Title: Targeted use of mega-doses of phytase in late finishing pigs to improve overall growth performance and profits – **NPB #18-086**

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Industry Summary

This project specifically evaluated the impact of ultra-high doses of phytase on production parameters of late finishing pigs and further evaluated whether the response to phytase was dependent on amino acid concentrations in the diet. Past research efforts have demonstrated positive effects of phytase supplementation at approximately 1,500 to 3,000 FTU/kg, but higher inclusion levels have not been adequately tested in commercial production environments. The cost of phytase has decreased substantially; therefore, inclusion of ultra-high levels of phytase (beyond those required for P release) becomes economically feasible. In the first experiment with 1,762 pigs (starting body weight of 84.3 kg), we demonstrated that mega-dosing of phytase at 4,500 and 6,750 FTU/kg decreased feed intake without improving feed efficiency compared to the control diet which contained a standard super-dosing concentration of phytase of 2,250 FTU/kg of feed. The floor space in the present study was 7.1 ft^2/pig and the pig density was 36.9 lbs/ft^2 prior to the first marketing (at day 35 of the study), which was expected to provide significant stress and erode feed efficiency. However, ultra-dosing of phytase did not impact feed efficiency, but could save a moderate amount of feed due to reduced feed intake. In the second experiment with 594 pigs (mean initial body weight of 29.5 kg) we evaluated the impact of phytase in pigs fed adequate levels of amino acids and pigs fed diets with reduced levels of amino acids (reduced by 15%). Pigs fed diets with reduced amino acid concentrations had lower daily gain only during the first grower stager. Reduced amino acid supply increased feed intake and feed:gain ratio. Supplementation of phytase at 3,000 and 6,000 FTU/kg of feed slightly decreased feed intake, although not significantly, and improved feed efficiency during the first grower stage only. For the overall period until market, phytase supplementation in control pigs had no effect on feed efficiency, but improved feed efficiency in pigs fed 6,000 FTU/kg of phytase in the reduced amino acid diet. Results indicate that mega-dosing phytase had relatively small effects on growth performance, largely unrelated to dietary amino acid concentration, but slightly reduced feed intake which could save feed costs

Key Findings:

- Supplementation of phytase appeared to slightly reduce feed intake without impacting daily gain, which could save on feed cost.
- If ultra-high levels of phytase liberate energy from dietary ingredients, then a decrease in feed intake would be expected, based on the premise that pigs eat to meet a constant energy need.
- Supplementation of phytase at ultra-dosing levels was expected to have a greater impact on growth performance than when supplemented to diets with control levels of amino acids, which tended to be the case for overall feed efficiency.

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Scientific Abstract
This project was designed to determine the impact of ultra-dosing phytase, especially during the late finishing period, on growth performance of pigs and to determine if the impact of phytase was dependent on the amino acid concentration of the diet. In Exp. 1, 1,762 pigs (initial BW was 84.3 kg) were randomly allotted to 3 dietary treatments within sex and initial BW blocks (77 pens; 22 to 23 pigs/pen). Treatments included: 1) control (2,250 FTU/kg of phytase); 2) diet with 4,500 FTU/kg of phytase; and 3) diet with 6,750 FTU/kg of phytase. In Exp. 2, 594 pigs (initial BW was 29.5 kg) were blocked by sex and BW and randomly allocated to pen and treatments within blocks (60 pens; 9 to 10 pigs/pen). Treatments were arranged in a 2 x 3 factorial randomized complete block design. Factors included: 1) amino acid concentration (AA; 85% or 100% of standardized ileal digestible (SID) lysine and 2) phytase supplementation (500, 3,000, or 6,000 FTU/kg). Pigs were fed a 4-phase diet program (1.05, 0.89, 0.76, and 0.68% and 0.89, 0.76, 0.65, and 0.58% standardized ileal digestible lysine for phase 1 to 4 for the control and reduced amino acid diets, respectively. In Exp. 1, ultra-dosing phytase decreased ($P \leq 0.05$) ADFI and ADG during the first 2 wk period. Phytase at 4,500 and 6,750 FTU/kg decreased feed intake ($P < 0.01$) for the 35 d period and for the marketing period when supplemented at 4,500 FTU/kg ($P = 0.027$), but not 6,750 FTU/kg ($P = 0.167$). In Exp. 2, reduced amino acid concentrations lowered ($P = 0.037$) ADG and BW during the initial 23 d period and increased ADFI during d 23 to 44 ($P = 0.008$), d 0 to 84 ($P = 0.030$) and d 0 to market ($P = 0.025$). Feed:gain increased with reduced amino acid supply for d 0 to 23 ($P = 0.042$), d 23 to 44 ($P = 0.048$), and d 0 to 84 ($P = 0.045$), but not for d 0 to market ($P = 0.104$). Phytase decreased ($P = 0.015$) feed intake for d 44 to 65 and improved feed efficiency ($P = 0.04$) during the initial phase. For the overall period until market, ultra-dosing phytase to control pigs had no effect on feed efficiency, but 6,000 FTU/kg of phytase improved feed efficiency in pigs fed the reduced amino acid diet (interaction, $P = 0.10$). Back fat depth, loin eye area, and percent lean were not impacted by amino acid supply, phytase, or their interaction. Results indicate that mega-dosing phytase had relatively small effects on growth performance, largely unrelated to dietary amino acid concentration, but slightly reduced feed intake which can save feed costs.

Introduction

Approximately 60-75% of the P in plant-based feedstuffs commonly used in swine diets is found in the form of phytic acid (inositol hexakisphosphate (IP6); Kornegay, 2001; NRC, 2012). The P associated with phytate is poorly used by pigs because the lack of significant endogenous phytase activity and low microbial populations in the upper part of the digestive tract (Woyengo and Nyachoti, 2013). Phytic acid is unstable in the free acid form and occurs predominately as a complex with cations such as Ca, Fe, Zn, Mg, Mn, Cu and K (Humer et al., 2015). Phytate is considered an anti-nutritional factor because it is a poly-anionic molecule, with chelating capacity. Phytate can form complexes with minerals, proteins, starch and lipids, making these nutrients less available to the animal (Selle et al., 2000). Phytate can form complexes with amino acids (mainly basic amino acids, such as Arg, His and Lys) at low and high pH conditions, which may results in a reduction of protein solubility, enzyme activity and amino acid digestibility. Similarly, phytate can form complexes with starch and inhibit α-amylase activity, decreasing starch digestibility and the absorption of glucose. Phytate can also associate with lipids to form "lipophytins". Lipid and Ca-phytate may participate in the formation of metallic soaps, limiting the energy utilization from lipid sources (Kumar et al., 2010; Humer et al., 2015). The enzyme phytase (myo-inositol hexaphosphate phosphohydrolase) can dephosphorylate phytate into a series of lower inositol phosphate esters, thereby reducing its potent antinutritional effects and increasing P availability to the pig (Selle et al., 2000).

Numerous reviews and studies have validated the positive effects of using exogenous phytase in monogastric animals (Simons et al., 1990; Cromwell et al., 1993; Radcliffe et al., 1998; Selle et al., 2000; Sands et al., 2001; Omogbenigun et al., 2003; Selle and Ravindran, 2007, 2008; Chu et al., 2009; Adeola and Cowieson, 2011; Woyengo and Nyachoti, 2013). Supplementation of phytase to swine diets has traditionally been focused on improving the utilization of phytate-P, thus increasing P availability and reducing P excretion in manure. However, in some cases, supplementation of phytase in P adequate diets has been demonstrated to improve performance of pigs and chickens, suggesting that improvements in growth performance are not completely explained by enhanced P availability (Selle and Ravindran, 2008). These extra-phosphoric effects of phytase may be related to improvement in Ca, Zn, Fe, Mg and Na utilization, enhanced amino acid and energy utilization, improved activity of gastric enzymes (pepsin, trypsin, and chymotrypsin) and reduced endogenous losses (enzymes or mucin). More recently, there has been interest in supplementing phytase at levels that exceed commercial levels aimed at releasing P (500-1500 FTU/kg) to take advantage of the potential extra-phosphoric effects of phytase (super-dosing). These relatively extreme levels of phytase aim to degrade at least 85% of insoluble anti-nutritional phytate esters and generate myo-inositol, which presumably plays an important role in facilitating transport of fats and fat soluble nutrients (Cowieson et al., 2011). The effect of super-dosing phytase and generation of myo-inositol have been studied primarily in poultry (Cowieson et al., 2013, 2015; Walk et al., 2014) and to a lesser extent in pigs. Several studies in pigs have demonstrated improved growth performance with high levels of phytase in nursery pigs, grower pigs and finisher pigs (Braña et al., 2006; Cowieson et al., 2006; Kies et al., 2006; Walk et al., 2013; Miller et al., 2016). However, others have observed no improvements in performance from super-dosing phytase (Holloway et al., 2016 using nutrient deficient diets; Miller et al., 2016 in grower pigs).

Most studies included super-doses of phytase at 1,500 to 2,500 FTU/kg. However, there is evidence that phytase continues to improve performance, bone characteristics, and Ca and P digestibility at doses up to 10,000 (Augspurger and Baker, 2004), 12,000, (Shirley and Edwards, 2003), 15,000 (Kies et al., 2006) and 20,000 FTU/kg (Zeng et al., 2014). Given the decreasing costs associated with phytase inclusion in practical diets and rising feed ingredient costs, higher levels of supplemental phytase above those typically used in super-dosing studies (2,500 to 3,000 FTU/kg) may be justified.

In our most recent study, funded by the Pork Board, we evaluated supplementation of ultra-high doses of phytase on growth performance of finishing pigs. In that study, a total of 2,150 pigs were supplemented with either 500 (control), 3,000, 4,500, or 6,000 FTU of phytase from 69.3 lbs to market weight. Mega-dosing phytase linearly improved daily gain and feed efficiency when considering the overall growth period until the first marketing cut. The improvement in feed efficiency was most dramatic during the final finishing phase (from 210 to 255 lbs of body weight, which was from day 64 to 84 of the study), improving feed efficiency from 3.76 to 3.41; a 9.3% improvement in feed efficiency. This would result in a feed savings of 8 tons per 1,000 pigs for this period alone.

The final finishing phase represents a period of increased stress related to decreasing floor space per unit of pig body weight, resulting in a relatively profound reduction in pig performance. Results of this previous study suggest that a targeted application of mega-doses of phytase during the final phase of production would provide a more cost-effective opportunity to improve growth performance than continuous administration. We propose that specifically targeting the latter portion of the growth phase of finishing pigs (from approximately 200 lbs of body weight) with the supplementation of mega-doses of phytase will improve growth and feed efficiency of pigs and will be economically attractive compared to supplementation of phytase for the entire growth period. In addition, the impact of phytase when it is supplied "on top" (above and beyond nutrient requirements) of the diet during targeted growth periods needs to be considered to take advantage of potential extra gain that can be accomplished and the economic benefits associated with reduced days to market, reduced feed costs per pig, and increased income per pig space.

Objectives

The goal of this project was to improve growth rate, feed efficiency, and net return on investment through the strategic application of mega-doses (above super-dosing levels that have been used in previous studies) of the enzyme phytase. We hypothesized that supplementation of mega-doses of phytase will result in the near complete destruction of the anti-nutrient phytate, thereby providing a cost effective means to promoting body weight gain and reducing feed cost relative to gain, leading to improved efficiency of pig production. We propose that mega-doses of phytase will be more effective at a lower overall cost when applied strategically during the final feeding phase of the finishing period. Specifically, our objectives were to determine:

1) Impacts of mega-dose levels of phytase and timing of supplementation on growth rate, feed efficiency, and economic metrics in pigs housed under the rigors of commercial production.
2) Determine the impact of mega-doses of phytase in diets of pigs fed different levels of amino acids throughout the finishing period on performance and carcass characteristics.

Materials & Methods

Experiment 1. A total of 1,762 pigs (gilts and barrows; initial body weight was 84.3 kg) were randomly allotted to 3 dietary treatments within sex and initial body weight blocks. Treatments were assigned to 77 pens (number of pens per treatment were 25, 26, and 26 for treatments 1 through 3, respectively). Pigs were housed at 22 to 23 pigs per pen (total of 571, 593, 598 pigs for treatment 1 to 3, respectively). Treatments included: 1) a control diet (standard program with phytase supplemented at 2,250 FTU/kg giving credit for available P and Ca; 2) diet with 4,500 FTU/kg of phytase with the same nutrient loadings for available P and Ca as used in the control diet; and 3) diet with 6,750 FTU/kg of phytase with the same nutrient loadings for available P and Ca as used in the control diet. The diet fed prior to implementation of dietary treatments (at the initial body weight of 84.3 kg) contained 2,250 FTU/kg of phytase and nutrient loadings for phytase included modified ME, amino acids, available P, and Ca. During the test phase, pens of pigs were weighed initially (day 0), on day 14 and on day 35 and number of pigs in each pen were determined. Feed additions to pens were recorded daily using an automated feeding system (Howema) and feed remaining in feeders at the time pigs were weighed was determined to calculate feed disappearance. Feed efficiency was calculated by dividing feed disappearance for each pen by total gain of each pen. Pigs were marketed when the barn (there were 2 barns of pigs) weight reached a minimum average pig weight of 122.5 kg. At that point, pigs were marketed in 3 marketing cuts, followed by a barn dump (emptying of the remaining pigs after the 3rd cut). The number of pigs and the weight of the pigs marketed was determined by pen for each marketing cut and barn dump.

Strict protocols were in place for individual pig medication and removal. Deaths and cull pigs were recorded by pen number with a reason and date of removal or death. Removed pigs were placed in designated sick pens, with 1 sick pen for each dietary treatment. Thus, appropriate dietary treatments were continued for pigs in sick pens. Any pigs removed from the test were weighed and the date and reason for removal was recorded. Removed pigs were tracked to determine their final outcome (died in sick pen, light, cull, or full value pig to market).

Data were analyzed as a randomized complete block design using the Mixed procedure of SAS. Pen was considered the experimental unit. The model included block and phytase inclusion level. An alpha level of 0.05 was used to assess significant differences between means.

Experiment 2. A total of 594 pigs (mean initial body weight of 29.5±0.17 kg) were blocked by sex and body weight and then randomly allocated to pen and experimental treatment within block. Pigs were assigned to one of six treatments arranged in a 2 x 3 factorial randomized complete block design. Factors included: 1) amino acid concentration (AA; 85% or 100% of standardized ileal digestible (SID) lysine and other amino acids according to NRC (2012) and 2) phytase supplementation (500, 3,000, or 6,000 FTU/kg). Pigs were housed 9 to 10 pigs per pen using a total of 60 pens. Therefore, each treatment was represented by 10 replicate pens. Pigs were fed a 4 phase diet program during the finisher phase, with diets containing 1.05, 0.89, 0.76, and 0.68% standardized ileal digestible (SID) lysine for the control diet and 0.89, 0.76, 0.65, and 0.58% for the reduced lysine diets for diet Phase 1 to 4, respectively. Other essential amino acids were provided based on their ideal ratio relative to SID lysine as suggested by NRC (2012). Available P concentrations of diets were 0.30, 0.28, 0.26, and 0.25%, for Phase 1 to 4 respectively with Ca set at 2.2 times the available P requirement. Phytase was given a credit of 0.12% for Ca and 0.10% for P for all inclusion levels of phytase. Diets were manufactured at the North Carolina State University Feed Mill Educational Unit and were provided in meal form. Diets with 500 FTU/kg phytase were mixed first (Control diet and then the Reduced AA diet), followed by the diets with 3,000 FTU/kg of phytase (Control and Reduced), and the 6,000 FTU/kg of phytase (Control and Reduced).

Pigs were weighed initially and on days 23, 44, 65, and 84 (end of Phase 1, 2, 3, and 4, respectively). At the end of the study, body weights were determined at a fixed time end point (84 days) and they were measured again when a replicate of pigs (6 pens) reached a target market weight of 118 kg (84, 92, and 98 days for the first, second, and third marketing group, respectively). Body weights at the initiation and the end of the study were determined on an individual pig basis, while intermediate weights were determined on a pen basis. Feed intake was measured at each phase change and for each marketing group. Average daily gain, average daily feed intake, and feed efficiency were calculated. Morbidity and mortality were recorded. Treatment with therapeutic antibiotics (injectable only), the number of pigs culled and mortality were recorded. Ultrasound measurements to determine backfat, loin eye area, percent lean and lean gain were taken at the end of the study for all pigs at the fixed time end point and at the targeted market body weight of 118 kg.

All data were analyzed using the mixed models procedure of SAS (SAS Institute, Cary, NC) as a randomized complete block design with factorial arrangement of treatments. The model included main effects of block (replicate), dietary amino acid concentration (control or reduced) and phytase supplementation (500, 3,000, or 6,000 FTU/kg) and the interaction between amino acid concentration and phytase supplementation. Differences between treatments were evaluated, where appropriate, using the LSD procedure. Orthogonal contrasts were used to determine linear and quadratic effects of phytase supplementation on performance measurements and carcass measurements.

Results

Experiment 1. The addition of ultra-high doses of phytase to diets of late finishing pigs decreased ($P \leq 0.05$) ADFI and ADG, but did not impact feed efficiency, during the first 2 weeks of the study (Table 1). During the 35 day pre-market period, supplemental phytase at 4,500 and 6,750 FTU/kg decreased feed intake ($P < 0.01$) without improving feed efficiency (**Table 1**). Close-out data (50.5 days on test) indicate that phytase decreased feed intake when supplemented at 4,500 FTU/kg ($P = 0.027$), but this was not significant when supplemented at 6,750 FTU/kg ($P = 0.167$). No differences were observed for ADG or feed efficiency. The floor space in the present study was 7.1 ft^2/pig and the pig density was 36.9 lbs/ft^2 prior to the first marketing (at day 35 of the study). This pig density was expected to provide significant stress and has been shown to erode feed efficiency. Ultra-dosing of phytase did not have an effect on feed efficiency (in contrast to our previous study), but could save a moderate amount of feed due to reduced ADFI (without impacting growth rate).

Experiment 2. Pigs fed diets with reduced amino acid concentrations had lower ADG during the initial 23 day period, resulting in a lower body weight on day 23 of the study ($P = 0.037$; Table 2). No other effects of reduced amino acid supply on ADG or body weight were observed. Reduced amino acid supply increased ADFI during day 23 to 44 ($P = 0.008$), day 0 to 84 ($P = 0.030$) and from day 0 to marketing ($P = 0.025$). Feed:gain was increased, indicating lower efficiency, in pigs fed diets with reduced amino acid supply during day 0 to 23 ($P = 0.042$), day 23 to 44 ($P = 0.048$), and day 0 to 84 ($P = 0.045$), but not when considering day 0 to marketing ($P = 0.104$).

Supplementation of phytase decreased ($P = 0.015$) feed intake during day 44 to 65 only and feed intake was not significantly affected by phytase during the overall period ($P = 0.146$ for the time end point and $P = 0.177$ for the marketing end point). Phytase supplementation improved feed efficiency ($P = 0.04$) during the initial phase only.

Interactions were observed between amino acid supply and phytase supplementation for BW and ADG from day 0 to 84 ($P = 0.034$) and day 0 to market ($P = 0.014$). This interaction was driven by the 3,000 FTU/kg phytase supplementation level, which had the highest ADG when the control diet was fed, but the lowest ADG when the reduced amino acid diet was fed. In addition, during day 23 to 44, ADG increased with increasing phytase supplementation in pigs fed control diets, but decreased in pigs fed reduced amino acid diets (interaction, $P = 0.008$). Feed efficiency during day 44 to 65 worsened with increasing phytase supplementation when pigs were fed control diets, but improved in pigs fed reduced amino acid diets (interaction, $P = 0.011$). A tendency for an interaction ($P = 0.101$) for overall feed efficiency to market was observed, indicating no effects of phytase supplementation in control pigs, but improved feed efficiency in pigs fed 6,000 FTU/kg of phytase in the reduced amino acid diet.

Carcass measurements, including back fat depth, loin eye area, percent lean, and average daily lean gain were not significantly impacted by amino acid supply, phytase supplementation, or their interaction, with the exception of lean gain (Table 3). Daily lean gain was impacted similarly as overall

ADG in that 3,000 FTU/kg of phytase increased lean gain in pigs fed control amino acid diets, whereas it decreased lean gain in pigs fed reduced amino acid levels.

Discussion

This project was designed to determine the impact of ultra-dosing phytase, especially during the late finishing period, on growth performance of pigs. In addition, we aimed to determine if the impact of phytase was dependent on the composition of the diet, specifically amino acid composition. Phytic acid can bind amino acids, making them unavailable to the host; therefore, supplementing phytase at high doses may liberate bound amino acids, providing an opportunity to assign an amino acid value to phytase, ultimately reducing diet costs. The cost of phytase has decreased substantially; therefore, inclusion of high levels of phytase (beyond those required for P release) becomes economically feasible.

In the first experiment, ultra-dosing of phytase did not impact final body weight at market, ADG, or feed efficiency, but feed intake was slightly reduced by 3.4 and 2.1% for the 4,500 and 6,750 FTU/kg of phytase, respectively, compared to the control level of 2,250 FTU/kg phytase. The control level of phytase (2,250 FTU/kg) used in the present study was the level commonly included in diets for finishing pigs in this pork production system. Thus, we specifically evaluated supplementation at ultra-high doses of phytase and we focused on the late finisher period based on the results of our past research study. In that study with 2,150 pigs, funded by the Pork Board, we demonstrated that mega-dosing of phytase (3,000, 4,500, or 6,000 FTU/kg) linearly improved daily gain and feed efficiency and that this improvement was most dramatic during the final finishing phase (210 to 255 lbs of body weight, improving feed efficiency from 3.76 to 3.41 (9.3% improvement). The results of the present study are much less profound. We were not able to demonstrate significant improvements in feed efficiency in late finishing pigs, although the small reduction in feed intake may provide an opportunity to save on feed costs.

In the second experiment, we determined whether phytase could liberate amino acids, such that the amino acid concentration in the diet could be reduced when ultra-high levels of phytase were included. The expected negative impact of reducing dietary amino acid concentrations was only observed during the first feeding phase, but not in subsequent phases. Feed intake of pigs in this study was very high, which may have provided sufficient intake of amino acids, even when fed the low amino acid diets, to allow them to grow at their maximum capacity. In addition, feed intake was increased in pigs fed the low amino acid diets, although this increase was less (2.3% for the overall period until market) compared to the difference in amino acid supply between the experimental diets (15% different based on calculated SID lysine in the diets; 10% based on analyzed lysine concentrations). Considering the high feed intake and the modest increase in feed intake in pigs fed the low amino acid diets, an interaction between amino acid supplementation level and phytase may not be expected. Nonetheless, feed efficiency in pigs fed low amino acid levels tended to be improved with phytase supplementation at 6,000 FTU/kg, which resulted in a feed efficiency similar to pigs fed control amino acid diets.

Overall, data from these studies indicate that mega-dosing phytase had relatively small effects on growth performance of pigs. Ultra-dosing phytase appeared to reduce feed intake slightly, which could save on feed cost. If ultra-high levels of phytase liberate energy from dietary ingredients, then a decrease in feed intake would be expected, based on the premise that pigs eat to meet a constant energy need. Similarly, we expected supplementation of phytase to diets with reduced levels of amino acids to have a greater impact on growth performance than when supplemented to diets with control levels of amino acids, which tended to be the case for overall feed efficiency.

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Table 1. Impact of mega-doses of phytase on performance of late-finishing pigs.

	Phytase, FTU/kg				P-value			
	2,250	**4,500**	**6,750**	**SEM**	**Main Trt**	**1 v 2**	**1 v 3**	**2 v 3**
Pens of pigs	25	26	26					
Pigs Placed	571	593	598					
Body weight, kg								
Day 0	84.0	84.5	84.4	1.3	0.952	0.775	0.793	0.981
Day 14	100.4	99.2	99.5	1.2	0.759	0.484	0.573	0.886
Day 35	119.0	118.3	118.8	1.2	0.914	0.677	0.881	0.788
Market	130.7	131.2	130.9	1.0	0.947	0.746	0.914	0.827
Average daily gain								
Day 0 to 14	1.15	1.06	1.08	0.03	0.061	0.031	0.054	0.796
Day 14 to 35	0.92	0.93	0.95	0.02	0.649	0.767	0.365	0.537
Day 0 to 35	1.01	0.99	1.00	0.02	0.673	0.384	0.766	0.568
Day 0 to Market	0.91	0.89	0.91	0.02	0.798	0.672	0.818	0.508
Average daily feed intake								
Day 0 to 14	3.73	3.44	3.31	0.07	<0.001	0.007	<0.001	0.189
Day 14 to 35	3.47	3.38	3.52	0.05	0.116	0.188	0.468	0.041
Day 0 to 35	3.58	3.41	3.43	0.04	0.006	0.004	0.008	0.780
Day 0 to Market	3.26	3.15	3.19	0.04	0.083	0.027	0.167	0.367
Feed:Gain								
Day 0 to 14	3.34	3.31	3.19	0.10	0.564	0.855	0.318	0.414
Day 14 to 35	3.85	3.69	3.77	0.10	0.537	0.268	0.608	0.545
Day 0 to 35	3.56	3.47	3.44	0.06	0.342	0.301	0.157	0.689
Day 0 to Market	3.63	3.57	3.53	0.08	0.703	0.619	0.405	0.745
Days to Market	50.5	50.3	50.6	0.3	0.836	0.739	0.798	0.552
Space/pig prior to 1st cut, ft^2	7.11	7.14	7.01	0.08	0.524	0.810	0.405	0.280
Dead or removed, %	1.40	1.68	0.88	0.50	0.507	0.695	0.457	0.252

Table 2. Impact of amino acid supply and mega-doses of phytase on performance of finishing pigs[1]

	Control			Reduced				P values		
	500	**3000**	**6000**	**500**	**3000**	**6000**	**SEM**	**AA**	**Phytase**	**AA*Phytase**
Body Weight, kg										
Day 0[2]	29.8	29.3	29.5	29.3	29.6	29.8	0.17	0.591	0.397	0.020
Day 23	52.8	52.8	52.8	52.2	51.8	53.0	0.28	0.037	0.105	0.127
Day 44	74.8	75.6	76.0	75.5	74.8	75.5	0.44	0.519	0.281	0.210
Day 65	100.4	101.0	100.5	101.0	99.7	101.2	0.71	0.974	0.772	0.278
Day 84	122.7	123.7	122.4	124.3	121.8	124.1	0.73	0.438	0.542	0.034
Market	128.6	129.8	127.8	130.6	128.0	130.5	0.78	0.143	0.679	0.014
ADG, kg/d										
Day 0 to 23	1.01	1.01	1.01	0.98	0.97	1.02	0.01	0.037	0.105	0.127
Day 23 to 44	1.05	1.09	1.11	1.11	1.09	1.07	0.01	0.296	0.699	0.008
Day 44 to 65	1.22	1.21	1.17	1.22	1.19	1.22	0.02	0.557	0.476	0.146
Day 65 to 84	1.18	1.19	1.15	1.22	1.17	1.20	0.03	0.255	0.616	0.294
Day 0 to 84	1.11	1.12	1.11	1.13	1.10	1.12	0.01	0.438	0.542	0.034
Day 0 to market	1.10	1.12	1.09	1.12	1.10	1.12	0.01	0.143	0.708	0.014
ADFI, kg/d										
Day 0 to 23	2.22	2.18	2.20	2.20	2.15	2.21	0.03	0.501	0.198	0.810
Day 23 to 44	2.75	2.77	2.82	2.93	2.88	2.80	0.04	0.008	0.753	0.066
Day 44 to 65	3.46	3.52	3.38	3.74	3.52	3.39	0.07	0.093	0.015	0.128
Day 65 to 84	3.90	3.86	3.82	3.93	3.92	3.98	0.06	0.084	0.932	0.593
Day 0 to 84	3.04	3.04	3.02	3.16	3.07	3.06	0.04	0.030	0.146	0.429
Day 0 to market	3.10	3.09	3.07	3.22	3.13	3.12	0.04	0.025	0.177	0.561
Feed:Gain										
Day 0 to 23	2.20	2.15	2.17	2.23	2.22	2.16	0.02	0.042	0.040	0.120
Day 23 to 44	2.62	2.55	2.55	2.64	2.64	2.61	0.03	0.048	0.297	0.510
Day 44 to 65	2.83	2.91	2.90	3.08	2.97	2.77	0.06	0.232	0.085	0.011
Day 65 to 84	3.33	3.25	3.32	3.23	3.37	3.31	0.07	0.888	0.834	0.295
Day 0 to 84	2.74	2.71	2.73	2.81	2.79	2.72	0.03	0.045	0.157	0.211
Day 0 to market	2.81	2.77	2.81	2.86	2.85	2.78	0.03	0.104	0.207	0.101

[1]Each value represents the mean of 10 pens with 9 to 10 pigs per pen
[2]Initial body weight was used as a covariate

Table 3. Impact of amino acid supply and mega-doses of phytase on carcass characteristics of finishing pigs[1]

	Control			Reduced				P values		
	500	**3000**	**6000**	**500**	**3000**	**6000**	**SEM**	**AA**	**Phytase**	**AA*Phytase**
Back fat depth, cm	1.98	2.00	2.05	2.00	2.12	2.10	0.05	0.104	0.160	0.566
Loin eye area, cm^2	52.44	52.56	51.68	53.10	51.36	52.53	0.50	0.798	0.219	0.080
Carcass lean, %	54.54	54.50	54.16	54.59	53.82	54.03	0.25	0.215	0.127	0.337
Lean gain, g/d	482	486	474	491	472	484	4	0.596	0.064	0.002

[1]Based on measurements involving a total of 567 pigs