Lowering the Dietary Calcium to Total Phosphorus Ratio Increases Phosphorus Utilization in Low-Phosphorus Corn-Soybean Meal Diets Supplemented with Microbial Phytase for Growing-Finishing Pigs

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ABSTRACT: Crossbred growing-finishing pigs \( n = 120 \) were used to investigate the effect of three dietary Ca:total P (tP) ratios (1.5:1, 1.3:1, or 1.0:1) on P utilization in low-P corn-soybean meal diets supplemented with microbial phytase at 500 phytase units/kg. The basal grower (23 to 54 kg BW) diet contained .39% tP including .07% added inorganic P (iP), and the basal finisher (54 to 123 kg BW) diet contained .32% tP without added iP. An adequate-P positive control diet without phytase supplementation contained .60% Ca and .50% tP during the growing phase and .50% Ca and .40% tP during the finishing phase. Lowering the Ca:tP ratio linearly increased ADG during the growing phase \( (P < .03) \) and overall \( (P < .08) \), gain:feed ratio during the growing phase \( (P < .001) \), and P absorption during the finishing phase \( (P < .04) \). Lowering the Ca:tP ratio linearly increased BW at slaughter \( (P < .02) \), carcass weight \( (P < .04) \), bone breaking strength \( (P < .04) \), and bone ash weight \( (P < .06) \), whereas dressing percentage and backfat depth remained unchanged. In conclusion, pig performance and P utilization were increased by lowering the Ca:tP ratio from 1.5:1 to 1.0:1 in low-P corn-soybean meal diets supplemented with microbial phytase.

Key Words: Calcium, Phosphorus, Phytase, Pigs

Introduction

High dietary Ca concentrations have a negative effect on the utilization of P because of the formation of an insoluble Ca-phytate complex (Nahapatian and Young, 1980; Wise, 1983). In many swine experiments when low-P diets were supplemented with microbial phytase, the Ca levels were kept at or slightly below the NRC (1988) requirements, resulting in wide Ca:total P (tP) ratios (Cromwell et al., 1993, 1995a; Lei et al., 1993).

Lowering the Ca:tP ratio in low-P diets supplemented with microbial phytase increased P utilization in weanling pigs (Lei et al., 1994; Qian et al., 1996). However, decreasing the Ca:tP ratio in low-P diets supplemented with microbial phytase did not affect P utilization in growing-finishing pigs (Cromwell et al., 1995b). Therefore, the effect of Ca:tP ratio on the utilization of P in pigs fed low-P diets supplemented with microbial phytase has been inconsistent.

The purpose of this study was to evaluate the effect of lowering the dietary Ca:tP ratio on the utilization of P in growing-finishing pigs fed low-P corn-soybean meal diets supplemented with microbial phytase. Criteria were growth performance, apparent absorption of P and Ca, carcass traits, bone breaking strength, and bone ash weight.

Materials and Methods

Dietary Treatments. A basal corn-soybean meal grower phase (23 to 54 kg BW) diet was formulated to contain 14.5% CP and .39% tP including .07% inorganic P (iP) added from mono-dicalcium phosphate. The basal finisher phase (54 to 123 kg BW) diet contained 12.4% CP and .32% tP without added iP. The basal diets were supplemented with microbial phytase (Natuphos 5000®, BASF, Mount Olive, NJ) at 500 phytase units \( (PU) / kg \) of diet and met or exceeded all nutrient requirements (NRC, 1988) except for Ca and(or) P. One PU is defined as the amount of enzyme that liberates 1 \( \mu \)mol of iP per minute from 5.1 mM sodium phytate at 37°C and pH 5.5 (Engelen et al., 1994).
### Table 1. Ingredient composition (%) of air-dry diets

<table>
<thead>
<tr>
<th>Item</th>
<th>Grower diets&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Finisher diets&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1:5:1</td>
<td>1:3:1</td>
</tr>
<tr>
<td>Ground corn</td>
<td>78.31</td>
<td>78.86</td>
</tr>
<tr>
<td>Soybean meal (49% CP)</td>
<td>16.98</td>
<td>16.89</td>
</tr>
<tr>
<td>Lard</td>
<td>2.33</td>
<td>2.12</td>
</tr>
<tr>
<td>Mono-dicalcium phosphate&lt;sup&gt;c&lt;/sup&gt;</td>
<td>.32</td>
<td>.32</td>
</tr>
<tr>
<td>Ground limestone</td>
<td>1.11</td>
<td>.86</td>
</tr>
<tr>
<td>White salt</td>
<td>.40</td>
<td>.40</td>
</tr>
<tr>
<td>L-Lysine·HCl</td>
<td>.10</td>
<td>.10</td>
</tr>
<tr>
<td>Vitamin premix&lt;sup&gt;d&lt;/sup&gt;</td>
<td>.20</td>
<td>.20</td>
</tr>
<tr>
<td>Trace mineral premix&lt;sup&gt;e&lt;/sup&gt;</td>
<td>.15</td>
<td>.15</td>
</tr>
<tr>
<td>Medication&lt;sup&gt;f&lt;/sup&gt;</td>
<td>.10</td>
<td>.10</td>
</tr>
<tr>
<td>Dietary composition&lt;sup&gt;g&lt;/sup&gt;</td>
<td>.07</td>
<td>.07</td>
</tr>
<tr>
<td>Ca</td>
<td>.60 (.63)</td>
<td>.50 (.52)</td>
</tr>
<tr>
<td>Total P</td>
<td>.39 (.39)</td>
<td>.39 (.39)</td>
</tr>
<tr>
<td>Added inorganic P</td>
<td>.07</td>
<td>.07</td>
</tr>
</tbody>
</table>

<sup>a</sup>Diets 1 to 3 were supplemented with 500 PU/kg of Aspergillus niger phytase (Natuphos<sup>®</sup>) supplied by BASF, Mount Olive, NJ. Duplicate analyses of the subsamples of the diets after mixing confirmed the phytase activity to be within 5% of the calculated value. The grower and finisher diets contained 14.5 and 12.4% CP, respectively.

<sup>b</sup>Adequate-P positive control (PC) diet.

<sup>c</sup>Contains 22.0% Ca and 18.5% P.

<sup>d</sup>Vitamin premix provided per kilogram of grower and finisher diets, respectively: 4,000 and 3,000 IU of vitamin A acetate; 400 and 300 IU of vitamin D3; 8.0 and 6.0 IU of vitamin E as dl-α-tocopheryl acetate; 1.5 and 1.1 mg of vitamin K as menadione sodium dimethylpyrimidinol bisulfite complex; 11.0 and 8.3 mg of vitamin B12; 3.0 and 2.3 mg of riboflavin; 10.2 and 7.7 mg of pantothenic acid as d-calcium pantothenate; and 12.0 and 9.0 mg of niacin.

<sup>e</sup>Trace mineral premix provided per kilogram of grower and finisher diets, respectively: 165 and 110 mg of Zn as ZnSO4; 165 and 110 mg of Fe as FeSO4; 33 and 22 mg of Mn as MnSO4; 16.5 and 11 mg of Cu as CuSO4; .3 and .1 mg of I as Ca(IO3)2; and .3 and .2 mg of Se as Na2SeO3.

<sup>f</sup>Aureomycin, 110 g/kg.

<sup>g</sup>Analyzed values in parentheses are based on quadruplicate analyses.

Three dietary Ca:tP ratio treatments were made by adjusting the percentage of ground limestone added to the basal grower and finisher diets. The treatments contained .60, .50, and .40% Ca during the growing phase and .50, .41 and .32% during the finishing phase, respectively. An adequate-P positive control (PC) diet contained .60% Ca and .50% tP during the growing phase and .50% Ca and .40% tP during the finishing phase. All the diets were fed in meal form. Samples of each grower and finisher diet were ground through a 1.0-mm screen. Quadruplicate samples were digested with a wet-ash procedure (AOAC, 1990) before analysis for the concentrations of P by the colorimetric molybdovanadate method (Anthos Reader 2001, Anthos Labtec Instruments, Salzburg, Austria) and for concentrations of Ca and Cr by atomic absorption spectrophotometry (SpectrAA-30, Varian Analytical Instruments, San Fernando, CA). The percentage of DM was also determined. The analytical values were close to the calculated values (Table 1). Thus, Ca:tP ratios for the three low-P treatments were 1.5, 1.3, and 1.0:1, respectively, and 1.2:1 for the PC treatment (Table 1).

Animals. Crossbred pigs (n = 56 barrows and 64 gilts) with an average initial BW and age of 23.0 kg and 60 d, respectively, were allotted to four dietary treatments by litter, weight, and sex. There were 10 replications per treatment. Pigs were housed three per pen (1.6 × 1.9 m) in an enclosed building with concrete slats. Temperature was maintained between 18 and 21°C with thermostatically controlled exhaust fans and heaters. Each pen had a nipple waterer and a self-feeder. This study was approved by the University of Missouri Animal Care and Use Committee.

Pigs were given ad libitum access to water and feed. Pigs were weighed and feed intake was determined every 2 wk. Replicate pens were changed from the grower phase to the finisher phase when the average BW per pen equaled or exceeded 50 kg with an average BW of 54 kg at the end of the growing phase. The finisher phase was terminated when the average BW per pen was 123 kg.

Sample Collection and Measurements. At an average BW of 70 kg, chromic oxide was added to the diets at .05% as an indigestible indicator to determine apparent digestibilities of Ca, P, and DM. Chromic oxide and ground corn were premixed at a ratio of 1:16 (wt: wt) before mixing the diets. After a 6-d adjustment to the chromic oxide diets, approximately equal amounts of fecal samples (about 50 g) were collected from individual pens once a day for five consecutive days. The daily collections were pooled and frozen at −20°C in plastic bags until analyzed. Frozen fecal samples were thawed and dried at 55°C for 48 h. The dried
Table 2. Effect of dietary Ca:total P ratio on growth performance of growing-finishing pigs

<table>
<thead>
<tr>
<th>Item</th>
<th>1.5:1</th>
<th>1.3:1</th>
<th>1.0:1</th>
<th>1.2:1 (PC)</th>
<th>SEM</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Phytase, PU/kg</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ADFI, g</td>
<td>500</td>
<td>500</td>
<td>500</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td>Growing phase</td>
<td>2,211</td>
<td>2,132</td>
<td>2,239</td>
<td>2,226</td>
<td>45</td>
</tr>
<tr>
<td>Finishing phase</td>
<td>3,233</td>
<td>3,220</td>
<td>3,357</td>
<td>3,437</td>
<td>67</td>
</tr>
<tr>
<td>Overall</td>
<td>2,823</td>
<td>2,787</td>
<td>2,912</td>
<td>2,959</td>
<td>52</td>
</tr>
<tr>
<td>ADG, g</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Growing phaseb</td>
<td>844</td>
<td>851</td>
<td>906</td>
<td>901</td>
<td>19</td>
</tr>
<tr>
<td>Finishing phasec</td>
<td>922</td>
<td>933</td>
<td>947</td>
<td>955</td>
<td>21</td>
</tr>
<tr>
<td>Overall</td>
<td>887</td>
<td>899</td>
<td>928</td>
<td>931</td>
<td>16</td>
</tr>
<tr>
<td>Gain:feed, g/kg</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Growing phaseb</td>
<td>382</td>
<td>399</td>
<td>405</td>
<td>407</td>
<td>4</td>
</tr>
<tr>
<td>Finishing phasec</td>
<td>286</td>
<td>290</td>
<td>282</td>
<td>279</td>
<td>5</td>
</tr>
<tr>
<td>Overall</td>
<td>315</td>
<td>323</td>
<td>319</td>
<td>316</td>
<td>4</td>
</tr>
</tbody>
</table>

Ten pens of pigs per treatment with three pigs per pen (experimental unit). Average BW at the start of the experiment, at the end of growing phase, and at the end of finishing phase were 23, 54, and 123 kg, respectively. PC = positive control.

aLinear effect of dietary Ca:total P ratio (P < .03).
bLinear effect of dietary Ca:total P ratio (P < .08).
cLinear effect of dietary Ca:total P ratio (P < .001).

During the 15-wk experiment, no visual signs of lameness that could be associated with a Ca or P deficiency were observed. However, three pigs from different treatments were removed from the study due to rectal prolapse unrelated to the dietary treatments.

Growth Performance. Lowering the dietary Ca:P ratio from 1.5:1 to 1.0:1 linearly increased ADG (P < .03) and gain:feed (G:F) ratio (P < .001) during the growing phase but had no effect (P > .2) on growth performance during the finishing phase (Table 2). Lowering the Ca:P ratio did not affect (P > .2) ADFI during the growing phase, finishing phase, or overall. Overall ADG increased linearly (P < .08) with decreasing dietary Ca:P ratios. Pigs fed the low-P diet with a Ca:P ratio of 1.0:1 had ADG, ADFI, and a G:F ratio similar (P > .2) to those of pigs fed the PC diet.

Nutrient Intake, Apparent Absorption, and Excretion. Lowering the Ca:P ratio linearly increased apparent P absorption in grams per day (P < .04) and percentage (P < .06) but had no effect (P > .2) on the grams of P consumed or excreted in feces daily (Table 3). Pigs fed the PC diet had higher (P < .0001) daily P intake and fecal P excretion and a lower (P < .0001) apparent percentage of P digestibility than pigs fed the low-P diet with a Ca:P ratio of 1.0:1, although grams of P absorbed per day were similar (P > .5) for those two treatments.
TABLE 3. Effect of dietary Ca:total P ratio on nutrient intake, digestion, and excretion of finishing pigs.

<table>
<thead>
<tr>
<th>Item</th>
<th>Ca:total P:</th>
<th>1.5:1</th>
<th>1.3:1</th>
<th>1.0:1</th>
<th>1.2:1 (PC)</th>
<th>SEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phytase, PU/kg</td>
<td></td>
<td>500</td>
<td>500</td>
<td>500</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td>P</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intake, g/d</td>
<td></td>
<td>10.35</td>
<td>10.30</td>
<td>10.74</td>
<td>13.75</td>
<td>.25</td>
</tr>
<tr>
<td>Feces, g/d</td>
<td></td>
<td>5.88</td>
<td>5.60</td>
<td>5.68</td>
<td>8.85</td>
<td>.25</td>
</tr>
<tr>
<td>Absorbed, g/d</td>
<td></td>
<td>4.47</td>
<td>4.70</td>
<td>5.06</td>
<td>4.90</td>
<td>.19</td>
</tr>
<tr>
<td>Digestibility, %d</td>
<td></td>
<td>43.2</td>
<td>45.5</td>
<td>47.1</td>
<td>35.6</td>
<td>1.4</td>
</tr>
<tr>
<td>Ca</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intake, g/d</td>
<td></td>
<td>16.17</td>
<td>13.20</td>
<td>10.74</td>
<td>17.18</td>
<td>.31</td>
</tr>
<tr>
<td>Feces, g/d</td>
<td></td>
<td>6.28</td>
<td>5.01</td>
<td>2.91</td>
<td>8.01</td>
<td>.25</td>
</tr>
<tr>
<td>Absorbed, g/d</td>
<td></td>
<td>9.89</td>
<td>8.19</td>
<td>7.83</td>
<td>9.17</td>
<td>.29</td>
</tr>
<tr>
<td>Digestibility, %d</td>
<td></td>
<td>61.4</td>
<td>62.3</td>
<td>72.8</td>
<td>53.6</td>
<td>1.3</td>
</tr>
</tbody>
</table>

*Ten pens of pigs per treatment with three pigs per pen (experimental unit). Diets containing 0.05% chromic oxide were fed to pigs starting at an average BW of 70 kg. After a 6-d adjustment to the chromic oxide diets, fecal samples were collected from each pen for five consecutive days. PC = positive control. The ADFI for the finishing phase is presented in Table 2.

bPC vs Ca:total P ratio of 1.0:1 (P < .0001).
cLinear effect of dietary Ca:total P ratio (P < .04).
dLinear effect of dietary Ca:total P ratio (P < .06).
eLinear effect of dietary Ca:total P ratio (P < .0001).
fPC vs Ca:total P ratio of 1.0:1 (P < .003).
gQuadratic effect of dietary Ca:total P ratio (P < .006).

Lowering the Ca:P ratio linearly decreased (P < .0001) Ca intake, apparent Ca absorption, and fecal Ca excretion in grams per day but quadratically increased (P < .006) the apparent percentage of Ca digestibility. For pigs fed the adequate-P PC diet, Ca intake and fecal Ca excretion in grams per day were higher (P < .0001) compared with pigs fed the low-P diet with a Ca:P ratio of 1.0:1. There was no effect of Ca:P ratio on the apparent percentage of DM digestibility (P > .7). The apparent percentage of DM digestibility of the PC treatment was similar (P > .2) to that of the low-P diet with a Ca:P ratio of 1.0:1.

Carcass Measurements. Lowering the Ca:P ratio in the low-P dietary treatments linearly increased BW at slaughter (P < .02) and hot carcass weight (P < .04; Table 4). There were no linear or quadratic effects (P > .2) of Ca:P ratio on dressing percentage and backfat thickness at the 10th rib. Carcass characteristics of pigs fed the diets with a Ca:P ratio of 1.0:1 were similar (P > .07) to those of pigs fed the PC diets.

Breaking Strength and Ash Weight of Metacarpal Bone. There were no linear or quadratic effects (P > .05) of dietary Ca:P ratio on breaking strength and ash weight of metacarpal bone.

TABLE 4. Effect of dietary Ca:total P ratio on slaughter BW, carcass measurements, bone breaking strength, and bone ash weight.

<table>
<thead>
<tr>
<th>Item</th>
<th>Ca:total P:</th>
<th>1.5:1</th>
<th>1.3:1</th>
<th>1.0:1</th>
<th>1.2:1 (PC)</th>
<th>SEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slaughter BW, kg</td>
<td></td>
<td>116.5</td>
<td>119.2</td>
<td>123.5</td>
<td>124.5</td>
<td>2.0</td>
</tr>
<tr>
<td>Hot carcass wt, kg</td>
<td></td>
<td>87.0</td>
<td>89.2</td>
<td>92.7</td>
<td>93.0</td>
<td>1.9</td>
</tr>
<tr>
<td>Dressing, %</td>
<td></td>
<td>74.6</td>
<td>74.7</td>
<td>75.0</td>
<td>74.9</td>
<td>.6</td>
</tr>
<tr>
<td>Backfat depth at 10th rib, mm</td>
<td></td>
<td>29.7</td>
<td>30.7</td>
<td>32.1</td>
<td>32.7</td>
<td>1.3</td>
</tr>
<tr>
<td>Metacarpal bone</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fresh wt, g</td>
<td></td>
<td>28.54</td>
<td>28.51</td>
<td>29.39</td>
<td>29.39</td>
<td>.61</td>
</tr>
<tr>
<td>Fat-free dry wt, g</td>
<td></td>
<td>13.08</td>
<td>12.85</td>
<td>13.52</td>
<td>14.21</td>
<td>.28</td>
</tr>
<tr>
<td>Breaking strength, kg</td>
<td></td>
<td>156.80</td>
<td>175.59</td>
<td>173.66</td>
<td>189.47</td>
<td>5.53</td>
</tr>
<tr>
<td>Ash wt, g</td>
<td></td>
<td>7.32</td>
<td>7.51</td>
<td>7.72</td>
<td>8.14</td>
<td>.14</td>
</tr>
</tbody>
</table>

*Ten pens (experimental units) of pigs per treatment. Two or three pigs per pen were slaughtered, and n = 22 per treatment. PC = positive control.

bPC vs the Ca:total P ratio of 1.0:1 (P < .09).
cPC vs the Ca:total P ratio of 1.0:1 (P < .05).
dLinear effect of dietary Ca:total P ratio (P < .06).
of Ca:tP ratio on fresh or fat-free dry metacarpal bone weights, whereas pigs fed the PC diets tended to have a higher (P < .09) fat-free dry metacarpal bone weight than pigs fed the diets with a Ca:tP ratio of 1.0:1 (Table 4). Lowering the dietary Ca:tP ratio linearly increased metacarpal bone breaking strength (P < .04) and ash weight (P < .06). Pigs fed the PC diets had higher (P < .05) metacarpal breaking strength and bone ash weight than pigs fed the low-P diet with a Ca:tP ratio of 1.0:1. The Ca:tP ratio treatments did not affect (P > .3) the metacarpal bone length, narrow midpoint width, or wide midpoint width measurements. Tabular data are not presented. Overall experimental means ± SE (mm) were 75.0 ± .8, 15.1 ± .2 and 19.5 ± .2, respectively.

Discussion

High dietary Ca concentrations decrease the utilization of phytate-P in diets for animals by the formation of insoluble Ca-phytate (Wise, 1983; Fisher, 1992). Furthermore, high dietary Ca concentrations reduce the intestinal activities of phytase and alkaline phosphatase in chicks (McCuaig et al., 1972) and reduce P utilization and the efficacy of supplemental microbial phytase in low-P diets fed to weanling (Lei et al., 1994; Qian et al., 1996) and growing pigs (Jongbloed et al., 1993; Lantzsch et al., 1995). The present study demonstrated that lowering the dietary Ca:tP ratio to 1.0:1 increases the utilization of P in growing-finishing pigs fed low-P corn-soybean meal diets supplemented with microbial phytase, as indicated by increases in growth performance, apparent P absorption, and bone strength criteria.

Three possible mechanisms have been proposed to explain the detrimental effect of wide Ca:tP ratios on the efficacy of microbial phytase: 1) The extra Ca forms an insoluble phytate complex that is not accessible for hydrolysis by phytase (Wise, 1983; Fisher, 1992). 2) High dietary Ca increases the pH of the intestinal contents, which in turn decreases microbial phytase activity (Sandberg et al., 1993). 3) The extra Ca could directly suppress phytase activity by competing for the active sites of the enzyme (Qian et al., 1996). Supplementation of low-P diets with microbial phytase increases the apparent digestibility of dietary Ca in growing-finishing pigs (Kemme et al., 1997; Liu et al., 1997a) and could further exacerbate the detrimental effects of a wide dietary Ca:tP ratio. Lowering the dietary Ca:tP ratio from 1.5:1 to 1.0:1 had no effect on the pH of the digesta in the small or large intestines of finishing pigs (Liu et al., 1997b), even though apparent P absorption was increased. Therefore, the detrimental effect of the dietary Ca:tP ratio of 1.5:1 on P utilization in the present study was not due to an increase in pH in the small intestine.

The increase in P utilization by growing-finishing pigs in our experiment is in agreement with experiments in which weanling (Lei et al., 1994; Qian et al., 1996) and growing pigs (Jongbloed et al., 1993) were fed low-P diets with various Ca:tP ratios and supplemented with microbial phytase. However, our results are in contrast to those of Cromwell et al. (1995b), who reported that lowering the dietary Ca:tP ratio from 1.9:1 to 1.5:1 in a grower diet or from 1.7:1 to 1.0:1 in a finisher diet had no effect on the efficacy of supplemental microbial phytase. One possible explanation for the lack of response to Ca:tP ratio in the experiment by Cromwell et al. (1995b) may be the high concentrations of microbial phytase they used in the grower (1,000 or 2,000 PU/kg) and finisher (1,250 PU/kg) diets. The negative effect of high dietary Ca concentrations on phytase activity was reduced in vitro when phytase was supplemented at high concentrations (Qian and Kornegay, 1995).

In the finishing phase of the present experiment, lowering the dietary Ca:tP ratio from 1.5:1 to 1.0:1 in a low-P corn-soybean meal diet supplemented with 500 PU/kg increased the grams of P absorbed daily and percentage of P absorbed by 13.2 and 9.0%, respectively. This response to lowering the Ca:tP ratio for finishing pigs is comparable to the responses reported for weanling (Qian et al., 1996) and growing pigs (Jongbloed et al., 1993). Because of this increase in P digestibility in the present experiment, the grams of P absorbed per day for pigs fed the low-P diet with a Ca:tP ratio of 1.0:1 were similar to those for the positive control pigs, and bone strength and bone ash weight remained lower than those of the positive control pigs. This discrepancy may be due to an increase in the metabolic loss of P through urine, which we did not measure in this experiment.

Compared to the adequate-P PC treatment, supplementation of the low-P diets with microbial phytase at 500 PU/kg reduced fecal P excretion by 35% in the present experiment with finishing pigs. This was close to the 40% reduction in fecal P excretion reported by Liu et al. (1997a) for growing pigs and less than the 54% reduction in fecal P excretion reported by Näs (1990) for finishing pigs when the pigs were fed corn-soybean meal diets supplemented with microbial phytase at 500 PU/kg. Some of this difference in P excretion may be attributed to the higher level of iP supplementation and the higher tP concentration in the finisher diet used by Näs (1990) compared to the finisher PC diet in the present experiment. Lowering the Ca:tP ratio from 1.5:1 to 1.0:1 did not further reduce the grams of fecal P excreted daily in the present experiment, which is in agreement with the data reported for weanling pigs (Qian et al., 1996). However, the grams of fecal Ca excreted daily were reduced 54% by lowering the Ca:tP ratio from 1.5:1 to 1.0:1 in the present study due to the decrease in Ca intake and the increase in Ca digestibility. Lowering the dietary Ca:tP ratio in the present experiment did not affect backfat thickness of the carcass. This
supports the report by O'Quinn et al. (1997) that phytase supplementation of low-P sorghum-based diets did not affect quantitative carcass traits other than dressing percentage.

In conclusion, decreasing the dietary Ca:P ratio from 1.5:1 to 1.0:1 in low-P corn-soybean meal diets supplemented with microbial phytase at 500 PU/kg increased growth performance, grams of P absorbed daily, metacarpal breaking strength, and metacarpal ash weight.

Implications

Phosphorus utilization was increased by lowering the dietary Ca:total P ratio from 1.5:1 to 1.0:1 in low-finishing corn-soybean meal diets fed to growing-finishing pigs based on growth performance, phosphorus absorption, bone strength, and bone ash criteria. Therefore, dietary calcium must be less than NRC recommended concentrations in low-phosphorus corn-soybean meal diets supplemented with microbial phytase for growing-finishing pigs.

Literature Cited


