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Effects of Added Calcium Carbonate on Weanling Pig Growth Performance

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Abstract

A total of 695 barrows (DNA Line 200 × 400; initially 12.9 lb) were used in two groups in a 28-d study to evaluate the effects of added dietary calcium carbonate on phase 1 nursery pig growth performance and fecal dry matter. Upon arrival to the nursery research facility, pigs were randomly assigned to pens (5 pigs per pen) and pens were allotted to 1 of 5 dietary treatments with 27 or 28 pens per treatment. Dietary treatments were formulated to provide 0, 0.45, 0.90, 1.35, and 1.80% calcium carbonate added at the expense of corn. Analyzed Ca for treatment diets were 0.61, 0.80, 0.99, 1.15, and 1.37%, respectively. Standardized total tract P concentration was formulated to 0.58% in all diets. Diets were fed in two phases with treatment diets fed from weaning (d 0) to d 14 and a common phase 2 diet fed from d 14 to 28. Treatment diets were fed in both meal (group 1) and pellet (group 2) form. There was no evidence for treatment × group interaction observed, so data from both groups were combined. From d 0 to 14 (treatment period), ADG, d 14 BW, and F/G worsened (linear, $P = 0.010$) as calcium carbonate increased. There was no evidence for difference for ADFI ($P > 0.10$). From d 14 to 28 (common period) and for the overall experiment (d 0 to 28), there was no evidence ($P > 0.10$) for differences observed for any growth performance criteria. For fecal dry matter, there was a tendency (quadratic, $P = 0.091$) with the highest and lowest calcium carbonate diets having the highest dry matter. In summary, increasing dietary calcium carbonate from 0 to 1.80% decreases ADG and worsens feed efficiency in phase 1 nursery diets. Despite the linear response, the largest decrease was observed when calcium carbonate increased from 0.45 to 0.90% with no difference in performance thereafter. These data suggest that lower levels of calcium carbonate can be used than are typically added to phase 1 diets.

Keywords

acid binding capacity, calcium carbonate, gain, feed efficiency, nursery pig

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Alan J. Warner, Joel M. DeRouchey, Mike D. Tokach, Jason C. Woodworth, Robert D. Goodband, and Jordan T. Gebhardt[1]

Summary

A total of 695 barrows (DNA Line 200 × 400; initially 12.9 lb) were used in two groups in a 28-d study to evaluate the effects of added dietary calcium carbonate on phase 1 nursery pig growth performance and fecal dry matter. Upon arrival to the nursery research facility, pigs were randomly assigned to pens (5 pigs per pen) and pens were allotted to 1 of 5 dietary treatments with 27 or 28 pens per treatment. Dietary treatments were formulated to provide 0, 0.45, 0.90, 1.35, and 1.80% calcium carbonate added at the expense of corn. Analyzed Ca for treatment diets were 0.61, 0.80, 0.99, 1.15, and 1.37%, respectively. Standardized total tract P concentration was formulated to 0.58% in all diets. Diets were fed in two phases with treatment diets fed from weaning (d 0) to d 14 and a common phase 2 diet fed from d 14 to 28. Treatment diets were fed in both meal (group 1) and pellet (group 2) form. There was no evidence for treatment × group interaction observed, so data from both groups were combined. From d 0 to 14 (treatment period), ADG, d 14 BW, and F/G worsened (linear, $P = 0.010$) as calcium carbonate increased. There was no evidence for difference for ADFI ($P > 0.10$). From d 14 to 28 (common period) and for the overall experiment (d 0 to 28), there was no evidence ($P > 0.10$) for differences observed for any growth performance criteria. For fecal dry matter, there was a tendency (quadratic, $P = 0.091$) with the highest and lowest calcium carbonate diets having the highest dry matter. In summary, increasing dietary calcium carbonate from 0 to 1.80% decreases ADG and worsens feed efficiency in phase 1 nursery diets. Despite the linear response, the largest decrease was observed when calcium carbonate increased from 0.45 to 0.90% with no difference in performance thereafter. These data suggest that lower levels of calcium carbonate can be used than are typically added to phase 1 diets.

Introduction

Acid binding capacity (ABC), or buffering capacity, is a feed ingredient's ability to change gastrointestinal pH. A low stomach pH (< 4) improves protein digestion and intestinal health, whereas a high gastric pH has been observed to result in negative gastrointestinal challenges including increased intestinal microflora.[2] For this reason, ABC has been used as a means of evaluating diets. The ABC – 4 is the amount of acid in

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[1] Department of Diagnostic Medicine/Pathobiology, College of Veterinary Medicine, Kansas State University.

[2] Ravindran, V. and E. T. Kornegay. 1993. Acidification of weaner pig diets: A review. J. Sci. Food. Agric. 62(4):313-322. doi: 10.1002/jsfa.2740620402.

milliequivalents (mEq) required to lower the pH of 1 kg of feed to 4. Therefore, ABC – 4 of diets is indicative of a low stomach pH which may improve protein digestion and growth performance. Some minerals have been shown to have high ABC in comparison to common ingredients used in swine diets such as cereal grains, vegetable proteins, fat sources and crystalline amino acids.[3] Calcium, in the form of calcium carbonate, is one such mineral with a relatively high ABC due to its cationic properties that would then increase the ABC of the diet and increase stomach pH. Because calcium carbonate is the main source of Ca in most swine diets, lowering dietary Ca may improve growth performance due to a decrease in ABC. However, bone mineralization would be a concern with prolonged feeding of low Ca diets. Therefore, the objective of this study was to investigate the effects of calcium carbonate level immediately post-weaning on growth performance and fecal dry matter of nursery pigs.

Materials and Methods

The Kansas State University Institutional Animal Care and Use Committee approved the protocol used in this experiment. The study was conducted at the Kansas State University Segregated Early Weaning Facility in Manhattan, KS. The facility has two identical barns that are completely enclosed, environmentally controlled, and mechanically ventilated. Each pen contains a 4-hole, dry self-feeder and a cup waterer to provide *ad libitum* access to feed and water. Pens (4 × 4 ft) had metal tri-bar floors and allowed approximately 2.7 ft^2/pig.

A total of 695 barrows (DNA Line 200 × 400; initially 12.9 ± 0.05 lb) were used in two groups in a 28-d study with 5 pigs per pen and 27 or 28 pens per treatment. Pigs were randomly assigned to pens and then pens were allotted to 1 of 5 dietary treatments. Dietary treatments were formulated to provide 0, 0.45, 0.90, 1.35, and 1.80% calcium carbonate at the expense of corn (Table 1). This corresponded with final calculated ABC – 4 values of 424, 481, 539, 597, and 655 mEq., respectively. A common phase 2 diet was formulated to contain 0.90% calcium carbonate which corresponded to a calculated ABC – 4 of 475 mEq. Treatment diets were fed from d 0 to 14 and a common phase 2 diet was fed from d 14 to 28. Treatment diets were fed in both meal (group 1) and pellet (group 2) form, with the common phase 2 diet fed in meal form. A single base diet was manufactured at Hubbard Feeds in Beloit, KS, with calcium carbonate and corn additions mixed and pelleted (group 2) at the O.H. Kruse Feed Technology Innovation Center at Kansas State University, Manhattan, KS. Pig weights and feed disappearances were measured on d 0, 14, and 28 of the experiment to determine ADG, ADFI, and F/G.

Complete diet samples of each treatment were taken with a grain probe from every other bag upon completion of manufacturing and were stored at -4°F (-20°C). Six sub-samples of each diet were ground with a food processor to create a homogeneous sample and then submitted for analysis of Ca and P (K-State Research and Extension Soil Testing Laboratory, Manhattan, KS).

[3] Lawlor, P. G., P. B. Lynch, P. J. Caffrey, J. J. O'Reilly, and M. K. O'Connell. 2005. Measurements of the acid binding capacity of ingredients used in pig diets. Ir. Vet. J. 58:447-452. doi:10.1186/2046-0481-58-8-447.

On d 10 of the experiment, feces were collected from 3 piglets per pen and dried at 130°F for 48 h to determine fecal dry matter. Pigs were removed for welfare concerns if they were observed to lose 2.0 lb or more through d 10 or were unthrifty.

Statistical analysis

Data were analyzed as a completely randomized design with pen serving as the experimental unit. Treatment was included in the statistical model as a fixed effect and block was incorporated in the model as a random effect, which accounted for initial pen average body weight and group. Data were analyzed using R Studio (Version 3.5.2, R Core Team, Vienna, Austria). Contrasts were used to test for linear and quadratic responses between treatments with results considered significant at $P \leq 0.05$ and marginally significant at $0.05 < P \leq 0.10$.

Results and Discussion

Diets were formulated to contain 0.49, 0.66, 0.84, 1.01, and 1.18% Ca. However, analyzed Ca values were greater than calculated levels, but increased in a linear fashion: 0.61, 0.80, 0.99, 1.15, and 1.37%, respectively (Table 2).

From day 0 to 14 (treatment period), ADG and d 14 BW decreased (linear, $P < 0.010$) as calcium carbonate increased (Table 3). Likewise, F/G worsened (linear, $P < 0.001$) as calcium carbonate increased with no evidence ($P > 0.10$) for difference in ADFI. From d 14 to 28 (common period) and for the overall experiment (d 0 to 28), there was no evidence ($P > 0.10$) for differences in growth performance between treatments.

For mortalities, there was a tendency for a quadratic ($P = 0.078$) response with intermediate levels of calcium carbonate having greater mortalities than the high and low dietary levels. However, there was no evidence ($P > 0.10$) for differences in removals or total mortality and removals. For fecal dry matter, there was a quadratic ($P = 0.091$) tendency where pigs fed the highest and lowest calcium carbonate diets had the greatest dry matter.

In summary, increasing calcium carbonate in the diets of nursery pigs decreased daily gain and worsened feed efficiency immediately after weaning. Despite the linear response, ADG decreased from 0 to 0.45% calcium carbonate, with no change thereafter. Interestingly, feed intake was not changed, thus indicating potential changes in feed utilization as influenced by the ABC – 4 of the diets. More research is needed to confirm if this response is indeed reflective of the ABC – 4 of the diets or if lower levels of calcium carbonate improved the phase 1 nursery pig growth performance.

Table 1. Phase 1 and 2 diet composition (as fed basis)[1]

	Calcium carbonate, %					
Item, %	**0**	**0.45**	**0.90**	**1.35**	**1.80**	**Phase 2[3]**
Ingredient						
Corn[2]	44.07	43.62	43.17	42.72	42.27	48.57
Soybean meal, 46.5% CP	17.65	17.65	17.65	17.65	17.65	23.73
Spray-dried whey	10.00	10.00	10.00	10.00	10.00	---
Whey permeate	10.00	10.00	10.00	10.00	10.00	10.00
Corn DDGS	5.00	5.00	5.00	5.00	5.00	7.50
HP 300[4]	5.00	5.00	5.00	5.00	5.00	5.00
Menhaden fish meal	2.50	2.50	2.50	2.50	2.50	---
Spray-dried bovine plasma	2.00	2.00	2.00	2.00	2.00	---
Choice white grease	1.00	1.00	1.00	1.00	1.00	1.00
Monocalcium P, 21.5% P	0.80	0.80	0.80	0.80	0.80	1.00
Calcium carbonate	---	0.45	0.90	1.35	1.80	0.90
Zinc oxide	0.40	0.40	0.40	0.40	0.40	0.25
Sodium chloride	0.30	0.30	0.30	0.30	0.30	0.50
Vitamin premix with phytase	0.25	0.25	0.25	0.25	0.25	0.25
Trace mineral premix	0.15	0.15	0.15	0.15	0.15	0.15
L-Lys-HCL	0.40	0.40	0.40	0.40	0.40	0.55
DL-Met	0.19	0.19	0.19	0.19	0.19	0.22
L-Thr	0.18	0.18	0.18	0.18	0.18	0.23
L-Trp	0.03	0.03	0.03	0.03	0.03	0.04
L-Val	0.09	0.09	0.09	0.09	0.09	0.13
Total	100	100	100	100	100	100

continued

Table 1. Phase 1 and 2 diet composition (as fed basis)[1]

	Calcium carbonate, %					
Item, %	**0**	**0.45**	**0.90**	**1.35**	**1.80**	**Phase 2[3]**
Calculated analysis						
SID amino acids, %						
Lys	1.35	1.35	1.35	1.35	1.35	1.35
Ile:Lys	56	56	56	56	56	55
Leu:Lys	118	118	118	118	117	116
Met:Lys	36	36	36	36	36	37
Met and Cys:Lys	58	58	58	58	58	57
Thr:Lys	64	64	64	64	64	63
Trp:Lys	19.3	19.3	19.3	19.3	19.3	19.3
Val:Lys	71	71	70	70	70	70
Total Lys, %	1.51	1.51	1.51	1.52	1.52	1.51
NE, kcal/lb	1,160	1,154	1,149	1,143	1,137	1,131
SID Lys:ME, g/Mcal	3.94	3.96	3.98	4.00	4.02	4.01
CP, %	21.5	21.5	21.4	21.4	21.4	21.4
Ca, %	0.49	0.66	0.84	1.01	1.18	0.72
P, %	0.68	0.68	0.68	0.68	0.68	0.63
STTD P %	0.59	0.59	0.59	0.59	0.59	0.51
Analyzed Ca:P	0.72	0.97	1.23	1.48	1.74	1.15
ABC – 4[5]	424	481	539	597	655	475

[1]Phase 1 experimental diets were fed for 14 days.
[2]Corn level was altered with increasing calcium carbonate inclusions.
[3]A common diet was fed for 14 days following the experimental period.
[4]Hamlet Protein, Findlay, OH.
[5]Acid binding capacity (ABC) was calculated based on published or estimated ingredient values.

Table 2. Phase 1 and 2 diet analysis (as-fed basis)[1]

	Calcium carbonate level, %					Phase 2
Item	**0**	**0.45**	**0.90**	**1.35**	**1.80**	**0.90**
Ca, %	0.61	0.80	0.99	1.15	1.37	0.89
P, %	0.75	0.75	0.77	0.70	0.71	0.60
ABC – 4, mEq[2]	318	347	376	368	409	---

[1]Six representative samples were collected from each treatment diet and two representative samples were collected from the phase 2 diet, ground with a food processor, and submitted for analysis to the Kansas State University Soil Testing Laboratory.

[2]Acid binding capacity (ABC) was measured and calculated as the amount of acid in milliequivalents (mEq) required to bring 1.0 kg of ground feed to a pH of 4.0.

Table 3. Effects of increasing calcium carbonate on weanling pig growth performance[1]

	Calcium carbonate, %						*P* =	
Item	**0**	**0.45**	**0.90**	**1.35**	**1.80**	**SEM**	**Linear**	**Quadratic**
BW, lb								
d 0	12.9	12.9	12.9	12.9	12.9	0.05	0.846	0.498
d 14	17.6	17.5	17.3	16.9	17.1	0.25	0.006	0.641
d 28	32.4	32.7	32.7	32.0	32.2	0.62	0.397	0.612
Experimental period[2] (d 0 to 14)								
ADG, lb	0.33	0.32	0.30	0.29	0.29	0.016	0.010	0.443
ADFI, lb	0.38	0.38	0.38	0.36	0.38	0.016	0.676	0.627
F/G	1.17	1.19	1.26	1.30	1.30	0.030	<0.001	0.513
Common period (d 14 to 28)[3]								
ADG, lb	1.05	1.08	1.10	1.07	1.09	0.033	0.331	0.470
ADFI, lb	1.45	1.48	1.50	1.46	1.48	0.034	0.798	0.424
F/G	1.39	1.39	1.38	1.37	1.37	0.022	0.236	0.918
Overall (d 0 to 28)								
ADG, lb	0.69	0.69	0.69	0.67	0.69	0.021	0.569	0.954
ADFI, lb	0.91	0.92	0.92	0.90	0.92	0.025	0.918	0.920
F/G	1.33	1.34	1.35	1.35	1.35	0.014	0.298	0.731
Removals, %								
Removals	1.8	3.1	3.2	2.4	3.1	1.6	0.613	0.635
Mortality	0.4	2.3	2.1	0.9	0.4	1.3	0.745	0.078
Total	2.5	6.5	6.1	3.8	3.8	2.2	0.833	0.134
Fecal DM, %[4]								
d 10	22.5	22.1	21.9	21.5	24.4	1.1	0.303	0.091

[1] A total of 695 weanling barrow pigs (DNA 200 × 400) approximately 21 days of age with average initial BW of 12.9 lb were used in 2, 28-d experiments with 5 pigs per pen and 27 or 28 pens per treatment.

[2]Analyzed Ca of the treatment diets were 0.61, 0.80, 0.99, 1.15, and 1.37%, respectively.

[3]Analyzed Ca of the common phase 2 diet was 0.89%.

[4]Feces from three piglets from each pen were pooled, weighed, and dried to measure fecal dry matter.