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The Impact of Dietary Analyzed Calcium to Phosphorus Ratios and Standardized Total Tract Digestible Phosphorus to Net Energy Ratios on Growth Performance, Bone, and Carcass Characteristics of Pigs[1]

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Summary

A total of 2,184 pigs (PIC 337 × 1050; initially 27.3 lb) were used to evaluate the effects of feeding varying analyzed calcium to phosphorus (Ca:P) ratios at two levels of standardized total tract digestible (STTD) P:NE. Pens of pigs (26 pigs per pen) were assigned to 6 dietary treatments in a randomized complete block design with 14 pens per treatment. Diets consisted of two levels of STTD P:NE, including the PIC recommendation (1.8, 1.62, 1.43, 1.25, 1.10, and 0.99 g STTD P/Mcal NE from 25 to 50, 50 to 90, 90 to 130, 130 to 180, 180 to 230, and 230 to 280 lb, respectively); or 75% of the PIC recommendation, and 3 analyzed Ca:P ratios: 0.90:1, 1.30:1, and 1.75:1. Diets were corn-soybean meal-based and contained phytase (Quantum Blue G, AB Vista, Marlborough, Wiltshire, UK); 500 to 210 FTU/kg with release values from 0.13 to 0.07% STTD P. There was a Ca:P × STTD P:NE interaction ($P < 0.05$) observed for average daily gain (ADG), feed efficiency (F/G), and final body weight (BW). For ADG and final BW, when feeding 75% of PIC STTD P recommendation, increasing the analyzed Ca:P ratio decreased ADG and final BW (linear, $P < 0.001$). However, when feeding the PIC STTD P recommendation, increasing the analyzed Ca:P ratio tended to improve ADG and final BW (linear, $P < 0.10$). For F/G, when feeding 75% of the PIC STTD P recommendation, increasing the analyzed Ca:P ratio tended to worsen F/G (linear, $P < 0.10$), whereas in pigs fed diets that met PIC STTD P recommendations, increasing the analyzed Ca:P ratio tended to improve F/G in a quadratic ($P < 0.10$) manner. Despite the interactions, pigs fed the PIC STTD P recommendations had increased ADG, final BW, and improved F/G compared to pigs fed 75% of PIC STTD P recommendations ($P < 0.001$). In summary, pigs fed at PIC STTD P

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recommendations had improved overall ADG and F/G compared to pigs fed diets at 75% of PIC STTD P recommendations. Additionally, increasing the analyzed Ca:P ratio worsened ADG and F/G when STTD P was below PIC recommendations but had marginal impacts when adequate STTD P was fed.

Introduction

Calcium (Ca) and phosphorus (P) are the most abundant minerals in the pig and are involved in lean tissue deposition and the synthesis and maintenance of the skeletal structure. Swine diets are typically formulated with low margins of safety for P. Dietary P is the third most expensive component of the diet, so feeding high levels leads to an increase in diet cost. Furthermore, excess P in the diet can lead to increased P excretion, which can result in negative effects on the environment. Several European countries have set limitations on dietary P concentrations due to the local legislation focusing on reducing the negative impact P excretion has on the environment. In fact, many European nutritionists set the STTD P:NE at approximately 75% of what is typically fed in the US.

To understand adequate utilization of both Ca and P, it is important to consider the Ca:P ratio when formulating pig diets. Research has shown that a wide Ca:P is detrimental to pig growth performance and bone mineralization when diets are low in STTD P.[5] Therefore, the objective of this study was to evaluate the impact of varying Ca:P ratios fed at two levels of STTD P:NE on growth performance, bone, and carcass characteristics of pigs from 27 to 280 lb.

Procedures

The Kansas State University Institutional Animal Care and Use Committee approved the protocol used for this experiment. This study was conducted at a commercial research facility in south-central Minnesota. The barn was naturally ventilated with completely slatted concrete flooring over deep pits for manure storage. Each pen shared a 4- × 8-ft comfort mat and brooder. The mats were sprinkled with feed from the feeder 2 times per day for the first 7 days post-weaning but not any other time during the day. The initial controller temperature setting was 85°F and followed an automatic growth curve setting. Once the room was filled, the set-point temperature was adjusted 0.5 degrees/d for the nursery period and was adjusted following SFI guidelines to 74°F.

Animals and diets

A total of 2,184 pigs (PIC 337 × 1050; initially 27.3 lb) were used in this experiment with 26 pigs per pen and 14 replicates per treatment. Pens of pigs were blocked by BW with an equal number of barrows and gilts in each pen, and randomly assigned to 1 of 6 treatments in a randomized complete block design. Experimental diets were fed in 6 phases with targeted STTD P:NE (Table 1) and Ca:P similar in all phases. Treatments consisted of two levels of STTD P:NE, including the PIC recommendation (1.8, 1.62, 1.43, 1.25, 1.10, and 0.99 g STTD P/Mcal NE from 25 to 50, 50 to 90, 90 to 130, 130 to 180, 180 to 230, and 230 to 280 lb, respectively), or 75% of the PIC recommendation, and 3 analyzed Ca:P ratios: 0.90:1, 1.30:1, and 1.75:1. Experimental diets were

[5] Vier, C.M., S.S. Dritz, M.D. Tokach, J.M. DeRouchey, R. D. Goodband, M.A.D. Gonçalves, U.A.D. Orlando, J.R. Bergstrom, and J.C. Woodworth. 2019. Calcium to phosphorus ratio requirement of 26- to 127-kg pigs fed diets with or without phytase. J. Anim. Sci. 97:4041-4052. doi: 10.1093/jas/skz257.

fed from d 0 to 20, 20 to 44, 44 to 62, 62 to 87, 87 to 107, and 107 to 143 for phases 1 to 6, respectively (Table 2 and 3). Prior to diet formulation, corn, soybean meal, and monocalcium phosphate were analyzed for Ca, P, and proximate analysis at Midwest Laboratories (Omaha, NE) and these values were used in diet formulation.

Pens of pigs were weighed, and feed disappearance was measured approximately every 14 d to determine ADG, ADFI, and F/G. On d 124 and 131 of the study, the 5 heaviest pigs from each pen were marketed. The remaining pigs were marketed approximately 7 days later at the conclusion of the experiment.

At the completion of the study, final pen weights were recorded, and individual pigs were weighed, tattooed with a pen identification number, and transported to a commercial abattoir for processing and carcass data collection. Carcass measurements included hot carcass weight (HCW), backfat depth, loin depth, and percentage lean. Carcass yields were then calculated by the individual pig HCW from the plant divided by the individual pig weight on the farm. Hot carcass weight was used as a covariate for backfat depth, loin depth, and percentage lean in the statistical analysis.

On d 138 of the study, two pigs per pen, 1 barrow, and 1 gilt that were an average weight of the pen were removed from the pen and sent to a commercial abattoir. The left front foot was removed from each pig at the junction of the carpal bones and radius and was further dissected to collect the third metacarpal. Bones were stored in a -4°F freezer until analysis. Each bone was analyzed for bone mineral content and density using a DXA machine (Hologic QDR4500A Dual Fan Beam X-Ray Bone Densitometer (DXA) (Hologic, INC., Waltham, MA)) and bone-breaking strength via the Instron machine (Instron 5569, NV Lab, Norwood, MA).

Statistical analysis

For the statistical analysis, data were analyzed as a randomized complete block design for two-way ANOVA using the lmer function from the lme4 package in R (version 3.5.1 (2018-07-02), R Foundation for Statistical Computing, Vienna, Austria), with pen considered as the experimental unit, body weight as blocking factor, and treatment as a fixed effect with 14 replicates per treatment. The main effects of Ca:P ratio and STTD P:NE, as well as their interactions, were tested. Preplanned linear and quadratic contrasts were used to determine the effects of increasing analyzed Ca:P ratios. Results were considered significant at $P \leq 0.05$ and marginally significant at $0.05 < P \leq 0.10$.

Results and Discussion

For final body weight, there was a Ca:P × STTD P:NE (linear, $P < 0.001$) interaction observed (Table 4). Increasing the Ca:P from 0.90:1 to 1.75:1 linearly decreased ($P < 0.001$) final body weight for pigs fed 75% of the current PIC STTD P:NE recommendation, whereas body weight tended (linear, $P = 0.063$) to increase as the Ca:P increased for pigs fed the current PIC STTD P:NE recommendations.

Overall, there was a Ca:P × STTD P:NE (linear, $P < 0.05$) interaction observed for ADG, ADFI, and F/G. For ADG, increasing the Ca:P from 0.90:1 to 1.75:1 linearly decreased ($P < 0.05$) ADG for pigs fed 75% of the current PIC STTD P:NE recommendation, whereas ADG tended (linear, $P < 0.10$) to increase as the Ca:P increased for pigs fed the current PIC STTD P:NE recommendations. Increasing the Ca:P from

0.90:1 to 1.75:1 linearly reduced ($P < 0.05$) intake for pigs fed 75% of the current PIC STTD P:NE recommendation while intake decreased and then increased (quadratic, $P < 0.05$) as Ca:P increased for pigs fed the current PIC STTD P:NE recommendation. Increasing the Ca:P from 0.90:1 to 1.75:1 tended to worsen (linear, $P = 0.081$) F/G for pigs fed 75% of the current PIC STTD P:NE recommendation. Increasing the Ca:P from 0.90:1 to 1.75:1 improved and then worsened (quadratic, $P = 0.069$) F/G for pigs fed the current PIC STTD P:NE recommendation. Pigs fed the current PIC STTD P:NE level had improved ($P < 0.001$) gain, intake, and F/G compared to the pigs fed 75% of the current PIC STTD P:NE recommendation (Table 5).

For bone characteristics, there was linear Ca:P × STTD P:NE interaction ($P < 0.05$) observed for bone mineral content, bone mineral density, and bone-breaking strength. Bone mineral content and density tended to decrease (linear, $P < 0.10$) with increasing Ca:P for pigs fed 75% of the current PIC STTD P:NE recommendation, but increased (linear, $P < 0.05$) for pigs fed the current PIC STTD P:NE recommendations. Increasing Ca:P ratio did not influence bone-breaking strength for pigs fed 75% of the current PIC STTD P:NE recommendations; however, increasing the Ca:P for pigs fed the current PIC STTD P:NE recommendation increased (linear, $P < 0.05$) bone-breaking strength.

For carcass characteristics, there was a Ca:P × STTD P:NE interaction ($P < 0.05$) for HCW and carcass yield. Increasing the Ca:P for pigs fed 75% of the current PIC STTD P:NE recommendation linearly reduced HCW (linear, $P < 0.001$), while there was no difference for HCW between Ca:P ratios for pigs fed the current PIC STTD P:NE recommendation ($P > 0.10$). Increasing the Ca:P for pigs fed 75% of the current PIC STTD P:NE recommendation did not influence carcass yield; however, increasing the Ca:P from 0.90:1 to 1.30:1 reduced carcass yield, with no difference as Ca:P further increased from 1.30:1 to 1.75:1 (quadratic, $P < 0.05$). Pigs fed 75% of the PIC STTD P:NE recommendation had increased ($P < 0.05$) back fat and reduced ($P < 0.05$) carcass lean compared to the pigs fed the current PIC STTD P:NE recommendation.

In summary, pigs fed the PIC STTD P:NE recommendations had improved overall ADG, F/G, and carcass lean compared to pigs fed diets at 75% PIC STTD P:NE recommendations. Increasing the Ca:P for pigs fed 75% of the current PIC STTD P:NE reduced ADG and worsened F/G which resulted in a decrease in final body weight and HCW. Increasing the Ca:P for pigs fed the current PIC STTD P:NE recommendation increased ADG and final body weight, but reduced HCW. The reduction in HCW was driven by the reduction in carcass yield as Ca:P increased from 0.90:1 to 1.75:1. Increasing the Ca:P for pigs fed the current PIC STTD P:NE recommendation can also increase bone mineralization. When feeding the current PIC STTD P:NE recommendation, widening the Ca:P can improve ADG, F/G, and final body weight. It is important to consider the Ca:P when feeding 75% of the STTD P:NE recommendation because widening the ratio can worsen growth performance and bone mineralization when STTD P is marginal or deficient.

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Table 1. STTD P:NE ratio (STTD P) at each dietary phase

Weight range, lb	PIC recommendations	75% of PIC
25 to 50	1.80 (0.45%)	1.35 (0.34%)
50 to 90	1.62 (0.40%)	1.22 (0.30%)
90 to 130	1.43 (0.36%)	1.07 (0.27%)
130 to 180	1.25 (0.31%)	0.94 (0.23%)
180 to 230	1.10 (0.27%)	0.83 (0.20%)
230 to 285	0.99 (0.25%)	0.74 (0.19%)

Table 2. Basal diet composition (as-fed basis)[1]

	Phase 1		Phase 2		Phase 3	
STTD P:NE[2]:	**1.35**	**1.80**	**1.22**	**1.62**	**1.43**	**1.07**
Ca:P ratio:	**0.90:1**	**0.90:1**	**0.90:1**	**0.90:1**	**0.90:1**	**0.90:1**
Ingredients, %[3]						
Corn	67.50	66.35	72.20	71.25	76.75	75.85
Soybean meal, 46.5% CP	29.40	29.55	20.40	20.45	20.40	20.45
Choice white grease	0.50	0.88	0.55	0.85	0.85	1.15
Calcium carbonate	0.45	0.46	0.47	0.48	0.48	0.49
Monocalcium phosphate	0.23	0.86	0.13	0.69	---	0.51
Salt	0.60	0.60	0.55	0.55	0.55	0.55
L-Lys-HCl	0.48	0.48	0.45	0.45	0.42	0.42
DL-Met	0.20	0.20	0.16	0.16	0.13	0.13
L-Thr	0.24	0.24	0.21	0.21	0.18	0.18
L-Trp	0.04	0.04	0.03	0.03	0.03	0.03
L-Val	0.09	0.09	0.08	0.08	0.06	0.06
VTM	0.20	0.20	0.17	0.17	0.15	0.15
Phytase[4]	0.03	0.03	0.03	0.03	0.03	0.03
Calculated analysis						
Standardized ileal digestible amino acids, %						
Lys	1.28	1.28	1.15	1.15	1.02	1.02
Ile:Lys	55	55	55	55	55	55
Leu:Lys	117	117	122	122	128	128
Met:Lys	36	36	35	35	35	35
Met and Cys:Lys	57	57	57	57	57	57
Thr:Lys	65	65	65	65	65	65
Trp:Lys	19.0	19.0	18.2	18.2	18.2	18.2
Val:Lys	68	68	68	68	68	68
CP, %	19.4	19.4	17.7	17.6	15.8	15.8
NE, kcal/lb	1,166	1,166	1,174	1,174	1,189	1,189
Ca, %	0.37	0.48	0.34	0.44	0.30	0.39
P, %	0.41	0.54	0.38	0.49	0.30	0.39
STTD P with phytase, %	0.32	0.43	0.30	0.39	0.26	0.35
Analyzed Ca:analyzed P	0.90:1	0.90:1	0.90:1	0.90:1	0.90:1	0.90:1

[1]Experimental diets were fed from d 0 to 20, 20 to 44, and 44 to 62 for phases 1 to 3, respectively.
[2]Phosphorus levels were based on PIC Nutrition and Feeding Guidelines (2021).
[3]Corn, soybean meal, choice white grease, and calcium carbonate were adjusted to keep diets isocaloric, with similar CP and SID Lys concentrations, while maintaining the intended Ca:P ratio.
[4]Quantum Blue 2G (AB Vista, Marlborough, Wiltshire, UK) provided 500 units of phytase (FTU/kg of diet) with the assumed release of 0.13% STTD P.

Table 3. Basal diet composition (as-fed basis)[1]

	Phase 4		Phase 5		Phase 6	
STTD P:NE[2]:	**1.25**	**0.94**	**1.10**	**0.83**	**0.99**	**0.74**
Ca:P ratio:	**0.90:1**	**0.90:1**	**0.90:1**	**0.90:1**	**0.90:1**	**0.90:1**
Ingredients, %[3]						
Corn	81.30	80.55	84.25	83.55	84.70	84.10
Soybean meal, 46.5% CP	16.20	16.25	13.40	13.45	12.80	12.85
Choice white grease	0.60	0.85	0.65	0.90	0.95	1.15
Calcium carbonate	0.50	0.50	0.50	0.51	0.50	0.51
Monocalcium phosphate	---	0.45	---	0.39	---	0.36
Salt	0.55	0.55	0.56	0.56	0.56	0.56
L-Lys-HCl	0.38	0.38	0.32	0.32	0.23	0.23
DL-Met	0.09	0.09	0.04	0.04	---	---
L-Thr	0.15	0.15	0.11	0.11	0.06	0.06
L-Trp	0.03	0.03	0.03	0.03	0.02	0.02
L-Val	0.04	0.04	0.03	0.03	---	---
VTM	0.15	0.15	0.15	0.15	0.15	0.15
Phytase[4]	0.02	0.02	0.01	0.01	0.01	0.01
Calculated analysis						
Standardized ileal digestible amino acids, %						
Lys	0.88	0.88	0.76	0.76	0.68	0.68
Ile:Lys	56	0.56	58	58	64	64
Leu:Lys	138	137	150	150	166	166
Met:Lys	34	33	31	31	29	29
Met and Cys:Lys	58	58	58	58	58	58
Thr:Lys	65	65	65	65	65	65
Trp:Lys	18.5	18.5	18.7	18.7	19.1	19.1
Val:Lys	69	69	72	72	76	76
CP, %	14.1	14.1	12.9	12.9	12.5	12.5
NE, kcal/lb	1,189	1,189	1,194	1,194	1,200	1,199
Ca, %	0.29	0.37	0.28	0.35	0.28	0.34
P, %	0.32	0.41	0.31	0.39	0.31	0.38
STTD P with phytase, %	0.23	0.31	0.21	0.27	0.19	0.25
Analyzed Ca:analyzed P	0.90:1	0.90:1	0.90:1	0.90:1	0.90:1	0.90:1

[1] Experimental diets were fed from d 62 to 87, 87 to 107, 107 to 143 for phases 4 to 6, respectively.
[2] Phosphorus levels were based on PIC Nutrition and Feeding Guidelines (2021).
[3] Corn, soybean meal, choice white grease, and calcium carbonate were adjusted to keep diets isocaloric, with similar CP and SID Lys concentrations, while maintaining the intended Ca:P.
[4]Quantum Blue 2G (AB Vista, Marlborough, Wiltshire, UK) provided 400 units of phytase (FTU/kg of diet) with the assumed release of 0.11% STTD P for phase 4. For phase 5, 290 units of phytase (FTU/kg of the diet) were used with the assumed release of 0.09% STTD P. For phase 6, 210 units of phytase (FTU/kg of the diet) were used with the assumed release of 0.07% STTD P.

Table 4. The interactive effect of analyzed Ca:P ratio on current or 75% of the PIC STTD P:NE requirement on wean to finish pigs[1]

								P-value					
								Interaction		Within 75% of current		Within current	
PIC STTD P:NE:	75% of current			Current									
Ca:P:	0.90	1.30	1.75	0.90	1.30	1.75	SEM	Linear	Quadratic	Linear	Quadratic	Linear	Quadratic
Body weight, lb													
d 0	27.3	27.3	27.3	27.3	27.3	27.3	0.37	0.811	0.055	0.796	0.178	0.552	0.167
d 143	287.2	280.9	276.6	292.1	295.8	297.1	1.98	0.001	0.422	0.001	0.580	0.063	0.559
Overall													
ADG, lb	1.92	1.88	1.86	1.96	1.97	1.98	0.013	0.001	0.767	0.001	0.391	0.092	0.658
ADFI, lb	4.49	4.38	4.39	4.53	4.48	4.55	0.032	0.017	0.980	0.008	0.042	0.477	0.046
F/G	2.34	2.33	2.37	2.31	2.28	2.30	0.020	0.046	0.793	0.081	0.145	0.274	0.069
Bone characteristics[2]													
Mineral content, g	3.49	3.49	3.20	4.07	4.27	4.53	0.140	0.003	0.494	0.094	0.391	0.013	0.915
Mineral density, g/cm	0.28	0.28	0.26	0.30	0.31	0.33	0.007	0.001	0.591	0.068	0.476	0.002	0.966
Breaking strength, kg	297.0	284.3	282.1	318.1	332.6	361.8	12.09	0.010	0.982	0.344	0.677	0.008	0.653
Carcass characteristics[3]													
Count, n	325	320	311	329	342	333	---	---	---	---	---	---	---
HCW, lb	216.9	211.5	209.4	220.7	220.1	221.2	1.28	0.001	0.609	0.001	0.179	0.726	0.530
Yield, %	74.4	74.5	74.3	74.7	74.2	74.3	0.13	0.399	0.026	0.471	0.364	0.057	0.025
Back fat, in.	0.74	0.73	0.76	0.71	0.71	0.71	0.010	0.100	0.174	0.055	0.025	0.699	0.721
Loin depth, in.	2.70	2.68	2.66	2.71	2.69	2.69	0.016	0.460	0.652	0.080	0.921	0.449	0.461
Lean, %	55.6	55.8	55.1	56.1	56.1	56.1	0.18	0.104	0.195	0.032	0.059	0.908	0.941

[1]A total of 2,184 pigs were used in a 143-d study to evaluate the interactive effects of different levels of analyzed Ca:P ratio in diets formulated to the current PIC STTD P:NE or 75% of the current PIC STTD P:NE. There were 14 pens per treatment, with 26 pigs per pen. Phase 1 was fed from d 0 to 20. Phase 2 was fed from d 20 to 44. Phase 3 was fed from d 44 to 62. Phase 4 was fed from d 62 to 87. Phase 5 was fed from d 87 to 107. Phase 6 was fed from d 107 to 143.

[2]The left 3rd metacarpal was used for bone characteristics analysis. The results from bone mineral content and bone mineral density are from analyzing the bones with a DXA machine (Hologic QDR4500A Dual Fan Beam X-Ray Bone Densitometer (DXA) (Hologic, INC., Waltham, Massachusetts, USA)).

[3]Pigs were marketed on d 124, 131, and dumped on d 143. On d 124 and 131, the 5 heaviest pigs were removed from the pen and marketed. On d 143, the remaining pigs in the pen were marketed. The carcass data is a weighted average of the 1st cut, 2nd cut, and dump. Hot carcass weight was used as a covariate in the statistical model for back fat, loin depth, and percent lean.

Table 5. Main effect of Ca:P ratios and STTD P:NE ratio on wean-to finish-pig growth performance[1]

	Ca:P				*P*-value		PIC STTD P:NE			
Item	0.90	1.30	1.75	SEM	Linear	Quadratic	75% of current	Current	SEM	*P*-value[3]
Body weight, lb										
d 0	27.3	27.3	27.3	0.009	0.546	0.982	27.3	27.3	0.022	0.322
d 143	289.6	288.4	286.8	1.853	0.137	0.982	281.6	295.0	4.534	< 0.001
Overall										
ADG, lb	1.94	1.92	1.92	0.010	0.070	0.358	1.87	1.97	0.025	< 0.001
ADFI, lb	4.51	4.43	4.47	0.024	0.157	0.005	4.42	4.52	0.059	< 0.001
F/G	2.33	2.31	2.33	0.011	0.636	0.022	2.35	2.30	0.026	< 0.001
Bone characteristics[2]										
Mineral content, g	3.78	3.88	3.87	0.088	0.503	0.593	3.39	4.29	0.073	0.001
Mineral density, g/cm	0.29	0.30	0.30	0.004	0.279	0.634	0.27	0.31	0.004	0.001
Breaking strength, kg	307.5	308.4	321.9	8.11	0.194	0.541	287.8	337.5	6.50	0.001
Carcass characteristics[3]										
HCW, lb	218.8	215.8	215.3	1.02	0.002	0.165	212.6	220.7	0.91	0.001
Yield, %	74.6	74.3	74.3	0.095	0.065	0.331	74.4	74.4	0.078	0.872
Back fat, in.	0.73	0.72	0.73	0.008	0.263	0.064	0.74	0.71	0.007	0.001
Loin depth, in.	2.70	2.68	2.68	0.012	0.075	0.555	2.68	2.70	0.010	0.104
Lean, %	55.9	56.0	55.6	0.14	0.141	0.162	55.5	56.1	0.12	0.001

[1]A total of 2,184 pigs were used in a 143-d study to evaluate the interactive effects of different levels of analyzed Ca:P ratio in diets formulated to the current PIC STTD P:NE or 75% of the current PIC STTD P:NE. There were 42 pens per treatment for the main effect of PIC STTD P:NE and 28 pens per treatment for the main effect of Ca:P, with 26 pigs per pen. Phase 1 was fed from d 0 to 20. Phase 2 was fed from d 20 to 44. Phase 3 was fed from d 44 to 62. Phase 4 was fed from d 62 to 87. Phase 5 was fed from d 87 to 107. Phase 6 was fed from d 107 to 143.

[2]The left 3rd metacarpal was used for bone characteristic analysis.

[3]Pigs were marketed on d 124, 131, and dumped on d 143. On d 124 and 131, the 5 heaviest pigs were removed from the pen and marketed. On d 143, the remaining pigs in the pen were marketed. The carcass data is a weighted average of the 1st cut, 2nd cut, and dump. Hot carcass weight was used as a covariate in the statistical model for back fat, loin depth, and percent lean.