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# G99-1390 Altering Swine Manure by Diet Modification

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# Altering Swine Manure by Diet Modification

**This NebGuide explores options for altering the nitrogen and phosphorus content of swine manure.**

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There are situations in which it is necessary to change the nutrient content and/or the odor-producing potential of swine manure in order for pork production to thrive. For example, current Nebraska Department of Environmental Quality (NDEQ) permit procedures for livestock facilities require producers to document that sufficient land is available for crop use of the nitrogen (N) in manure. If sufficient land is not available for managing nutrients in manure, producers can alter the nitrogen and phosphorus content of swine manure by modifying the pig's diet. The objective of this article is to review how to alter the nitrogen and phosphorus content of swine manure and the emission of ammonia and odor from pork production systems by modifying the pig's diet.

## Nitrogen and Phosphorus Nutrition in the Pig

Pigs consume nitrogen in the form of protein which comprises several amino acids. During digestion, amino acids are released from proteins and used to build new proteins. Ten amino acids are essential, which means they must be provided in the diet.

Pigs consume phosphorus in two forms — organic (plant or animal origin) and inorganic (for example, dicalcium phosphate). Phosphorus in plant material is bound inside a molecule called phytate. Releasing the phosphorus in phytate and making it available to the pig requires the intestinal enzyme phytase. Pigs, however, lack phytase.

The quantity of nitrogen and phosphorus that pigs excrete is affected by three factors (*Figure 1*):

- The amount of nitrogen and phosphorus consumed
- The proportions of the nitrogen and phosphorus consumed that are used for growth and reproduction
- The amount of nitrogen and phosphorus represented by secretions, sloughed cells and bacteria in the intestine (commonly called endogenous nitrogen and phosphorus). This is a small contributor.

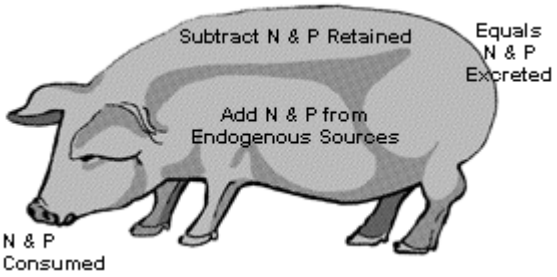


**Figure 1. Factors that affect the amount of nitrogen (N) and phosphorus (P) pigs excrete.**

To reduce the amount of nitrogen and Phosphorus excreted by pigs, either the amount of nitrogen and phosphorus consumed must be decreased, or more of the nitrogen and phosphorus consumed must be utilized by the animal, or both must occur. The following methods are effective in accomplishing these tasks.

## Nutritional Strategies for Reducing Nitrogen in Pig Manure

### Meet the Pig's Dietary Amino Acid Needs

Pigs require certain amounts of essential amino acids in their diet for growth and other functions. The amount required depends on several factors, including their genetic capacity for muscle growth, health status, phase of production, and sex. To ensure a low nitrogen excretion rate and optimum pig performance, it is important to provide pigs with the exact amount (no more or less) of essential amino acids needed. An amino acid deficiency will reduce the efficiency of nitrogen utilization and increase nitrogen excretion. The nitrogen from amino acids that are provided in excess of what the pig requires also will be excreted.

Techniques are available for reducing the chances of under- and overfeeding amino acids to pigs. Producers are encouraged to monitor pig performance (e.g., rate of lean gain, feed intake, etc.) on their farm and formulate diets based on the observed production level rather than using a general set of nutrient recommendations. Details on how to collect information to use in formulating diets are given in the Nebraska and South Dakota Swine Nutrition Guide. In addition, as pigs grow their nutrient requirements decrease when expressed as a percentage of the diet. Thus, as pigs approach market weight they should be fed diets that contain a lower density of amino acids. This is commonly called "phase feeding." In typical phase feeding programs, pigs growing from 50 to 250 pounds would be fed four or five different diets. Also, because barrows eat more feed than gilts during the growing-finishing period, amino acid requirements (percent of the diet) for barrows are lower. Thus, it is recommended that barrows be separated from gilts and fed diets containing different amino acid densities. Nutrient recommendations for various classes of swine are given in the Nebraska and South Dakota Swine Nutrition Guide.

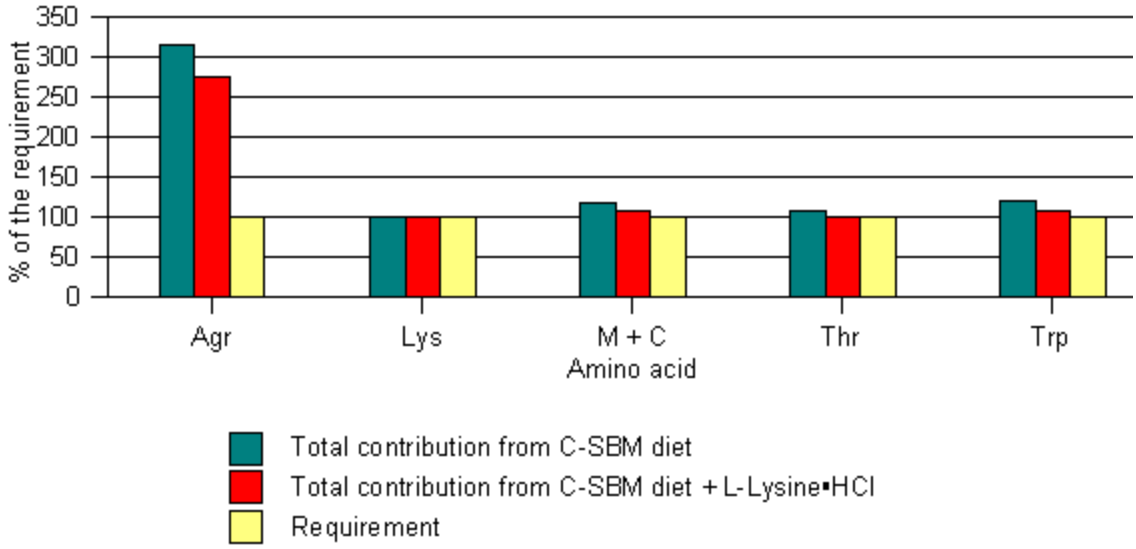


**Figure 2. The total contribution of the essential amino acids from a corn/soybean meal (C-SBM) diet compared to the requirements for a 110 lb. pig and the effect of the removal of 100 lb. of soybean meal and the addition of 3 lb. of Lysine HCl and 97 lb. of corn per ton of complete feed in the total contribution of the essential amino acids in the diet. Agr = Agrinine; Lys = Lysine; M + C = Methionine + Cystine; Thr = Threonine; Trp = Tryptophan.**

**Reduce Dietary Amino Acid Excesses**

When standard diets are formulated to meet the pigs' requirement for lysine (the most limiting amino acid in corn or milo-soybean meal diets), there is an excess of all other amino acids in the diet (*Figure 2*). If all the essential amino acids were provided in the diet at exactly 100 percent of the required level (i.e., a perfect balance of amino acids), significantly less nitrogen would be consumed and excreted.

There are two practical ways to achieve a more ideal balance of amino acids in pig feed. One way is to use a combination of supplemental protein sources in the diet that complement each others' amino acid profiles. The other way is to formulate the diet with crystalline amino acids. When crystalline amino acids, such as lysine, are added to the diet and some soybean meal is removed, the extent that many amino acids in the diet is in excess of the pig's requirement is reduced (*Figure 2*). Crystalline lysine is commonly used to supply a portion of the total lysine needs of the pig.

It has been estimated that for each 1 percentage point reduction in the crude protein content of a corn-soybean meal diet, nitrogen excretion is reduced by about 8 percent. When 100 pounds of soybean meal is replaced with 3 pounds of crystalline lysine and 97 pounds of corn in one ton of feed, dietary crude protein level is reduced by about 2 percentage points. This should reduce nitrogen excretion by about 16 percent, with no affect on pig performance. Crude protein reductions beyond 2 percentage points often decreases lean gain; however, nitrogen excretion is reduced. Supplementing a corn-soybean meal diet with crystalline tryptophan, threonine, methionine, and lysine will result in a diet with 4 percentage points less crude protein and reduce nitrogen excretion by about 32 percent. At present, crystalline tryptophan and threonine are not cost competitive. However, this cost comparison assumes no credit is given to producing manure containing less N.

Using crystalline amino acids to replace a portion of the soybean meal in corn-based diets can reduce land requirements by 20 to 50 acres for a 1,000 head finishing operation with a manure management system that conserves nitrogen (*Table I*). For an anaerobic lagoon and center pivot application system, 3

to 9 acres less land is needed per 1,000 finishing hogs.

| **Table I. Effect of adding crystalline amino acids to a corn-soybean meal diet (C-SBM) on the land application area required for a 1,000 head capacity pig finishing facility[1]** | | | |
|---|---|---|---|
| *Diet options* | *Manure N excretion (lb N/yr)* | *Manure N after losses (lb N/yr)* | *Land requirement for managing N* |
| **Manure storage and incorporation during application [5]** | | | |
| C-SBM[2] | 26,300 | 21,300 | 130 |
| C-SBM + lysine[3] | 22,900 | 18,500 | 113 |
| C-SBM + lysine, tryptophan, threonine, and methionine[4] | 16,600 | 13,400 | 82 |
| **Anaerobic lagoon and pivot irrigation [6]** | | | |
| C-SBM[2] | 26,300 | 4,000 | 25 |
| C-SBM + lysine[3] | 22,900 | 3,400 | 22 |
| C-SBM + lysine, tryptophan, threonine, and methionine[4] | 16,600 | 2,500 | 16 |

[1]Nutrient use in crop production assumed a corn (170 bushels/acre) and soybean rotation (50 bu/acre).
[2]Dietary crude protein level was 17.9%, 16.5%, 15.1%, and 13.0% for 45-80 lb, 80-130 lb, 130-190 lb, and 190-250 lb pigs, respectively.
[3]Dietary crude protein level was 16.4%, 14.9%, 13.6%, and 12.1% for 45-80 lb, 80-130 lb, 130-190 lb, and 190-250 lb pigs, respectively.
[4]Dietary crude protein level was 14.0%, 12.6%, 11.1%, and 9.6% for 45-80 lb, 80-130 lb, 130-190 lb, and 190-250 lb pigs, respectively. A significant reduction in pig performance would be expected.
[5]80% of the nitrogen and 100% of the phosphorus is conserved.
[6]20% of the nitrogen and 35% of the phosphorus is conserved.

**Use Highly Digestible Amino Acid Sources**

Nutrients present in feedstuffs are not fully available to pigs. Generally, only a portion of each nutrient can be used. This is because feedstuffs are not fully digested and because nutrients occur in forms that pigs are unable to use. The portion of a nutrient that is available to the pig for growth and other functions depends primarily on the ingredient itself. For example, the lysine in soybean meal is more digestible than lysine in meat and bone meal. Using ingredients that have a high amino acid digestibility will result in a greater proportion of the consumed nitrogen being retained in the body and less manure nitrogen.

Because the digestibility of amino acids varies among ingredients, it is important to formulate swine diets on a digestible rather than total amino acid basis when ingredients other than corn, milo and soybean meal are used in the diet. Otherwise, the diet may not meet the amino-acid needs of the pig and the amount of nitrogen excreted will increase. Amino-acid digestibility coefficients for several feed ingredients are presented in the Nebraska and South Dakota Swine Nutrition Guide.

**Process Grain Adequately**

Process grain to achieve an average particle size between 650 and 750 microns to help ensure that the digestibility of nitrogen in the grain is optimized.

## Nutritional Strategies for Reducing Phosphorus in Pig Manure

### Meet the Pig's Dietary Phosphorus Needs

The same techniques used to more accurately meet the amino acid needs of pigs mentioned previously also apply to phosphorus. The dietary phosphorus level to achieve maximum growth and feed efficiency is at least 0.1 percent less than that needed to achieve maximum bone mineralization. Thus, it is recommended that terminal market hogs be fed separately from developing replacement gilts.

### Use High Quality Phosphorus Sources

There is significant variation in the availability of phosphorus from different feed ingredients. The majority of the phosphorus in cereal grains and other plant protein sources (phytate) is not available to pigs for growth and other functions, because pigs lack the intestinal enzyme phytase. Thus, pigs often exhibit phosphorus deficiency symptoms when fed diets containing only plant sources of phosphorus. Inorganic forms of phosphorus, which have a higher phosphorus availability, must be included in the diet to prevent a deficiency. To minimize phosphorus excretion, choose inorganic sources of phosphorus that have a high availability of phosphorus. For example, use dicalcium phosphate (100 percent availability of phosphorus) instead of soft rock phosphate (72 percent availability of phosphorus) as a supplemental source of phosphorus in the diet. The availability of phosphorus in several feed ingredients is presented in the Nebraska and South Dakota Swine Nutrition Guide. Also, formulating diets on available phosphorus basis, rather than on a total phosphorus basis, is more precise and can lower phosphorus excretion.

### Supplement Diets With Phytase

Phytase is now available as a feed additive. When phytase is added to the diet at the rate of 300 to 500 FTU/kg of complete feed, 10 to 13 pounds of dicalcium phosphate can be removed from one ton of feed. This lowers the total amount of phosphorus in the diet by about 0.1 percent and reduces phosphorus excretion by 20 to 30 percent. In addition, there is evidence that phytase improves energy and amino-acid digestibility by 1 to 3 percentage points which may further increase its value in the diet. Currently, the savings generated by reducing the amount of dicalcium phosphate used in the diet is about the same as the additional cost of phytase. Thus, the main incentive to use phytase in the diet should be to reduce the amount of phosphorus in the manure.

### Feed Low-Phytate Corn

Hybrid seed corn companies are developing low-phytate corn as a means of reducing phosphorus excretion when used in swine diets. Usually about 14 percent of the phosphorus in normal corn is available to the pig. The lowered phytate level in some of the new corn varieties allows about 75 percent of the phosphorus in the corn to be available to the pig. Research has shown that 11 to 13 pounds of dicalcium phosphate can be removed from one ton of feed when normal corn is replaced with the experimental low-phytate corns. phosphorus excretion is reduced by 25 to 30 percent. It is important to consider the impact of any yield loss when evaluating whether to grow and feed low-phytate corn to pigs.

Substituting normal corn for low-phytate corn in the diet or adding phytase to normal corn-based diets can reduce land requirements by approximately 80 acres for a 1,000 head finishing operation with a manure management system that conserves phosphorus (*Table II*). For an anaerobic lagoon and center pivot application system, about 30 acres less land is needed per 1,000 finishing hogs. Also, note that the

land requirements for managing phosphorus (*Table II*) are at least twice that required for managing nitrogen (*Table 1*).

**Table II. Effect of reducing dietary phosphorus level by 0.1% on the land application area required for a 1000 head capacity pig finishing facility[1]**

| *Diet options* | *Manure phosphorus excretion (lb $P_2O_5$/yr)* | *Manure phosphorus after losses (lb $P_2O_5$/yr)* | *Land requirement for managing phosphorus* |
|---|---|---|---|
| **Manure storage and incorporation during application** | | | |
| Normal corn/soybean meal[2] | 13,000 | 13,000 | 257 |
| Reduced dietary P[3] | 8,900 | 8,900 | 177 |
| **Anaerobic lagoon and pivot irrigation** | | | |
| Normal corn/soybean meal[2] | 13,000 | 4,600 | 90 |
| Reduced dietary P[3] | 8,900 | 3,100 | 62 |

[1]Nutrient use in crop production assumed a corn (170 bushels/acre) and soybean rotation (50 bu/acre).
[2]Dietary phosphorus levels were 0.60%, 0.55%, 0.50%, and 0.45% for 45-80 lb, 80-130 lb, 130-190 lb, and 190-250 lb pigs, respectively.
[3]Dietary phosphorus levels were 0.50%, 0.45%, 0.40%, and 0.35% for 45-80 lb, 80-130 lb, 130-190 lb, and 190-250 lb pigs, respectively. Dietary phosphorus level reduced by removing 11 lb of dicalcium phosphate per ton of complete feed and substituting normal corn for low-phytate corn or adding phytase to normal corn-based diets.

## Nutritional Strategies for Reducing Ammonia and Odor Emissions

Several compounds originating from stored pig manure contribute to odor. Many of them appear to be related to the degradation of excess amino acids not digested and used by the pig.

Research has shown that adding crystalline amino acids to the diet and reducing dietary crude protein by 4 percentage points resulted in a 71 percent reduction in aerial ammonia and a reduction in odor by about half. However, pig performance is often reduced when dietary protein is reduced by 4 percentage points although crystalline amino acids are included in the diet. Research also has shown that hydrogen sulfide level and odor in confinement nursery facilities may be reduced by minimizing the use of high-sulfur ingredients in the diet and replacing them with lower-sulfur ingredients. High-sulfur ingredients include dried whey, dicalcium phosphate, and sulfur-based forms of trace minerals.

Ammonia emission also may be reduced by the addition of nonstarch polysaccharides (NSP) to the diet. NSP are found in the cell wall of plants. The most abundant plant cell wall NSP include cellulose, hemicelluloses and pectins. Pigs lack enzymes to digest NSP. Instead NSP are fermented by microorganisms in the large intestine.

Pigs eliminate the majority of the nitrogen not retained in the body in the form of urea via the urine. Urea is a significant source of ammonia that is emitted to the atmosphere. The amount of ammonia released is primarily a function of urinary urea concentration, and the pH and temperature of the slurry.

The addition of NSP to pig diets shifts how nitrogen is eliminated from the body. Pigs that consume more NSP excrete less nitrogen via the urine in the form of urea and more nitrogen via the feces in the

form of microbial protein. Because the nitrogen in microbial protein is more stable and less volatile than nitrogen in urea, less ammonia is emitted from the slurry.

Ammonia emission from slurry also is reduced due to the increased microbial activities in the hindgut of pigs fed diets containing NSP. When the amount of fermentable NSP in the diet is increased, volatile fatty acid production in the hind gut of the pig increases which lowers the pH of the feces and slurry. A lower pH is associated with lower ammonia emission. Sources of NPS differ in the extent that they reduce ammonia emission.

The pH of the urine also can be reduced by lowering dietary electrolyte balance (the proportion of sodium, potassium and chloride in the diet) and adding acidifying calcium salts to the diet. Replacing calcium carbonate or limestone in the diet with calcium chloride reduced ammonia emission by 30 percent in one study.

Odors and gasses are carried in the atmosphere on dust particles. Odorous compounds attach to dust particles. Addition of fat to swine diets has been shown to reduce aerial dust and possibly ammonia concentrations. In general, for each 20 pounds of fat added to one ton of feed, aerial dust concentration is reduced by 10 percent. Preliminary evidence suggests that fat addition to the diet may reduce odor concentration by amounts similar to the reduction of dust.

These results suggest that there may be opportunities to reduce odor emissions from pork producing operations by manipulating the diet. Further research is needed before recommendations on how to formulate diets can be provided.

## Summary

The choice of ingredients and the nutrient content of the diet affects the nutrient composition of the manure that pigs produce. There are practical and cost-effective measures that pork producers can use to reduce the nitrogen and phosphorus content of pig manure. A checklist for evaluating swine feeding programs from an environmental standpoint is shown in *Table III*. Technologies to reduce ammonia and odor emissions from pig manure are under development.

**Table III. An environmental steward's checklist for evaluating swine feeding programs**

| | | *Yes* | *No* | *Unsure* | *Good option for future application* |
|---|---|---|---|---|---|
| **Nutritional strategies to reduce nitrogen in pig manure** | | | | | |
| 1. | Do dietary amino acid levels meet the pigs' requirements? | | | | |
| 2. | Is phase feeding (4 to 5 diets) used in grow/finish production? | | | | |
| 3. | Are barrows and gilts separated and fed diets containing appropriate amino acid densities? | | | | |
| 4. | Are crystalline amino acids used to replace soybean meal in pig diets? | | | | |
| 5. | Is amino acid digestibility considered when using alternative feeds? | | | | |
| | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| 6. | Is feed particle size between 650 and 750 microns? | | | | |
| **Nutritional strategies to reduce phosphorus in pig manure** | | | | | |
| 1. | Do dietary phosphorus levels meet the pigs' requirements? | | | | |
| 2. | Is the availability of phosphorus in inorganic phosphorus supplements high? | | | | |
| 3. | Is phytase used to replace some inorganic phosphorus in the diet? | | | | |
| 4. | Is low-phytate corn used in diet? | | | | |

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