fish Meal	44	9
Meat and Bone Meal	46	7
Peas	30	0
Soybean Meal	46	7
Wheat	51	6

Adapted from John, R.E., 1990. Proc. Symp. Feed Quality Assurance, Centre for Veterinary Medicine, USDA, Arlington, VA.

## Fungi and Mycotoxins

Fungi impair feed quality in at least two ways. They may alter the nutritional quality of feeds by destroying or making unavailable important nutrients such as vitamins or they may produce mycotoxins that are harmful to the pig.

The direct effect on nutrient composition is difficult to predict and attempts have failed to demonstrate impaired pig performance due solely to fungal growth. Documented cases of feeding extremely moldy corn to swine without difficulty demonstrate that mold by itself probably represents only minimal risk to the pig. It is not until the fungi produce mycotoxins that animal performance suffers. Some toxins need only be present in very small concentrations to affect pig health.

While it would be useful to have tables summarizing maximum tolerances for the various toxins of importance in swine production, the reality is that such tables are very difficult to produce. The maximum tolerance for any particular toxin will be affected by many factors, including the response criteria (animal performance versus tissue damage), time frame (short-term versus long-term effects) and, interestingly, the nutrient specifications of the diet. For example, some toxins are involved in the metabolism of highly toxic compounds called free radicals; protection from free radicals is obtained by consuming increased quantities of antioxidants, such as vitamin E. Consequently, the toxic level of certain mycotoxins will vary, depending on the vitamin E level of the diet.

Another problem in determining the toxicity of a moldy grain sample is the occurrence of multiple toxins, some of which may be present at low levels or which are difficult to identify. While the toxin(s) assayed may be below tolerance, associated toxins which may not have been measured may contribute to the overall toxicity of the sample. This is a particularly troubling aspect of mycotoxin technology, since there are literally dozens of toxins known to man and one cannot practically assay them all!

The molds of greatest interest in Canada and the United States are *Aspergillus flavus* which produces

aflatoxin, and *Fusarium roseum* which produces zearalenone and vomitoxin. Several other fusarium varieties also produce toxins while *Penicillium* and *Aspergillus* produce ochratoxin. These are explained in detail later in the chapter.

## Ergot

Ergot alkaloids are very potent toxins produced by the fungi ergot (*Claviceps purpurea*). Triticale and rye are the most susceptible grains, but wheat, barley, oats and corn can also become infected. Visual inspection of suspect grain is useful, since the infected kernels are usually dark, swollen and have a rough coat. Once the grain is ground, detection requires laboratory analysis.

Ergot alkaloids can severely affect pig health and performance. They impair blood flow to the extremities, affecting tissues such as the kidney and uterus. Reduced blood flow to the reproductive tissues can result in spontaneous abortion in poisoned sows. In fact, in ancient times, abortions in humans were induced by feeding ergot. Piglets born to infected sows have poor viability, due to impaired lactation of the dam.

Poor blood flow also explains other symptoms of ergot toxicity such as blackening of the tips of ears and sloughing of hooves. In these examples, poor blood flow actually results in the death of the respective tissue. Ergot poisoning can also reduce feed intake, induce convulsions and muscle incoordination, cause respiratory distress and precipitate an outbreak of diarrhea.

At the present time, only imprecise recommendations on ergot are available. Suspect grains should never be fed to breeding animals and the quantity of contaminated kernels fed to growing pigs should not exceed 0.1% of the total grain in the ration (one infected kernel for every 1000 clean kernels).

## Ochratoxin A

Ochratoxin affects the kidneys in swine. Post mortems of infected pigs reveal swollen kidneys which are lighter in colour and firmer than healthy kidneys. Ochratoxin can cause birth defects when sows are infected and impairs growth in market

hogs. Swollen kidneys will occur at levels much lower than those required to impair performance. Immunosuppression has also been associated with Ochratoxin A.

Ochratoxin infects many crops including barley, oats, wheat, corn and soybean meal. It is produced by the fungi *Aspergillus* and *Penicillium* and is generally restricted to areas of temperate climate such as those found in the southeastern United States. Safe levels of ochratoxin for swine have not been defined, although it is known that weanling pigs fed 28 ppm ochratoxin will die within three weeks.

### Zearalenone

Zearalenone, sometimes referred to as F2 toxin, is a mycotoxin produced by the fungi *Fusarium*. It is often associated with corn but can infect many other crops including wheat. It is an estrogenic compound; as a result, its effects on the pig are similar to those of the natural hormone, estrogen. Estrogen particularly affects reproduction and consequently, most research on zearalenone has been carried out on sows and gilts, with less information being available on growing pigs. Pigs, as a species, are particularly susceptible to zearalenone toxicity. Levels between 1 and 5 ppm are sufficient to elicit a number of estrogenic symptoms.

#### SYMPTOMS OF ZEARALENONE TOXICITY

- swollen vulvas in gilts
- vaginal or rectal prolapse
- swollen mammary tissue
- reduced testicle size in young boars
- shrunken ovaries in gilts
  - enlarged uteruses
  - infertility
  - abortion
- reduced litter size
- birth of small, weak piglets often suffering from spraddle leg

Photo 11-1a.



Aborted and mummified piglets.

Photo 11-1b.



Rectal prolapse.

The effect on neonatal piglets depends on when the infected feed was eaten. If consumed in late pregnancy, the incidence of stillbirths and spraddle leg is increased. If eaten in mid-pregnancy, only spraddle leg increases. If the zearalenone is eaten in early pregnancy, litter size (total number of piglets born) is reduced, but no effect on spraddle leg conditions or stillbirths is detected.

Zearalenone can also be carried in the sow's or gilt's milk and thus affect the growth rate of newborn piglets. Up to 30 ppm of pure zearalenone appears to have a minimal effect on litter size in gilts while levels of 60 to 90 ppm result in the complete loss of fetuses. The impact of zearalenone remains with gilts for many months after the infected diet is removed.

Zearalenone appears to also affect boars. It reduces libido (sex drive) and delays sexual maturity in growing boars. However, diets containing up to 60 ppm zearalenone have no apparent effect on semen quality or libido of mature boars.

The effect of zearalenone on growth is less clear. Some experiments have demonstrated that as little as 10 ppm of zearalenone depresses pig growth and appetite. Other experiments suggest that there is no effect on growth at levels of toxin as high as 50 ppm. There is even the suggestion that growth is actually enhanced by zearalenone. Part of the problem with the variable responses produced by zearalenone may be due to contamination of the test ingredients with other toxins such as vomitoxin. Vomitoxin is known to impair performance and is often found in samples of grain contaminated with zearalenone.

### Tricothecenes

Tricothecenes are a group of very toxic compounds which include deoxynovalenol (also called DON or vomitoxin), HT-2 toxin, diacetoxyscirpenol and T-2 toxin. They are produced by *Fusarium* molds and are very toxic to pigs. T-2 toxin is unique in that it forms during storage at low temperatures (6 - 18°C).

One feature of tricothecenes that is particularly troubling is its suppression of the immune system. Even low levels in the diet may increase the pig's susceptibility to pathogenic organisms that normally would not create health problems. Studies with contaminated wheat indicate that as little as 1 ppm vomitoxin reduces feed intake and growth rate in market hogs. Levels in excess of 20-40 ppm cause vomiting and feed refusal. One of the most striking features of DON contamination is feed refusal.

Vomitoxin contaminated feed does not appear to affect reproductive performance in gilts. Levels up to 8 ppm vomitoxin did not produce adverse results with regards to reproduction. Since vomitoxin is often found in grains containing zearalenone, it is difficult to determine which of these toxins is causing a given problem. From research to date, it appears reproductive impairment is most likely due to zearalenone and not to vomitoxin contamination.

Other tricothecenes may be even more toxic than vomitoxin. They cause feed refusal, vomiting, irritation of the skin and the gut and may also result in the birth of deformed piglets. One to 10 ppm diacetoxyscirpenol will reduce growth rates. Diets containing 8 ppm T-2 toxin do not affect weight gains but increasing levels to 16 ppm will depress growth rate.

### Aflatoxin

Aflatoxin is produced primarily by the fungus, *Aspergillus*. Ideal conditions for *Aspergillus* growth include moisture content above 14%, temperature above 25°C and the presence of oxygen. It is known to affect many feed ingredients including corn, rye, oats, wheat, barley, soybean meal, sunflower meal, rapeseed and alfalfa. There are four types of aflatoxin: B<sub>1</sub>, B<sub>2</sub>, G<sub>1</sub> and G<sub>2</sub>. Aflatoxin B<sub>1</sub> is considered to be the most potent for swine.

The impact of aflatoxin on swine is age and dose dependent, and ranges from depressed performance through immune suppression. Acceptable upper limits have been defined by various agencies; for young pigs, levels in excess of 20 ppb should be avoided, for finishing swine, the limit is 200 ppb and for breeding animals, the limit is 100 ppb. Recovery from aflatoxin toxicity is rapid in growing pigs. Seven days on clean feed will usually result in a full recovery. In younger pigs, scouring can result from aflatoxin poisoning. In sows, milk production is impaired.



## Prevention of Mycotoxin Contamination

Since effective treatment methods have not been developed, prevention of mold contamination is very important. Cropping practices can play a useful role in prevention. Rye and triticale are examples of crops that are particularly susceptible to ergot. The selection of more resistant grain varieties is a major consideration. Late maturing corn may provide greater yields but the seeds are at a susceptible stage of development during the wet weather that often occurs in the late summer and fall. Crop rotation can help break the life cycle of infecting spores. Corn and wheat can be rotated with less susceptible crops. Profitability in the short term may be reduced, but this must be compared to the long-term benefits. Researchers have also observed that scabiness caused by *Fusarium* molds, especially in wheat, can be reduced by fertilizer selection. The use of urea fertilizer in place of ammonium nitrate can be helpful.

*Fusarium* infestation is favoured by warm (15°C-35°C), windy, rainy weather. These conditions provide an excellent environment for infecting spores to spread. Therefore, this kind of weather during late growth and harvest should raise concerns about potential contamination.

Once grains are harvested, other practices can be beneficial. The cleaning of grains to remove damaged kernels will help to remove sources of infestation. Broken kernels and related material often contain the highest concentration of mycotoxins. Their removal greatly improves the feeding value of the grain. The addition of mold inhibitors will not kill mycotoxins already present but will prevent further formation.

'Water activity' is an important factor influencing mold growth and mycotoxin production in grain. It differs substantially from simple moisture content because it also takes into consideration ambient temperature and the nature of the grain. These three conditions determine the susceptibility of the grain to mold growth. It is important to keep water activity below 0.75, which means keeping both moisture and temperature as low as is practical. If ambient temperatures are expected to rise as high as 32°C, moisture in corn must be kept below 13% to

prevent mold from growing. At 21°C, moisture can rise to 15% before there will be a problem. In soybean meal, moisture should be kept below 14%.

In summary, it is important to recognize that mold contamination of grains can occur at many stages: during growth, at the time of harvest, during storage as seed or after being processed into livestock feed. Field contamination is worse when kernels are damaged, when the weather conditions are moist or if insects infest the crop. The satisfactory storage of grains or mixed feeds requires low moisture levels and temperatures as cool as possible.

## Treatment

If grain contamination is suspected, samples should be submitted to a laboratory for analysis. Increasing numbers of labs are setting up to conduct mycotoxin analyses. It is a difficult analysis due to the sophisticated tests required and also due to problems with sampling. A heavy infestation of only a small portion of a field of corn can result in swine diets contaminated above acceptable limits. If sampling failed to include the contaminated area of the field, tests would be falsely negative.

If grains are suspected of being infected, a sample can be fed to a group of young gilts. If swelling or reddening of the vulva appears or if feed intake is impaired, contamination should be suspected. The infected grain should not be fed to breeding animals



Accumulation of water or wet feed in augers, feed trucks, or storage bins can lead to mycotoxin contamination of feeds.

and if it is fed to market hogs, it should be diluted as much as possible with "clean" grain.

Chemical treatments of infected grains are being investigated. It has been shown that sodium bisulphite added to infected corn and then autoclaved can reduce DON (deoxynivalenol or vomitoxin) concentrations by a factor of 10. To date, this is not commercially practical, because autoclaving is slow and expensive. However, other heating processes may prove to be as beneficial.

Another possibility is the addition of hydrated sodium calcium aluminosilicate (HSCAS) to diets containing vomitoxin and/or zearalenone. Preliminary results suggest that there may be some value in the use of such products, although more research is required.

If mild contamination is suspected, the nutrient density of the diet can be increased to help compensate for reduced intake. The vitamin, mineral and amino acid concentrations should be increased by 5-20% depending on the severity of feed refusal expected.

## Safety

Molds and mycotoxins can also be harmful to humans. Symptoms include allergies, skin and eye irritation, headaches and vomiting. *Fusarium* spores are a well-known toxin and must be avoided. *Aspergillus* poisoning has also been recorded. If the grain must be handled, ventilation is important and the use of gloves and respirators is advised.



If contaminated grain must be handled, gloves and respirators should be used.

## Additional Reading and References

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