

# Feed Management Practices to Minimize Odors from Swine Operations

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## Introduction

Among the issues that can affect pork producers in the United States is concern about the potential for generation of odors from swine operations. Swine farms have the potential to emit various gasses that can serve as a source of odors and that can affect the quality of the air surrounding the farm.

Feed management techniques can have a significant impact on odor generation and control.

Nutrients in the manure are one potential source of odor emissions. Since the pig is the source of manure nutrient excretions, feed management techniques can have a significant impact on odor generation and control. The forms, levels and source ingredients of pig diets and feed management practices used on the farm can influence the level of nutrients excreted in pig manure that can have a direct impact on gas and odor emissions. After excretion and during storage, anaerobic microbial degradation of organic matter in animal manure generates gasses and the potential for odors.



Numerous compounds have been identified from the anaerobic degradation of animal manure. These have been generally grouped as volatile sulfur compounds, indoles and phenols, volatile fatty acids, ammonia and volatile amines. Many of these compounds (ammonia and volatile sulfur compounds) come from the degradation of amino acids and proteins. Many of the volatile organic acids, phenols and methane come from degradation of specific amino acids and starch, and degradation of a multitude of organic compounds.

## Feed Management

Any diet formulation and management procedure that improves the overall efficiency of feed nutrient utilization by the pig should:

- Reduce the total amount of manure produced,
- Reduce levels of nutrients excreted in the manure,
- Potentially decrease the precursors to volatile compounds,
- Potentially decrease the emissions of gasses, and
- Control the potential for generating offensive odors.

Improving the feed efficiency by 0.1 points will generally result in a 3.3 percent reduction in nutrient excretion (assuming similar growth and nutrient retention in the animal).

Other feed management practices that enhance feed efficiency and reduce nutrient excretion include:

- Feed processing techniques such as fine grinding or pelleting,
- Dividing the pig's growth period into phases and feeding different formulations to accommodate feed intake and nutrient requirements in each phase (phase feeding), and
- Formulating diets to match nutrient requirements of the sex of the pig, or split-sex feeding.

Reducing the particle size of feed through fine grinding will increase the surface area of the grain particles and allow greater interaction of digestive

enzymes to free nutrients for use by the pig. When particle size is reduced from 1000 microns to 600 microns, dry matter and nitrogen (N) digestibility is increased 5 to 12 percent and nitrogen excretion in manure is reduced by 20 to 24 percent. A target particle size is between 650 to 750 microns and any additional reduction in particle size will increase processing costs and may increase the incidence of stomach ulcers in pigs causing significant loss in performance or even death.

Providing feed in a pellet form reduces feed wastage and dust and can improve nutrient utilization in the diet if proper pelleting procedures are followed. Overheating pellets may reduce protein utilization in the feed and, consequently, pig performance.

The requirement of growing pigs for most available amino acids and minerals, expressed as a percentage of the total diet decreases as the pigs grow heavier. Phase feeding and split-sex feeding allow the producer to formulate diets to more closely meet the animal's protein and other nutrient requirements. These management practices may result in:

- Less feed wastage,
- Reduced feed costs, and
- Reduced nutrients excreted in the manure.

For example, increasing the number of phases in grow-finish from one to three can reduce nitrogen excretion in manure by 15 percent and ammonia emissions by 17 percent. Feeding three or four diets during the grow-finish period compared to feeding only two diets could reduce nitrogen excretion by 5 to 8 percent. Additional reductions in ammonia emissions from three or more phases may be realized depending upon the initial protein levels in the diet of the pig. There have been increased reductions of ammonia emissions of 45 percent and odors of 55 percent reported when more phases of feeds are fed throughout the life cycle of the pig.

Similarly, split-sex feeding will result in a reduction in nutrient excretion, savings in diet costs and minimizing gas emissions.

Proper feeder management is essential to reduce feed wastage and improve the efficiency of feed utilization in the swine operation. Studies have shown that feed waste can account for up to 3 to 8 percent of the feed offered. Spilled feed provides a readily available source of nutrients for bacterial activity in the manure system that can create additional gas emissions and odors. Routinely checking feeder adjustment can greatly reduce this problem and help save money. In addition, proper storage of feed is important. Spoiled feed causes odors and is costly to the operation. Therefore, using "good housekeeping" practices of routinely cleaning up spilled and spoiled feed is imperative.

Feeds and the feed delivery system can generate considerable dust in swine buildings. Dust can cause the threat of respiratory ailments to the pigs, in addition to carrying gases, odors and bacteria into the atmosphere. Therefore, minimizing dust will improve the environmental conditions inside and outside of the building. A low-dust emission feed distribution system or adding fat to the diet (1 percent or more) will reduce dust formation in the building. Liquid feeding pigs (3:1 water to feed ratio) has been shown in European studies to reduce dust in the buildings and reduce odors by 23 to 31 percent.

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## Diet Formulation

There are numerous feed ingredients that can be formulated into pig diets; however, availability and cost of ingredients generally dictate the selection of feeds used in the diet assuming that performance goals will be met.



Producers often include additional nutrients to the diets as a "safety factor" to ensure that the potential for pig performance is reached. Excess nutrients in the resulting diet may result in substantial excretion of these nutrients in the manure increasing gas and odor emissions. Therefore, formulation of nutrients in the diet to closely meet the nutrient requirements of the animals must be followed. This can be met by following National Research Council (NRC) requirements or industry standards for specific genetic lines of pigs.

Formulation of diets on an available or digestible nutrient basis will help meet animal requirements without excessive nutrients being placed in the diet and resultant excessive nutrient excretion. Routine analysis of feed ingredient sources and estimates of nutrient availability are needed to accomplish accurate feed formulation.

Diets including byproducts such as dried distillers grains and solubles (DDGS) from ethanol production must be formulated carefully because of the ingredient's nutrient variability. In some cases, these byproducts can increase the availability of nutrients, create an imbalance in some nutrients or provide excess levels of nutrients above the animal requirements.

Balancing the diet to avoid excessive excretion of nitrogen, sulfur and carbohydrate compounds is optimal to mitigate gas emissions and odors.



## Protein

The level and source of protein in pig diets is important. The availability of amino acids and the relative ratio of certain amino acids to each other in a diet will dictate the amount of excess nitrogenous compounds such as ammonia that will be excreted.

Soybean meal is the most commonly used protein source in pig diets in the United States. However, the amino acid ratios in a corn-soybean meal based diet are not ideal to meet the pig's requirements. The introduction of the "ideal protein" concept implemented the use of synthetic amino acids in reduced crude protein (or reduced soybean meal) diets so that less excess amino acids would be present in the diet and less nitrogen would be excreted. Considerable research has shown that pigs fed reduced crude protein in diets supplemented with synthetic amino acids will perform similar to, or better than, pigs on corn-soybean meal diets with no synthetic amino acid additions. However, carcasses of pigs fed the low crude protein diets will generally have slightly higher backfat depths.

The use of high quality protein sources that have a good balance of amino acids (a high biological value) or reducing the crude protein level in the diet and using synthetic amino acids will allow one to meet the dietary requirement of pigs and reduce nitrogen excretion and the potential for gas emissions.

Research has shown that a 3.5 to 4.5 percent reduction in crude protein in a corn-soy diet with synthetic amino acids (lysine, methionine, tryptophan and threonine) fed to grow-finish pigs when compared to a standard commercial diet:

- Reduced pH (0.4 units),
- Lowered total nitrogen excretion (30 – 40 percent),
- Lowered ammonium nitrogen excretion (20 – 31 percent),
- Reduced aerial ammonia emission (40 – 60 percent),
- Reduced hydrogen sulfide emission (30 – 40 percent) and
- Reduced total odors (30 – 40 percent).

Based on numerous studies, for every percent of reduction in dietary crude protein, nitrogen excretion and ammonia emissions are reduced by 8 to 10 percent.

Modifying the mineral mix with lower levels of sulfate-containing mineral sources in the pig's diet will:

Aid in reducing volatile sulfur compound emissions.

However, the availability of the minerals for use by the pig in these alternate mineral sources and costs of these mineral sources must be considered. Similarly, the amount of synthetic amino acids that can be formulated in the diet will depend upon their cost versus natural protein sources (generally soybean meal).



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**Table 1. Protein sources and their effect on odor**

DDGS	Soy protein	Blood meal	Fish meal	Feather meal	Yeast
<ul style="list-style-type: none"> <li>• Phosphorous (P) availability increased</li> <li>• Potential increase in P excretion if high inclusion rate</li> <li>• Amino acid digestibility potentially reduced</li> <li>• Additional nitrogen (N) excretion may result when synthetic amino acids are included to replace low digestibility amino acids from DDGS</li> </ul> <p>At 5-10 percent inclusion</p> <ul style="list-style-type: none"> <li>• No difference in N and P manure content</li> <li>• Odors increase as inclusion rates increase</li> </ul> <p>At 10 percent inclusion</p> <ul style="list-style-type: none"> <li>• One study shows no difference in odor</li> </ul>	<ul style="list-style-type: none"> <li>• Soy Concentrates reduce N excretion</li> <li>• Soy concentrates improve feed efficiency</li> <li>• Soy concentrates increase organic acids</li> <li>• Soy isolates increase alcohols in manure</li> <li>• May have an impact on odor</li> </ul>	<p>At 1-3 percent</p> <ul style="list-style-type: none"> <li>• No impact on odors</li> </ul>	<p>At 17 percent</p> <ul style="list-style-type: none"> <li>• High odor scores</li> </ul>	<p>At 12 percent</p> <ul style="list-style-type: none"> <li>• High odor scores</li> <li>• Added high level of sulfur to diet</li> </ul>	<p>At 2-5 percent</p> <ul style="list-style-type: none"> <li>• Reduced odorous compounds – indole and skatole – in manure</li> <li>• Did not affect human test panel measurements of odor</li> </ul>

## Energy (carbohydrate sources; fiber)

The source of carbohydrates and fiber included in pig diets also can affect gas and odor emissions. In some cases, the amount of odors emitted may not change, however, the composition or character of the odors may change dramatically. Carbohydrates and non-starch polysaccharides (carbohydrates that are highly fermentable in the gastrointestinal tract of the pig) are prime precursors for compounds such as the short chain volatile fatty acids, alcohols and other volatile organic acids.

Cereal grains, such as corn, barley, wheat, sorghums and oats are common examples of carbohydrate sources with varying levels of starch and non-starch polysaccharides.

Generally, corn is the more frequently used energy source in the pig's diet. In some areas of the United States, barley and wheat are commonly used in pig diets. Often, when grains containing high fiber content are used to replace corn in the pig's diet:

- The amount of manure produced is higher,
- Nutrient excretion can be higher, and
- Odor generation is changed with less ammonia emissions but possibly greater volatile fatty acid emissions. This generally takes place when the fiber content increases in the diet or when specific fiber sources are added to the diet.

Sources of fiber are often added to sow diets because of the laxative effect of fiber on lactating sows and the need to limit energy in gestating sows. However, because fiber is not effectively utilized by growing pigs, it is not added to nursery pig diets and generally not

added to grow-finish pig diets.

Depending on the level and source of fiber, potential negative impacts of fiber addition to a pig diet are:

- Reduced digestibility of protein,
- Reduced digestibility of fat,
- Reduced digestibility of minerals, and
- Reduced digestibility of energy.
- Reduced pig performance (live weight gain and feed efficiency) as a result of lower digestibility of feed ingredients.

Pigs may compensate for reduced available energy in the diet by consuming more feed, which also results in an increased production of manure. The reduction in dietary energy from the inclusion of fiber can be compensated for by adding more fat to the diet.

The addition of fermentable carbohydrates to diets results in less nitrogen excretion in urine as urea, a shift to more nitrogen excretion in feces and a reduced pH of the manure. As a result, the nitrogen excreted is much more stable to degradation when manure is stored and applied to cropland and there is less ammonia emission.

Some examples of fermentable carbohydrates are soybean hulls, sugar beet pulp, wheat bran or midds and distillers grains. Other more unique carbohydrate sources are coconut meal, potato starch, safflower meal and sunflower meal.

Many sources of carbohydrates and fiber available to producers have yet to be tested on their impact on odor or gaseous emissions.

**Table 2. Fermentable carbohydrates and their effect on odor**

Soybean hulls	Wheat bran, wheat midds	Sugar beet pulp
<ul style="list-style-type: none"> <li>• A 17 to 36 percent reduction in ammonia (NH<sub>3</sub>) emissions</li> <li>• May increase short chain volatile fatty acids (VFA) in feces</li> </ul> <p>Inclusion of 10 percent with 3.4 percent fat to a standard commercial diet</p> <ul style="list-style-type: none"> <li>• Reduced aerial NH<sub>3</sub> by 20 percent</li> <li>• Reduced hydrogen sulfide (H<sub>2</sub>S) by 32 percent</li> <li>• Reduced odor threshold by 11 percent</li> <li>• Nitrogen (N) in manure increased 21 percent</li> <li>• pH of manure decreased</li> <li>• VFA increased 32 percent in manure</li> </ul> <p>Five percent inclusion with reduced crude protein and supplemental amino acids in corn-soy diets</p> <ul style="list-style-type: none"> <li>• Reduced aerial NH<sub>3</sub> by 50 percent</li> <li>• Reduced aerial H<sub>2</sub>S by 48 percent</li> <li>• Reduced odor detection threshold by 37 percent</li> </ul>	<p>Ten percent inclusion with reduced crude protein and supplemental amino acids in corn-soy diets</p> <ul style="list-style-type: none"> <li>• Reduced ammonia N by 22 percent</li> <li>• Little effect on VFA emissions</li> <li>• Additional research is needed to determine effect on odor and gas emissions</li> </ul>	<ul style="list-style-type: none"> <li>• Odorous compound emissions have been variable</li> <li>• Additional research is needed to determine effect on odor</li> </ul>

## Other Feed Ingredients

Inorganic forms of minerals are commonly added to diets to meet specific mineral nutrient requirements of the pig. Depending upon costs and availability, some mineral sulfates are used, which may be a source of sulfur odor compounds. Even though sulfur amino acids are the primary source of volatile sulfur compound generation, mineral sources can also contribute. Organic forms of minerals are more biologically available and smaller amounts are required in the diet to meet the pig's needs. This results in less excretion of minerals and potentially less volatile sulfur compound emissions. However, the effect of organic mineral sources on odors and volatile sulfur gas emissions has not been determined.

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Attempts have been made to isolate and identify the microbial populations in the digestive systems of pigs that control or are involved in the creation of odors. Compounds such as dairy byproducts (lactulose, lactitol, lactose and whey), and organic acids (propionic, fumaric and citric) have been added to manipulate the microflora populations in pig digestive systems.



**Table 3. Other feed ingredients and their effect on odor\***

Growth promoters	Dietary calcium salts (sulfate, chloride and benzoate)	Bentonite and zeolite	Organic acids	Enzymes (protease, amylase, and carbohydrase)
<ul style="list-style-type: none"> <li>• Improve feed efficiency 5 to 10 percent</li> <li>• Potentially reduces odors</li> </ul> <p>Beta-agonist</p> <ul style="list-style-type: none"> <li>• Reduce N excretion</li> <li>• Reduce NH<sub>3</sub> in slurry</li> <li>• Reduce NH<sub>3</sub> emissions</li> <li>• Reduce volatile fatty acids</li> </ul>	<p>Calcium benzoate at increasing levels (2,4 and 8g /kg of feed) in sows</p> <ul style="list-style-type: none"> <li>• Reduced pH of urine from 7.7 to 5.5</li> <li>• Reduced ammonia (NH<sub>3</sub>) emissions up to 53 percent</li> </ul> <p>Calcium benzoate is currently not approved for animal feeds.</p> <p>Calcium chloride at 1.96 percent in nursery diets</p> <ul style="list-style-type: none"> <li>• Reduced NH<sub>3</sub> emissions from nursery rooms</li> <li>• Reduced feed intake</li> <li>• Depressed performance</li> </ul>	<ul style="list-style-type: none"> <li>• Effect on NH<sub>3</sub> emissions is inconclusive</li> <li>• Minimal effect on odor</li> </ul>	<ul style="list-style-type: none"> <li>• Citric, hydrochloric, propionic, fumaric and sulfuric acid at dietary levels of 1 to 4 percent</li> <li>• Variable results on the pH of the digestive contents and pig growth.</li> </ul> <p>Fumaric or citric acid addition at 1.5 percent</p> <ul style="list-style-type: none"> <li>• Very little effect on pH</li> <li>• Very little effect on volatile fatty acid concentrations of intestinal contents of pigs.</li> </ul> <p>Adipic acid inclusion</p> <ul style="list-style-type: none"> <li>• Reduces pH</li> <li>• Reduces NH<sub>3</sub> emissions</li> <li>• Does not improve lysine utilization</li> </ul> <p>There has been little research on the effects of organic and inorganic acids on gas and odor emissions.</p>	<ul style="list-style-type: none"> <li>• Improve the digestibility of specific nutrients</li> <li>• Can reduce manure generation</li> <li>• May reduce potential odor generation.</li> </ul>

\*Individual operations need to evaluate the use of these ingredients as cost and availability will vary.

## Summary

Techniques to increase the availability and retention of nutrients can reduce excretion of compounds in manure that commonly cause odors. Feed management practices such as formulating diets to meet the requirements of specific genetic lines, phase feeding, split-sex feeding, minimizing feed wastage and feed processing technologies will assist in reducing nutrient excretions. Implementation of several of these technologies and practices, often in combination, has the potential of reducing ammonia and hydrogen sulfide emissions by 30 to 50 percent and reducing odors by 30 percent at very little additional cost to the producer.

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Feed management practices along with feed formulation can affect nutrient excretions and ultimately gaseous and odor emissions from manure. Inclusion of enzymes to enhance feed utilization can reduce nutrient excretions and reduce potential gaseous emissions and the potential for odor generation on swine farms. Amino acid balanced (correct ratios and concentrations) diets with lower crude protein levels and addition of small amounts of fiber (less than 10 percent) can be effective in reducing aerial ammonia, hydrogen sulfide, manure nitrogen, pH and odors. The relative costs of these practices must be considered when implementing them.

## Additional Resource Information:

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To learn more about odor mitigation practices, visit the Checkoff-funded Air Management Practices Assessment Tool at <http://www.extension.iastate.edu/airquality/practices/homepage.html>.