Department of Biosystems Engineering and Soil Science

The Use of the Phytase Enzyme in U.S. Swine Production: Phosphorus Reductions in Manure and Producer Adoption

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Robert T. Burns, Distinguished Professor, Department of Biosystems Engineering and Soil Science

Summary

The addition of phytase to swine diets is a well-established and widely adopted practice by the U.S. swine industry. This publication reviews the function of phytase in swine, the reported reductions in phosphorus (P) excretion in swine manure and the reported adoption of dietary phytase by swine producers. Phytase is an exogenous enzyme that hydrolyzes phytate, the principal storage form of P in cereal grains and oilseeds, releasing P in a form available to pigs. Because pigs do not have the ability to produce sufficient phytase to efficiently degrade dietary phytate, a substantial proportion of swine dietary P can remain unused and excreted in manure. Current literature reports swine diet phytase supplementation reduces P excretion in wean/grow stage pigs by up to 25 percent and in grow/finish pigs up to 51 percent. A phytase study with sows reports a 6 percent reduction in combined manure and urine excreted P. The literature reports that phytase is now nearly universally employed with supplemental dietary P in commercial swine rations.

Introduction

Phosphorus (P) is an essential mineral required by swine for skeletal development, energy metabolism and numerous physiological functions, and it must be supplied through the diet (Jacela et al., 2010). Although P is abundant in the corn and soybean meal that form the basis of U.S. commercial swine diets, much of that P is bound as phytate (phytic acid), which pigs digest inefficiently because they have insufficient endogenous phytase activity (Jacela et al., 2010). The estimate of P availability depends on the evaluation system used. Bioavailability studies report the standardized total-tract P digestibility of to be approximately 38 percent and 57 percent respectively for corn and soybean meal (Jacela et al., 2010; She et al., 2018). Phytase addition in swine diets typically increases standardized total-tract digestibility (STTD) by up to 30 percentage points in both corn and soybean meal, depending on the phytase source, dose, calcium level, and diet composition (Almeida et al., 2017). Phytase breaks down phytate, releasing P and reducing its ability to bind other nutrients (Selle and Ravindran, 2008).

Two consequences result from low phytate P bioavailability. First, inorganic P must be added to swine diets, typically monocalcium or dicalcium phosphate, which are expensive, as they represent the third most costly component of the diet after energy and amino acids (Olsen et al., 2021). Second, the undigested phytate P is excreted in manure, elevating the P in swine manure. Because manure P has been identified as a potential nonpoint-source pollutant of surface water, strategies to reduce manure P excretion have become a focus of environmentally responsible swine production (National Pork Board, 2004). The commercial development of microbial phytase, which hydrolyzes phytate to release inorganic P, is widely regarded as one of the most important advances in swine nutrition of the past half century (Olsen et al., 2021). Early work by Harper et al. (1997) provided some of the first controlled evidence that phytase supplementation of low-P growing-finishing diets simultaneously improves performance and bone mineralization while reducing P excretion. These positive results resulted in the widespread commercial adoption over the following decades. This publication addresses phytase function, quantifies its documented effect on manure P reduction, and evaluates the available evidence regarding the extent of its adoption by U.S. producers.

Phytase Enzyme Function

Phytate, or phytic acid, is the main storage form of P in grains and oilseeds (Jacela et al., 2010). Corn and soybean meal contain negligible intrinsic phytase activity, and what little exists in some feedstuffs can be destroyed by the heat during feed pelletization (Jacela et al., 2010). Phytase is an enzyme that acts specifically on phytate, separating inorganic P from the phytate molecule and making it available for absorption by pigs. Its activity is expressed in phytase units (FTU), defined as the quantity of enzyme required to liberate one micromole of inorganic P per minute from sodium phytate under standardized conditions (Jacela et al., 2010).

By improving the digestibility of phytate-bound P, phytase reduces the need for supplemental inorganic P. The dual effect of greater utilization of dietary phytate P and reduced inclusion of inorganic P, is how phytase reduces the amount of P excreted in swine manure (Jacela et al., 2010; Kansas State University, 2026). Several dietary and management factors impact the magnitude of this response, including the amount of phytate in the diet, the dose and source of phytase, and the calcium-to-phosphorus (Ca:P) ratio in the swine diet. Beyond P, phytase can improve the availability of calcium, and studies report improved availability of energy and amino acids as well (Jacela et al., 2010; Olsen et al., 2021).

Phytase efficacy varies across the pig's growth curve. In a time-series evaluation using growing and finishing pigs fed P-deficient diets with or without phytase at 1,000 FTU/kg, Babatunde and Adeola (2022) reported that the magnitude of phytase benefits on growth performance, P digestibility, and P excretion changed measurably across the grow-finish period, generally becoming more pronounced as pigs aged and consumed more feed. This finding suggests that the practical benefit of phytase, in both nutritional and environmental terms, accumulates disproportionately during the later stages of production and supports the case for maintaining phytase inclusion through market weight rather than limiting its use to the nursery or early grower phases.

Quantitative Reductions in Swine Manure Phosphorus

The environmental benefit of phytase is documented across all swine production phases. In a comprehensive review of dietary additives to reduce P excretion, phytase supplementation was reported to lower manure P by approximately 21–51 percent in growing-finishing pigs and by approximately 20–25 percent in weaning–growing pigs (National Pork Board, 2004). Controlled metabolism studies demonstrate that swine manure P concentrations decrease with increasing phytase inclusion, in lower P swine rations. Olsen et al. (2021) fed growing barrows corn–soybean meal diets that were either deficient or adequate in P, supplemented with a Citrobacter braakii-derived 6-phytase at 350, 600 or 1,000 phytase units per kilogram. Increasing phytase inclusion improved the apparent and standardized total tract digestibility of P and reduced daily manure P output and total P excretion in both dietary contexts (Olsen et al., 2021). The authors demonstrated that the P released by phytase is greater in P-deficient diets than in P-adequate diets. These findings have direct implications for how commercial diets, which are typically formulated near or at the P requirement, should account for phytase contributions (Olsen et al., 2021).

Whole-period estimates from growth and digestibility trials provide complementary evidence of environmental benefit. Compared with pigs fed a P-adequate diet containing inorganic P, pigs fed a low-P corn–soybean meal diet supplemented with 1,000 FTU/kg phytase had reductions in total P excretion of 49 percent, 41 percent and 42 percent during the growing, finishing and combined grow-finish periods, respectively. Water-soluble phosphorus (WSP) excretion was reduced by 45 percent, 32 percent and 35 percent over the same periods (Babatunde and Adeola, 2022). When benchmarked against pigs fed the P-adequate diet formulated with conventional inorganic P, the phytase supplemented pigs also had substantially lower estimated WSP excretion while requiring slightly more feed and time to reach comparable body weight. The results indicate that replacing inorganic P with phytase in a properly formulated low-P diet can meaningfully reduce P excretion in swine manure (Babatunde and Adeola, 2022).

These findings are consistent with earlier, foundational dose-response research. Harper et al. (1997) showed that phytase supplementation of low-P growing-finishing diets improved growth performance, P digestibility and bone ash while reducing P excretion, establishing that the P-sparing effect of phytase is robust across a range of production stages. Jones et al. (2010) subsequently developed an available P release curve for *E. coli* derived phytases in nursery pigs, demonstrating that P release increases curvilinearly with phytase dose and that different commercial products can differ meaningfully in their P-release efficiency at a given inclusion rate. This dose-response relationship has since been refined for growing-finishing pigs; Wensley et al. (2020) re-evaluated current phytase release values for calcium, P, amino acids and energy under modern commercial conditions.

Although most of the phytase literature addresses growing and finishing pigs, phytase can also be incorporated into gestation and lactation diets for breeding sows, where its role extends beyond reducing P excretion to improving mineral utilization and reducing diet cost across the reproductive cycle. Sows undergo repeated cycles of skeletal Ca and P mobilization to support fetal growth and milk production, and inadequate dietary P availability across parities can contribute to lameness, reduced longevity and impaired bone mineralization (Espinosa et al., 2024). Sow diets are designed as P-adequate with supplemental inorganic phosphorus to ensure that reproductive performance and skeletal health are maintained, despite limited and variable availability of P bound as phytate. As already noted, phytase is more effective in conjunction with P-deficient diets rather than P-adequate diets. As such, reductions in sow manure P are not as dramatic compared to those achieved from phytase use with growing and finishing pigs. For example, Lee et al. (2022) fed sows on diets with 0 or 1,000 FTU/kg and reported that the phytase diet reduced manure P output by 16 percent, while increasing urinary P output. Consequently, combined fecal-plus-urinary sow P excretion decreased only 6 percent. Incorporating phytase into sow diets can improve mineral digestibility, reduce P excretion, and support skeletal integrity relevant to sow longevity (Espinosa et al., 2024; Lee et al., 2022; Velayudhan et al., 2020).

Table 1 summarizes the documented reductions in phosphorus excretion and improvements in phosphorus digestibility associated with phytase supplementation across the major U.S. swine production phases discussed above.

Pig Type / Phase	Reported P-excretion or digestibility effect	Typical Phytase Dose	Source(s)
Weaning–growing pigs	20–25% reduction in P excretion	500–1,000 FTU/kg	National Pork Board, 2004
Growing–finishing pigs	21–51% reduction in P excretion; estimated reductions across growing, finishing, and entire grow-finish periods: 41–49% in total P excretion and 32–45% in water-soluble P when a low-P, phytase-supplemented diet was compared with a P-adequate diet containing inorganic P	350–1,000 FTU or FTU/kg, as reported	National Pork Board, 2004; Babatunde and Adeola, 2022
Gestating sows	Late gestation: fecal P output reduced 16.2% (8.56 to 7.17 g/day); combined fecal-plus-urinary P excretion reduced approximately 6.0% (9.40 to 8.84 g/day	500 FTU/kg; 1,000–2,000 FTU/kg; or 1,000 microbial phytase units/kg	Lee et al., 2022; Espinosa et al., 2024; Velayudhan et al., 2020
Lactating sows	Improved apparent total-tract P digestibility. Direct manure-P reductions may have occurred but were not reported in these studies.	500 FTU/kg or 1,000–2,000 FTU/kg	Espinosa et al., 2024; Velayudhan et al., 2020

Note: FTU denotes phytase activity units reported by the respective studies or manufacturers; numerical units from different products or assay systems are not necessarily directly equivalent. The late-gestation percentage values are calculations from the main-effect means reported by Lee et al. (2022). The approximately 6 percent value combines fecal and urinary P excretion; the larger 16.2 percent value applies to fecal P alone. A direct whole-manure P-reduction percentage has not been reported for lactating sows.

Published research and Extension literature confirms that phytase use reliably reduces swine P excretion in manure (Jacela et al., 2010; Kansas State University, 2026; National Pork Board, 2004; Babatunde and Adeola, 2022). In addition, the literature confirms that phytase is effective across all stages of production, with the highest manure P reductions being realized in grow-finish pigs, followed by wean-grow pigs, and with the lowest manure P reductions reported in sows.

Adoption of Phytase Among U.S. Swine Producers

An exact quantification of the percentage of U.S. swine producers that include phytase in their rations is difficult because no nationally representative survey publishes a producer phytase-adoption percentage. For example, the 2021 USDA National Animal Health Monitoring System surveyed 2,700 large-enterprise swine operations in 13 states, which represented 96 percent of U.S. swine operations with 1,000 or more pigs. The published objectives emphasized housing, biosecurity, pathogen prevalence and antimicrobial stewardship, but did not include feed-enzyme inclusion (U.S. Department of Agriculture, 2024).

In the absence of discrete survey statistics, the strongest available evidence comes from applied swine nutritionists and researchers who characterize the practice directly. Olsen et al. (2021) state that phytase "is now nearly universally employed in swine diets whenever additional available P is required," reflecting the enzyme's status as a standard rather than optional ingredient in modern commercial formulations. This near universal use is corroborated by the observation that phytase is "the only exogenous enzyme that has been consistently shown to be highly beneficial to pigs," a proven efficacy that has driven its worldwide acceptance (Jacela et al., 2010). Land-grant university Extension programs also consider phytase as a default tool of least-cost, environmentally conscious formulation and maintain dedicated calculators for its inclusion, further signaling routine industry use (Kansas State University, 2026).

Taken together, these sources indicate that phytase use is ubiquitous in U.S. commercial swine production, but they do not provide a precise national adoption percentage. The economic incentive of displacing costly inorganic P, together with nutritional benefits and reductions in swine P excretion, has made phytase an integral component of modern commercial diets (National Pork Board, 2004; Olsen et al., 2021).

Conclusion

Phytase supplementation addresses the limited capacity of pigs to digest phytate P, and its use delivers both economic and environmental benefits. By enhancing P digestibility and reducing the addition of inorganic P, phytase can reduce P excretion by approximately 21–51 percent in growing–finishing pigs and 20–25 percent in weaning–growing pigs, depending on diet formulation and production phase (National Pork Board, 2004). Whole-period estimates from growth and digestibility trials found 41–49 percent reductions in total P excretion and 32–45 percent reductions in water-soluble P excretion when a low-P diet supplemented with phytase replaced a phosphorus-adequate diet containing inorganic P (Babatunde and Adeola, 2022). Metabolism research further demonstrates that measured phytase P release depends on dietary P status, an important consideration for precise commercial formulation (Olsen et al., 2021). In late-gestating sows, phytase reduced combined fecal-plus-urinary P excretion by approximately 6.0 percent under diets in which inorganic P was not removed as a phytase matrix credit (Lee et al., 2022).

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