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Effect of Benzoic Acid Feeding Strategy on Weanling Pig Growth Performance and Fecal Dry Matter

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Abstract

A total of 350 weanling barrows (DNA 200 × 400, DNA; initially 13.0 ± 0.08 lb) were used in a 38-d study to evaluate the effects of different benzoic acid feeding strategies on nursery growth performance and fecal dry matter. Pigs were randomly assigned to pens (5 pigs per pen) and pens were allotted to 1 of 5 dietary treatments with 14 pens per treatment. Diets were fed in 3 phases: phase 1 from weaning to d 10, phase 2 from d 10 to 18, and phase 3 from d 18 to 38. Dietary treatments were formulated to provide 0, 0.25, or 0.50% benzoic acid (VevoVitall, DSM Nutritional Products, Parsippany, NJ) added at the expense of corn. Treatment 1 served as the control without benzoic acid throughout all three dietary phases. Inversely, treatment 2 included 0.50% benzoic acid throughout all three phases. Treatment 3 contained 0.50% benzoic acid for phase 1 and phase 2, and 0.25% benzoic acid in phase 3. Treatment 4 contained 0.50% benzoic acid for phase 1 and phase 2, but no benzoic acid in phase 3. Finally, treatment 5 contained 0.50% benzoic acid in phase 1, 0.25% benzoic acid in phase 2, and no benzoic acid in phase 3. From d 0 to 10 (phase 1), pigs fed 0.50% benzoic acid had increased ($P = 0.034$) ADG, improved ($P = 0.049$) F/G, and were heavier ($P = 0.040$) on d 10 than those fed the control diet. From d 10 to 18 (phase 2), pigs fed 0.50% benzoic acid had increased ($P < 0.01$) ADG compared to pigs fed either none or 0.25% benzoic acid, while pigs fed 0.25% benzoic acid had poorer ($P < 0.001$) feed efficiency compared to pigs fed 0 or 0.50% benzoic acid. From d 18 to 38 (phase 3), pigs fed 0.50% and 0.25% benzoic acid had increased ($P < 0.01$) ADG and ADFI compared with pigs fed no benzoic acid. For the overall experimental period (d 0 to 38), pigs fed 0.50% in the first two phases and 0.25% benzoic acid in the final phase had a greater ($P < 0.05$) ADG than pigs fed no benzoic acid through all three phases, or pigs fed 0.50% in the first two phases and no benzoic acid in the final phase, with the other treatments intermediate. Additionally, pigs fed 0.50% in the first two phases and 0.25% benzoic acid in the final phase had improved ($P < 0.05$) F/G compared with pigs fed no benzoic acid throughout all three phases, pigs fed 0.50% in the first two phases and no benzoic acid in the third phase, or pigs fed 0.50%, 0.25%, and no benzoic acid, respectively. There was no evidence for differences ($P > 0.10$) in fecal DM among treatments for samples collected on d 10 or d 18. These data suggests that nursery pigs fed benzoic acid had improved growth performance compared to control pigs. However, when the benzoic acid was removed from the diet before the end of the nursery phase, the pigs experienced a reduction in performance which resulted in similar overall nursery performance to the control diet without benzoic acid.

Keywords

acidifier, nursery pigs, growth performance, benzoic acid

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Katelyn N. Gaffield, Joel M. DeRouchey, Mike D. Tokach, Jason C. Woodworth, Robert D. Goodband, and Jordan T. Gebhardt

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KANSAS STATE UNIVERSITY SWINE INDUSTRY DAY 2022

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Katelyn N. Gaffield, Joel M. DeRouchey, Mike D. Tokach, Jason C. Woodworth, Robert D. Goodband, and Jordan T. Gebhardt[1]

Summary

A total of 350 weanling barrows (DNA 200 × 400, DNA; initially 13.0 ± 0.08 lb) were used in a 38-d study to evaluate the effects of different benzoic acid feeding strategies on nursery growth performance and fecal dry matter. Pigs were randomly assigned to pens (5 pigs per pen) and pens were allotted to 1 of 5 dietary treatments with 14 pens per treatment. Diets were fed in 3 phases: phase 1 from weaning to d 10, phase 2 from d 10 to 18, and phase 3 from d 18 to 38. Dietary treatments were formulated to provide 0, 0.25, or 0.50% benzoic acid (VevoVitall, DSM Nutritional Products, Parsippany, NJ) added at the expense of corn. Treatment 1 served as the control without benzoic acid throughout all three dietary phases. Inversely, treatment 2 included 0.50% benzoic acid throughout all three phases. Treatment 3 contained 0.50% benzoic acid for phase 1 and phase 2, and 0.25% benzoic acid in phase 3. Treatment 4 contained 0.50% benzoic acid for phase 1 and phase 2, but no benzoic acid in phase 3. Finally, treatment 5 contained 0.50% benzoic acid in phase 1, 0.25% benzoic acid in phase 2, and no benzoic acid in phase 3. From d 0 to 10 (phase 1), pigs fed 0.50% benzoic acid had increased ($P = 0.034$) ADG, improved ($P = 0.049$) F/G, and were heavier ($P = 0.040$) on d 10 than those fed the control diet. From d 10 to 18 (phase 2), pigs fed 0.50% benzoic acid had increased ($P < 0.01$) ADG compared to pigs fed either none or 0.25% benzoic acid, while pigs fed 0.25% benzoic acid had poorer ($P < 0.001$) feed efficiency compared to pigs fed 0 or 0.50% benzoic acid. From d 18 to 38 (phase 3), pigs fed 0.50% and 0.25% benzoic acid had increased ($P < 0.01$) ADG and ADFI compared with pigs fed no benzoic acid. For the overall experimental period (d 0 to 38), pigs fed 0.50% in the first two phases and 0.25% benzoic acid in the final phase had a greater ($P < 0.05$) ADG than pigs fed no benzoic acid through all three phases, or pigs fed 0.50% in the first two phases and no benzoic acid in the final phase, with the other treatments intermediate. Additionally, pigs fed 0.50% in the first two phases and 0.25% benzoic acid in the final phase had improved ($P < 0.05$) F/G compared with pigs fed no benzoic acid throughout all three phases, pigs fed 0.50% in the first two phases and no benzoic acid in the third phase, or pigs fed 0.50%, 0.25%, and no benzoic acid, respectively. There was no evidence for differences ($P > 0.10$) in fecal DM among treatments for samples collected on d 10 or d 18. These data suggests that nursery pigs fed benzoic acid had improved growth performance compared to control pigs. However, when the benzoic

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acid was removed from the diet before the end of the nursery phase, the pigs experienced a reduction in performance which resulted in similar overall nursery performance to the control diet without benzoic acid.

Introduction

Including an optimal level of an acidifier within the diet throughout the nursery phase has the potential to improve growth performance of weaned pigs and improve economic return for producers. Acidifiers, such as benzoic acid, are suggested to lower the pH of the gastrointestinal tract. The reduction in pH can potentially lead to improved nutrient digestion, growth performance, and gut microbiota.[2] Benzoic acid has been studied when evaluating growth performance and intestinal changes in nursery pigs.[3] However, there is limited research describing the effects of various levels of benzoic acid fed throughout the nursery phase. Therefore, the objective of this study was to investigate the effects of varying levels and feeding durations of benzoic acid in nursery diets on growth performance and fecal dry matter.

Procedures

The protocol used in this experiment was approved by the Kansas State University Institutional Animal Care and Use Committee. The study was conducted at the Kansas State University Segregated Early Weaning Facility located in Manhattan, KS. The pigs were housed in two identical barns. Each barn was enclosed and environmentally controlled using mechanical ventilation. Pens had a metal tri-bar floor, contained a cup waterer, and had a 4-hole, dry self-feeder. Pens (4 × 4 ft) housed 5 pigs which allowed approximately 2.7 ft^2/pig.

A total of 350 weanling barrows (DNA 200 × 400; initially 13.0 ± 0.08 lb) were randomly assigned to pens and pens were allotted to 1 of 5 dietary treatments with 14 pens per treatment. The pigs had *ad libitum* access to the treatment diets and water for the entirety of the 38-d study. Diets were fed in 3 phases: phase 1 from weaning to d 10, phase 2 from d 10 to 18, and phase 3 from d 18 to 38. Dietary treatments were formulated to provided 0, 0.25, or 0.50% benzoic acid (VevoVitall, DSM Nutritional Products, Parsippany, NJ) added at the expense of corn. Treatment 1 served as the control and contained no benzoic acid throughout all three phases. Treatment 2 included 0.50% benzoic acid throughout all three phases. Treatment 3 contained 0.50% benzoic acid for phase 1 and phase 2, but only 0.25% benzoic acid in phase 3. Treatment 4 contained 0.50% benzoic acid in phase 1 and phase 2, and no benzoic acid in phase 3. Treatment 5 contained 0.50% benzoic acid in phase 1, 0.25% benzoic acid in phase 2, and no benzoic acid in phase 3. A single base diet was manufactured at Hubbard Feeds in Beloit, KS, with benzoic acid and corn additions mixed in at the Kansas State University O.H. Kruse Feed Technology Innovation Center, Manhattan, KS, for both the phase 1 and phase 2 diets. For phase 3, complete diets were manufactured at Hubbard Feeds in Beloit, KS. The diets were fed in meal form and pig weights and feed disappearance were measured on d 0, 10, 18, 24, and 38 to determine ADG, ADFI, and F/G. Feces was collected on d 10 and d 24 from 3 pigs per pen to determine

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[2] Torrallardona, D., I. Badiola, and J. Broz. 2007. Effects of benzoic acid on performance and ecology of gastrointestinal microbiota in weanling piglets. Livest. Sci. 108:210-213. doi: 10.1016/j.livsci.2007.01.062.

[3] 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.

fecal dry matter. Samples were dried at 130°F for 48 h and loss of weight used to determine fecal dry matter percent.

Statistical analysis

Data were analyzed as a randomized complete block design with pen serving as the experimental unit, treatment as a fixed effect, and barn as a random effect. Data were analyzed using R Studio (Version 3.5.2, R Core Team, Vienna, Austria). Contrasts were used to test for the main effects of the different benzoic acid feeding levels (0, 0.25, and 0.50%), within the three phases. Overall performance data were analyzed as a one-way ANOVA using the lmer function from the lme4 package. Differences for treatments demonstrating a significant source of variation were determined through pairwise comparisons using the Tukey-Kramer multiplicity adjustment to control for type I error. All results were considered significant at $P \leq 0.05$ and marginally significant at $0.05 > P \leq 0.10$. Similarly, contrasts were used to test for the main effects of treatment, day, and interaction between treatment and day of different benzoic acid feeding levels on fecal DM.

Results and Discussion

From d 0 to 10 (phase 1), pigs fed 0.50% benzoic acid had increased ($P = 0.034$) ADG, improved ($P = 0.049$) F/G, and heavier ($P = 0.040$) d 10 BW than those fed the control diet (Table 2). From d 10 to 18 (phase 2), pigs fed 0.50% benzoic acid had increased ($P < 0.01$) ADG compared to pigs fed either 0 or 0.25% benzoic acid, while pigs fed 0.25% benzoic acid had poorer ($P < 0.001$) feed efficiency compared to pigs fed 0 or 0.50% benzoic acid. There was a significant increase in ADFI for pigs fed 0.25% ($P = 0.033$) benzoic acid and a marginally significant increase in ADFI for pigs fed 0.50% ($P = 0.069$) benzoic acid in phase 2 compared to pigs fed no benzoic acid; however, they did not differ from each other. Additionally, pigs fed 0.50% benzoic acid had increased ($P = 0.012$) d 18 BW compared to pigs fed no benzoic acid, while pigs fed 0.25% benzoic acid were intermediate. From d 18 to 38 (phase 3), pigs fed 0.50 or 0.25% benzoic acid had increased ($P < 0.01$) ADG and ADFI compared with pigs fed no benzoic acid. Additionally, pigs fed 0.25% benzoic acid in phase 3 had improved ($P < 0.05$) F/G compared to pigs fed 0% or 0.50% benzoic acid.

For the overall experimental period (d 0 to 38), pigs fed 0.50% benzoic acid in the first two phases and 0.25% benzoic acid in the final phase had a greater ($P < 0.05$) ADG than pigs fed no benzoic acid through all three phases and pigs fed 0.50% benzoic acid in the first two phases with no benzoic acid in the final phase, while pigs fed the other treatments were intermediate. Additionally, pigs fed 0.50% in the first two phases and 0.25% benzoic acid in the final phase had improved ($P < 0.05$) F/G compared with pigs fed no benzoic acid throughout all three phases, pigs fed 0.50% in the first two phases and no benzoic acid in the third phase, and pigs fed 0.50%, 0.25%, and no benzoic acid, respectively. There was also evidence for differences ($P < 0.01$) in d 38 BW with pigs fed 0.50% benzoic acid in the first two phases and 0.25% benzoic acid in the third phase having increased ($P < 0.01$) BW, compared to pigs fed no benzoic acid throughout all three phases and pigs fed 0.50% benzoic acid in the first two phases with no benzoic acid in the final phase. There was no evidence ($P = 0.679$) of an interaction between treatment and day for fecal DM. Furthermore, there was no evidence of a main effect of treatment ($P = 0.199$). However, there was evidence for a main effect of day ($P < 0.001$) with fecal DM being lower on d 18 compared to d 10.

In summary, the data suggest that feeding benzoic acid for the first 38 days post-weaning improves ADG and F/G. However, when benzoic acid was removed from the diet, the pigs experienced a reduction in performance and ultimately performed similar to pigs which received no benzoic acid throughout the entire experimental period. Thus, it appears that in this study feeding 0.50% benzoic acid in all three phases or 0.50% benzoic acid for the first two phases and 0.25% in the third phase resulted in improved growth performance throughout the 38-d period. A unique finding of this research was the reduction in performance once benzoic acid was removed, suggesting more research is needed to further determine the impacts of removing benzoic acid later in the nursery period.

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Table 1. Diet composition (as-fed basis)[1]

Item, %	Phase 1	Phase 2	Phase 3
Ingredients, %			
Corn	44.90	50.15	64.25
Soybean meal, 46.5% CP	17.40	23.75	31.80
Spray-dried whey	10.00	---	---
Whey permeate, 80% lactose	10.00	10.00	---
DDGS	5.00	7.50	---
Fish meal, 60% CP	2.50	---	---
Fermented soybean meal[2]	4.00	3.85	---
Spray-dried bovine plasma	2.00	---	---
Choice white grease	1.00	1.00	---
Monocalcium P, 21% P	0.80	1.00	1.00
Calcium carbonate	0.45	0.45	0.90
Zinc oxide	0.40	0.25	---
Salt	0.30	0.50	0.60
Vitamin premix with phytase	0.25	0.25	0.25
Trace mineral premix	0.15	0.15	0.15
L-Lys-HCL	0.40	0.55	0.50
DL-Met	0.19	0.22	0.21
L-Thr	0.17	0.22	0.21
L-Trp	0.02	0.04	0.04
L-Val	0.08	0.12	0.13
Benzoic acid[3]	+/-	+/-	+/-
Total	100	100	100

continued

Table 1. Diet composition (as-fed basis)[1]

Item, %	Phase 1	Phase 2	Phase 3
Calculated analysis			
SID amino acids, %			
Lys	1.35	1.35	1.35
Ile:Lys	57	57	56
Leu:Lys	120	118	115
Met:Lys	36	37	36
Met and Cys:Lys	59	58	58
Thr:Lys	64	63	63
Trp:Lys	19.2	19.3	19.4
Val:Lys	70	70	70
Total Lys, %	1.51	1.51	1.50
NE, kcal/lb	1,153	1,135	1,097
SID Lys:NE, g/Mcal	5.31	5.40	5.58
CP, %	21.5	21.5	21.3
Ca, %	0.66	0.54	0.71
P, %	0.66	0.61	0.61
STTD P, %	0.58	0.51	0.47

[1] Phase 1 diets were fed from 13.0 lb to 16.4 lb, phase 2 diets were fed from 16.4 lb to 23.1 lb, and phase 3 diets were fed from 23.1 lb to 46.2 lb.
[2] MEPro, Prairie Aquatech, Brookings, SD.
[3] Benzoic acid (VevoVitall, DSM Nutritional Products, Parsippany, NJ) at 0.25 or 0.50% of the diet was included at the expense of corn.

Table 2. Effects of benzoic acid feeding strategy on nursery pig performance and fecal dry matter[1,2]

	Benzoic acid, %[3]						Contrast, P =		
Phase 1:	0	0.50	0.50	0.50	0.50				
Phase 2:	0	0.50	0.50	0.50	0.25		0% vs.	0% vs.	0.25 vs.
Phase 3:	0	0.50	0.25	0	0	SEM	0.5%	0.25%	0.50%
Initial BW, lb									
d 0	13.0	13.0	13.1	13.1	13.1	0.077	0.785	---	---
d 10	16.1	16.6	16.3	16.4	16.9	0.208	0.040	---	---
d 18	22.5	23.6	23.4	23.1	23.0	0.302	0.012	0.186	0.340
d 38	45.0[bc]	47.7[ab]	48.3[a]	44.5[c]	45.8[abc]	0.784	0.003	< 0.001	0.553
d 0 to 10 (Phase 1)									
ADG, lb	0.30	0.36	0.32	0.33	0.38	0.022	0.034	---	---
ADFI, lb	0.36	0.41	0.39	0.38	0.43	0.023	0.144	---	---
F/G	1.23	1.14	1.20	1.16	1.12	0.039	0.049	---	---
d 10 to 18 (Phase 2)									
ADG, lb	0.80	0.87	0.88	0.84	0.77	0.022	0.009	0.333	< 0.001
ADFI, lb	1.00	1.07	1.07	1.04	1.09	0.027	0.069	0.033	0.412
F/G	1.25	1.23	1.21	1.24	1.41	0.032	0.488	< 0.001	< 0.001
d 18 to 38 (Phase 3)									
ADG, lb	1.13	1.20	1.24	1.07	1.14	0.032	0.003	< 0.001	0.233
ADFI, lb	1.70	1.82	1.81	1.66	1.73	0.054	0.004	0.008	0.869
F/G	1.51	1.52	1.46	1.56	1.52	0.017	0.457	< 0.001	0.013
d 0 to 38 (Overall)									
ADG, lb	0.84[bc]	0.90[ab]	0.92[a]	0.82[c]	0.86[abc]	0.022	---	---	---
ADFI, lb	1.20	1.28	1.27	1.19	1.25	0.036	---	---	---
F/G	1.43[a]	1.42[ab]	1.38[b]	1.44[a]	1.45[a]	0.013	---	---	---
Fecal DM, %[4]									
d 10	26.32	26.62	24.65	26.18	26.68	0.675	0.739	---	---
d 18	23.58	24.02	23.54	24.51	24.57	0.675	0.450	0.173	0.356

[1]A total of 350 weanling barrows (DNA 200 × 400, DNA; initially 13.0 ± 0.08 lb) approximately 21 days of age were used in a 38-d experiment with 5 pigs per pen and 14 pens per treatment.

[2]Different superscript letters within the same row reflect dietary treatment differences ($P \leq 0.05$).

[3]VevoVitall, DSM Nutritional Products, Parsippany, NJ.

[4]Feces from three piglets from each pen were pooled, weighed, and dried to measure fecal dry matter. Treatment × day, $P = 0.679$; Treatment, $P = 0.199$; Day, $P < 0.001$.