National Swine Nutrition Guide

Utilization of Weather-Stressed Feedstuffs in Swine Diets

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Introduction

In any given year, late plantings, cool growing seasons, early frost, and/or drought conditions occur in parts of the US, and this typically results in lower quality grains and soybeans. Weather-stressed grains and soybeans often have a lighter bushel weight than normal crops, and they can also contain mycotoxins or molds that produce mycotoxins. While these factors decrease the feeding value of thee crops to pigs, depending on the price discount or dock at the elevator, weather-stressed crops at a low enough price to make them viable alternative feedstuff for swine. The purpose of this factsheet is to help determine if, when, and how weather-stressed feedstuffs should be used in swine diets.

Objectives

- Provide guidelines on the use of weather-stressed grains and soybeans in swine feed
- Describe mycotoxins and concerns about their presence in swine feeds

Grain Test Weight and Feeding Value

Older research indicates low test weight grains contain more protein and fiber and less starch than normal grains, implying that low test weight grains have a lower feeding value than normal grains (Table 1). However, more recent research with corn [1] and barley [2] suggests there is a poor relationship between test weight and nutritional value. There is general agreement however, that pig growth rate is seldom affected by grain test weight as long as the test weight is not reduced by more than approximately 25%. Depending on the grain used, test weight can be reduced up to 10% without affecting feed conversion. However, if the test weight is reduced more than 10%, reductions in feed conversion can be expected.

Table 1. Normal test or bushel[a] weight of grains

Grain	lb/bushel
Barley	48
Corn	56
Milo	56
Oats	38[b]
Wheat	60

[a]1 bushel (U.S.) = 32 quarts.
[b]Although 32 lb test weight is the standard, oat producers are paid on a 38 lb/bushel basis.

Fat can be added to diets containing low test weight grains to increase the energy level and to offset a possible reduction in pig performance. However, due to higher fat and oil costs, this is seldom an economically viable option. Low test weight grain can be blended with normal grain, however, to minimize performance effects.

In general it is best to use low test weight grains that are free of mycotoxins in finishing and gestation diets because older pigs utilize lower energy feedstuffs more efficiently than younger pigs and gut-fill is less of an issue. The feeding level (lb/d) during gestation may have to be increased to compensate for the lower energy value of the light test weight grain.

Low test weight corn

Corn weighing between 40 to 56 lb/bushel will produce the same weight gains in growing finishing swine when compared on an equal moisture basis to 56 lb/bushel corn. However, when test weight drops below about 40 lb/bushel, growth rate and feed efficiency may decrease by 5 to 10% [1, 3, 4, 5].

Low test weight milo

Late planting, a cool growing season, drought, or an early frost can lead to low test weight milo. It should be used only in growing, finishing, and gestation diets. According to a recent study, there was no difference in gain or feed efficiency for growing finishing pigs fed either 45 or 55 lb/bushel milo. However, feeding 35 lb/bushel milo resulted in 13% and 6% poorer feed efficiencies in the growing and finishing phases, respectively. For milo weighing less than 45 lb/bushel, use local prices to determine what price the milo has to be to offset the expected poorer feed efficiency [6,7].

Low test weight wheat

Test weight on wheat can go down to 52 lb/bushel without adversely affecting pig performance. However, when wheat test weight is below 52 lb/bushel, performance may decrease, but the response is inconsistent [8].

Low test weight barley

In growing finishing pigs, feeding 41 lb/bushel barley and above will result in normal growth performance. However, when barley test weight is below 41 lb/bushel, there is a risk of reduced performance, however, the response is inconsistent. If the barley is scab infested, it should be fed only to growing finishing pigs and limited to 10% or less of the diet [9].

Low test weight oats

Research indicates that low test weight oats can be effectively fed to finishing swine. Pigs fed diets containing 33% oats (32 lb/bushel oats) gained the same as pigs fed corn diets but required 5.1% more feed [10]. Therefore, depending on economics, light test weight oats can be used in finishing diets.

Frost damaged soybeans

If soybeans receive an early frost before complete maturity, the individual beans will be green instead of tan-colored due to the higher levels of chlorophyll left in the beans. However, if the beans are normal size, extruded green soybeans have the same feeding value as regular extruded soybeans [11]. Because of anti-growth factors (e.g., trypsin inhibitor), mature and immature raw soybeans must be heat-treated to inactivate these compounds before feeding them to swine. The only exception is gestating sows, which can use raw soybeans as the sole source of supplemental protein. Factors to consider when determining whether or not to feed extruded green soybeans include extrusion costs, shrink (8 to 10%), lower protein content of extruded beans, improvement in feed efficiency due to fat addition, and the cost of trucking and storing the product. However, it appears that the chlorophyll levels will dissipate over time during storage so green beans going into the bin in the fall may come out tan in the spring. Also, elevators tend to dock less for beans in the spring than they do at harvest time.

High moisture corn

High-moisture corn (>18% moisture) will have the same feeding value as dry corn (12% moisture) on a dry-matter basis. Since high moisture corn contains a higher percentage of water, a larger percentage of high moisture corn must be added to a ton of feed to achieve the same nutrient levels achieved with "normal" corn. Also, it must be kept in mind that ensiled or organic acid-treated corn can not be marketed at the elevator. It can only be used for livestock feed so only make what can be used up in a year.

Economics of weather-stressed grains

Light-weight grains and frost-damaged soybeans are typically severely docked at the elevator, especially during harvest. Oftentimes this dockage more than offsets any reduction in pig performance from using these weather-stressed feedstuffs in swine diets. Therefore, producers can make money feeding lower quality grains if the purchase price is low enough.

Since reductions in daily gains only occur when feeding extremely light weight feedstuffs, producers can determine the economics of feeding weather-stressed grains and soybeans by calculating the cost of decreased feed efficiency from utilizing these ingredients. Below is a formula that can be used:

$$\frac{\text{New diet cost} - \text{Old diet cost}}{\text{Old diet cost}} \times 100 = \text{maximum \% reduction in feed efficiency allowable to use weather stressed grains}$$

If this value is greater than the % reduction in feed efficiency anticipated from using weather stressed grains, then the producer can make money feeding the light-weight grain. However, if the % change in diet cost is less than the % change in feed efficiency, then the feedstuff should not be used.

For example, assume that using light-weight corn will reduce total diet cost from $220/ton to $196/ton. That's an 11% reduction in feed cost so if the pig is only 6% less efficient, it is economically advantageous for the producer to use the light weight corn.

$$\frac{196 - 220}{220} \times 100 = \text{11\% maximum allowable reduction in feed efficiency}$$

Phases to utilize weather-stressed grains and soybeans

Since light weight grains contain more fiber and less starch than normal grains, they should not be used in production phases where energy consumption is a limiting factor due to gut fill. These include the nursery and early growing phases, and lactation. However, they can be successfully used in the late growing and finishing phases, and throughout gestation as long as they are free of mycotoxins.

Molds and Mycotoxins

The environmental conditions that create weather-stressed grains are also the same conditions that make those grains susceptible to mold growth. A very important fact to remember is that it is not the molds themselves that cause the performance problems, but rather the mycotoxins the molds produce that cause the negative effects. The main mycotoxins associated with grains are aflatoxin, zearalenone, vomitoxin or deoxynivalenol (DON), fumonisins, and ergot.

Aflatoxins are found primarily in warmer climates, whereas zearalenone and DON occur in cool, wet conditions. Aflatoxins suppress the immune system, cause a reduction in performance, and at high concentrations (1,000 ppb) death. Zearalenone will cause reproductive problems, infertility, high preweaning death loss, and possibly abortions. Though zearalenone's effects on growing and finishing pigs are minimal, it will cause prepubertal gilts to exhibit red, swollen vulvas, and could affect future breeding. Vomitoxin causes feed refusal with little effect on the reproductive herd. However, feed refusal associated with vomitoxin will result in a decrease in daily gain. Fumonisins can cause respiratory problems in pigs. Ergot occurs mainly in rye, wheat, barley, and triticale, and results in vascular constriction leading to lactating sows and poor growth with pigs. More detailed information about mycotoxins including their effects on swine at particular dietary concentrations is shown in Table 2 [12].

A conservative approach is to keep all mycotoxin contaminated grains out of breeding herd and nursery pig diets, and not to exceed the following rates in other phases [13]:

Aflatoxin	200 ppb in finishing diets
Zearalenone	1 ppm in growing diets and 3 ppm in finishing diets
Vomitoxin (DON)	1 ppm in growing-finishing diets
Fumonisins	5 ppm
Ergot	1,000 ppm (growth) & 500 ppm (feed intake) Keep out of diets for gilts to be used in the breeding herd

Drying the grain and adding mold inhibitors to mycotoxin-contaminated grains will decrease any further mold growth, but they have no effect on the mycotoxins already present. If the intent is to use a mycotoxin-contaminated ingredient, blend it with a non-contaminated ingredient so the total mycotoxin concentration in the diet does not exceed the values listed above. Also, in the case of aflatoxin, consider using non-nutritive binding agents like sodium bentonite, hydrated sodium calcium aluminosilicates, and certain zeolites that can decrease the absorption of aflatoxin [14, 15, 16]. Evidence is not clear on the role of non-nutritive additives in negating the detrimental effects of zearalenone, DON, and fumonisins [17-21], so blending it with "clean" grain is probably the best option when dealing with these mycotoxins.

Table 2. Clinical guide to mycotoxins in swine[a]

Toxin	Category of swine	Dietary level	Clinical effect
Aflatoxins	Growing-finishing	<100 ppb	No clinical effect
		200-400 ppb	Reduced growth and feed efficiency; possible immuno-supperession
		400-800 ppb	Microscopic liver lesions, cholangiohepatitis; increased serum liver enzymes; immunosuppression
		800-1200 ppb	Reduced growth; decreased feed consumption, rough hair coat; icterus, hyproproteinemia
	Sows and gilts	>2000 ppb	Acute hepatosis and coagulopathy; deaths in 3-10 days
		500-750 ppb	No effect on conception; deliver normal piglets that grow slowly due to aflatoxin in milk
Ochratoxin and Citrinin	Finishing	200 ppb	Mild renal lesions seen at slaughter; reduced weight gain
		1000 ppb	Polydipsia; reduced growth; azotemia and glycosuria
		4000 ppb	Polydipsia and polyuria
	Sows and gilts	3-9 ppm	Normal pregnancy when fed first month
Trichothecenes T-2 and DAS	Growing-finishing	1 ppm	No effect
		3 ppm	Decreased feed consumption
		10 ppm	Decreased feed consumption; oral/dermal irritation; immunosuppression
		20 ppm	Complete feed refusal, vomiting
Doxynivalenol (DON, vomitoxin)	Growing-finishing	1 ppm	No clinical effect; minimal (10%) reduction in feed consumption
		5-10 ppm	25-50% reduction in feed consumption; taste aversion to same diet
		20 ppm	Complete feed refusal
Zearalenone	Prepuberal gilts	1-3 ppm	Estrogenic; swollen, red vulva, prolapse in prepuberal gilts
	Cycling sows and gilts	3-10 pm	Retained corpora lutea; anestrous; pseudopregnancy
	Pregnant sows	>30 ppm	Early embryonic death when fed 1-3 weeks post mating
Ergot	All swine	0.1%	Reduced weight gain
	Sows last trimester	0.3%	Gangrene of ears, tail, feet
		3.0%	Decreased feed consumption
		0.3%	Agalactia, reduced piglet birth weight; piglet starvation
Fumonisins	All swine	25 ppm	Minimal changes in clinical chemistry – increased AST, AP
		50-75 ppm	Minimal reduction in feed intake; possible mild hepatosis
		75-100ppm	Reduced feed intake, reduced weight gain; hepatosis with icterus and increased bilirubin and GGT
		>100 ppm	Acute pulmonary edema after 3-5 days consumption; survivors develop hepatosis

[a]Adapted from [12]

There are four methods of detecting either the molds that produce mycotoxins or the mycotoxins themselves [13]. Those methods are:

1. Visual inspection: red to pink kernels indicate the presence of the mold Gibberella
2. Blacklight: detects only the mold Aspergilllus when alive and not the aflatoxin it produces. If the mold is dead, it won't fluoresce even though the grain may contain aflatoxin. Using the blacklight can result in "false" negatives in such situations.
3. Immunoassays: these are commercially available kits to detect the presence of aflatoxin, DON, and zearalenone. They are relatively easy to run, inexpensive, and also serve as relative indicators of the amount of mycotoxin in a sample.
4. Chromatography: these are the tests done in a commercial lab when a more accurate indication of actual mycotoxin concentration is needed.

Again, visual inspection and blacklights provide no information on mycotoxin contamination, and they should not be used for mycotoxin screening.

Analyzing Weather-Stressed Grains

If grains are suspected of containing mycotoxins, they must either be analyzed with an immunoassay kit or sent to a commercial lab. To make sure the assay is valid, it is critical to get a representative sample. Since it is common for there to be "hotspots" with in a bin, a grain probe must be used to take 10-30 samples at evenly disturbed locations within the storage facility. If the grain is being combined, 10-30 samples can be taken at periodic intervals during the unloading process. The samples from all the different locations should be mixed together and a smaller subsample collected. This 10 lb minimum subsample should then be placed in either a paper or cloth bag and sent to the lab for analysis. Avoid using plastic bags when testing for mycotoxins since they retain moisture and promote additional mold growth. For more information, see PIG Factsheet #07-04-02 (Swine Feed and Ingredient Sampling and Analysis).

Manufacturing Feed Using Light Weight Grains

Because light weight grains have less bulk density than normal grains, volumetric proportioning systems will not provide the required amount of grain unless the whole system is recalibrated to account for the difference in bulk density. For example, a 2-ton mixer can hold 4,000 lb or 71.5 bushels of normal corn. If using 50 lb/bushel corn, that same 71.5 bushel mixer will only hold a total of 3575 lb of corn. That is a 10.6% reduction in corn added, and would cause a significant deviation away from the calculated nutrient analysis for the feed. Therefore, it is essential that the grains are added according to weight, and not volume. Proportioning systems that use scales are the best way to successfully incorporate light weight grains into a feed manufacturing program.

Light weight grains contain more fiber and less oil, therefore they tend to be dustier during the grinding process. Also, the additional fiber and lower bulk density may also cause bridging problems in the bulk bins and feeders. To make the extra fiber more digestible, it is recommended that the grain be ground to 600 microns. As with adding any other new feed ingredient to a feed manufacturing program, it will result in a need for increased bin space unless a currently used feedstuff will be eliminated. Also, it will take more bin space to hold the same weight of light weight grain as it does normal weight grain so if there is a specific requirement for a certain tonnage of grain, additional bin space will have to be added to accommodate that.

Summary

Adverse weather conditions can result in the production of light weight grains and green soybeans, which are of lower economic value than normal weight grains and soybeans. Often the price discounts are large enough to more than offsets the lower performance experienced when feeding weather-damaged feed-stuffs. The grains must be analyzed for mycotoxin concentrations to ensure that the total diet does not exceed the recommended limits of the various mycotoxins. When properly formulated and manufactured, diets utilizing weather-stressed grains can oftentimes make producers money.

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Frequently asked questions

Can I feed light test weight grains to pigs without reducing performance?

If the grains are mycotoxin-free, test weight can be reduced up to 25% without adversely affecting weight gain. However, feed efficiency will worsen as you add light weight grains. Light weight grains should only be fed in the late grower, finishing, and gestation diets.

How do I utilize mycotoxin-contaminated feedstuffs in swine diets?

First, a representative sample must be analyzed by an immunoassay kit or sent to a commercial lab to determine the exact level of mycotoxins in the feedstuff. Once that is known, mycotoxin-contaminated grains can be blended with clean grains so the mycotoxin level in the total diet is at acceptable levels. Non-nutritive additives can be used to bind aflatoxin, but their effectiveness is questionable with the other mycotoxins.

How do I calculate the value of light test weight grains?

The reduction in diet cost has to be equal to or more than the economic loss in feed efficiency experienced from feeding light weight grains. The formula in the text allows those values to be calculated.