Swine
UPDATE

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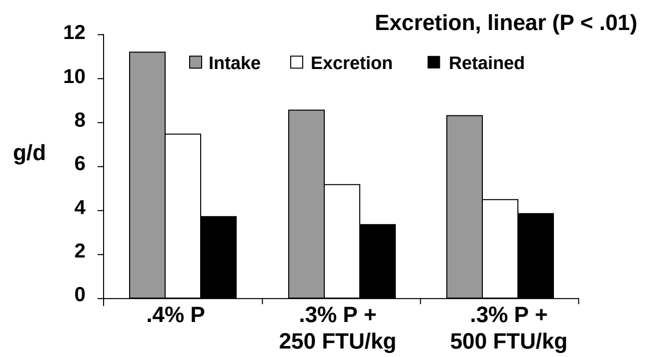
Reducing Phosphorus Excretion in Swine Waste With Phytase

The ultimate response criteria in swine nutrition research have evolved over time from average daily gain and feed efficiency, to include carcass leanness and quality, and now, nutrient excretion and environmental impact. As our industry consolidates and intensifies, greater pressure is being placed on swine units to develop waste management plans that frequently may require some dietary manipulation to help comply with local requirements. Many producers are already implementing many dietary and management strategies that have a tremendous impact on the amount and composition of swine waste. Many of these technologies have been implemented for their economic enhancement of the swine business, but their impact on the environment should not be overlooked. Management strategies such as phase feeding, split-sex feeding, and customizing diets based on lean growth potential not only decrease the cost to produce pork, but also decrease nutrient excretion. The swine industry has already adopted many technologies that affect nutrient excretion. As new technologies become available, the potential for further reductions in nutrient excretion will increase.

Why the Concern About Phosphorus Excretion ?

Phosphorus has been identified as the primary nutrient to concentrate on when evaluating swine waste management plans. This is because relative to nitrogen, there is much less phosphorus uptake by plants. Furthermore, phosphorus does not migrate through the soil like other nutrients; thus, there is a greater potential for runoff. These problems are further confounded by the fact that approximately 50 to 70% of the phosphorus in cereal grains and oil seed meals is in the form of phytate phosphorus, a form that is unavailable to swine and poultry. The low availability of phosphorus in grains and oilseed meals has been a major limitation in reducing phosphorus excretion by swine and poultry. However, the recently approved feed enzyme, phytase, has been shown to increase digestibility of phytate phosphorus in swine diets. Phytase can have a tremendous impact on reducing the amount of inorganic phosphorus added to swine diets.

Figure 1. Effects of Phytase on P Balance in Finishing Pigs



Carter et al. 1996

The Effects of Phytase in Swine Diets

Studies have shown that phytase can reduce phosphorus excretion in finishing pigs between 30 to 40% (Carter et al., 1996; Figure 1). For a 500 sow farrow-to-finish operation, this would equate to a reduction of 88 pounds of phosphorus per day or approximately 16 tons of phosphorus per year.

Table 1. Dietary Phosphorus Adjustments By Phytase Level[a]

Phytase, FTU/kg	Phytate P Digestibility, %	P released/dietary P adjustment, % Dical (18.5%P)	Monocal (21%P)
200	39.7	.067	.055
250	42.1	.081	.067
300	44.5	.095	.081
400	47.2	.110	.092
500	48.9	.120	.099
600	50.2	.124	.106
700	51.0	.129	.110

[a]BASF, 1999.

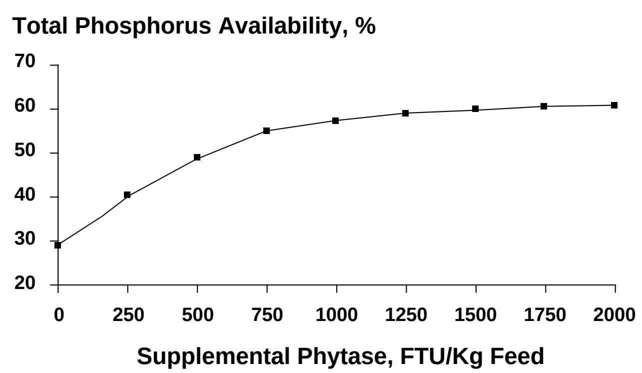
Table 2. Breakeven Prices for Added Phytase At Different Inclusion Rates

Phytase,	Dicalcium Phosphate, $/lb[a]		
FTU/kg	.13	.15	.17
200	.94	1.09	1.23
250	1.14	1.31	1.49
300	1.34	1.54	1.75
400	1.55	1.78	2.02
500	1.69	1.95	2.21
600	1.74	2.01	2.28
700	1.81	2.09	2.37

[a]Maximum price of phytase to breakeven based only on P substitution.

While the phytase enzyme has been commercially available for approximately two years, its incorporation into swine diets is beginning to increase rapidly. This is a result of new environmental regulations being adopted in many states as well as a better understanding of the economical use of phytase in swine diets. In the past, the recommended amount of phytase to add to a diet has varied from 1,000 to 500 FTU of phytase/kg of diet. Depending on the study, a dosage within this range provided the maximum reduction of phosphorus excretion and was shown not to affect pig growth performance or bone strength. Unfortunately, these high dosages were also very expensive and increased diets costs by as much a $4 per ton of feed. However, as more data is collected on the effects of added phytase, it is becoming evident that the response to added phytase is not in a linear dose-dependent fashion. A review of over 20 studies evaluating the effects of added phytase on phosphorus utilization indicates a curvilinear response to phytate phosphorus release with added phytase (Figure 2). Application of this data suggests that a dietary addition of 250 FTU/kg will allow phosphorus levels to be reduced .076% or .081% in diets containing monocalcuim phosphate or dicalcium phosphate, respectively (Table 1). A 500

Figure 2. Effect of Supplemental Phytase On Phosphorus Availability In Swine



BASF, 1999. Summary of 21 studies.

Table 3. Breakeven Prices for Added Phytase At Different Inclusion Rates

Phytase,	Monocalcium P, $/lb[a]		
FTU/kg	.13	.15	.17
200	.68	.79	.89
250	.83	.96	1.08
300	1.00	1.16	1.31
400	1.14	1.31	1.49
500	1.23	1.41	1.60
600	1.31	1.51	1.72
700	1.36	1.57	1.78

[a]Maximum price of phytase to breakeven based only on P substitution.

FTU/kg of phytase inclusion will allow dietary P to be reduced by .099% or .12%. As a result, lower phytase inclusions, although not maximizing the amount of dietary P that can be reduced, will more likely be economically justified relative to the cost of inorganic phosphorus sources. Using the estimated phosphorus replacement adjustment for incremental amounts of added phytase listed in Table 1, the corresponding maximum allowable price that can be paid for phytase based on dicalcium- or monocalcium phosphate price is listed in Tables 2 and 3. The differences in replacement value of phytase based on monocalcium- or dicalcium phosphate are based on differences in phosphorus availability between the two sources. The prices listed in the tables are estimates of how much you can afford to pay for the addition of phytase to your diets strictly on a phosphorus replacement basis. Therefore, it is extremely important that producers and nutritionists know exactly which mineral source is being used in diets.

The above calculations only take into account the price of phytase on a phosphorus replacement basis. No allowance is made for phytase's affects on digestibility of other nutrients or ramifications on waste management plans. If regulations on swine waste application are based on soil phosphorus concentrations, the addition of phytase to swine diets may be a more economical alternative to purchasing or renting more land for manure application.

Table 4. Total and Available Phosphorus Requirements

Weight, lb	Ca, %	Phosphorus, %	
		Total	Available
50–80	.75	.65	.34
80–120	.70	.60	.29
120–160	.55	.50	.21
160–200	.55	.50	.21
> 200	.50	.45	.18

K-State Swine Nutrition Guide, 1997

In addition, some studies have shown that the phytase enzyme may also increase the digestibility of energy, amino acids, and other minerals in the diet, thus increasing its value. Additional research will be important to help establish this price relationship between phytase and other nutrients in the diet.

In addition to phytase, there are other methods available to reduce phosphorus excretion. The first would be to switch from total to available phosphorus requirements. For many years, swine nutritionists have based their requirement estimates on a total phosphorus basis. Because of the recent concern for minimizing phosphorus excretion, the industry has moved towards expressing phosphorus requirements on an available basis (Table 4). Available phosphorus requirements offer an economic advantage to the less traditional feed ingredients used in swine diets such as grain sorghum, barley, and wheat. These grains have similar total phosphorus concentrations as corn, but approximately twice the available phosphorus (see the K-State Swine Nutrition Guide for further details). Therefore, diets containing these ingredients will require less inorganic phosphorus supplementation.

A second method to minimize phosphorus excretion in swine waste is to lower the large margin of safety generally built into phosphorus requirements. In the past, gilts and barrows were typically fed together with replacement gilts selected as they approached market weight. Because of this, both barrows and gilts were fed diets fortified not only to maximize growth, but also to promote maximum bone strength. With today's specialized gilt development, phase- and split-sex feeding management programs, diets can be specifically tailored to phosphorus requirements of either terminal market hogs versus replacement gilts. This will allow phosphorus levels to be reduced in diets of market hogs because bone strength is not as critical as for replacement gilts (Table 4). More closely meeting the pig's phosphorus requirements by phase- and split-sex feeding will reduce phosphorus excretion 5 to 10%.

While from an environmental standpoint, it is extremely important to minimize phosphorus excretion, one should not go too far in reducing dietary phosphorus levels. Dritz et al. (1998) recently reported a case study where a producer's loin trim loss was running three times the plant average because of broken vertebra. Research has demonstrated that if phosphorus intake is marginal, vertebra and ribs will be the first bones most likely to weaken compared with the bones of the feet and legs. This was apparent by the fact that as pigs were processed at the packing plant, there tended to be more broken vertebra, which resulted in damage to loins. Because of the combination of low-feed intake genetics and high fat diets, it was found that the Ca and P levels fed were marginally deficient. This problem was corrected by increasing Ca and P levels to values similar in Table 4. Trim losses and loin damage returned to levels similar to the average for the plant as pigs fed the adjusted diets began to be marketed

Conclusion

It is apparent that nutrition and feed management can have a large impact on the amount of waste and nutrients excreted on a swine operation. Many nutritional or management systems can reduce nutrient excretion 5 to 10% with little added cost of production. In addition, the future looks positive for development and implementation of new technologies for even greater benefits. Advances in technology could possibly reduce the nitrogen and phosphorus loading of the environment by 40 to 50%. While some of these options are currently not economically feasible to commercial swine production from a nutritional or "least cost" basis, expenses associated with waste management plans may necessitate their implementation.

Attend Swine Classic!

July 9 and 10, 1999

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