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The Effects of Feeding Benzoic Acid and Essential Oils on Growth Performance, Survivability and Fecal Characteristics of Grower Pigs

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Abstract
A total of 200 pigs (DNA Line 200 × 400) with an initial body weight of 81 lb were used to determine the effects of feeding benzoic acid and an essential oil blend (Vevo- Vitall and CRINA Piglets AF, DSM Nutritional Products, Parsippany, NJ) to grower pigs. There were 10 pigs per pen and 10 pens per treatment in this 28-d grower trial. Pigs were allotted by BW and randomly assigned to 1 of 2 dietary treatments. Dietary treatments included a control diet, or the control diet with added benzoic acid (6.00 lb/ ton) paired with an essential oil blend (0.20 lb/ton). For overall growth performance (d 0 to 28), adding benzoic acid and an essential oil blend to the grower diet did not affect ($P > 0.05$) ADG, ADFI, or F/G. Throughout the duration of this study, a trend ($P = 0.06$) was found for an increased loss from death and removals in pigs fed the control diet compared to pigs fed a diet containing an acidifier and essential oil blend. *Lawsonia* was detected in all d 28 fecal samples collected, except for one, whereas *Salmonella* was not detected in any of the fecal samples. Although there was no hemolytic *Escherichia coli* detected, there were other coliforms that were sporadic in occurrence. When comparing fecal samples collected on d 14, there was a tendency ($P = 0.10$) for pigs fed the control diet to have greater amounts of *E. coli* detected than those pigs fed the diet containing benzoic acid and an essential oil blend. More research is needed to confirm the reduced death loss found for pigs fed benzoic acid and an essential oil blend compared to pigs fed a control diet.

Keywords
benzoic acid, essential oils, grower pigs

Cover Page Footnote
The authors wish to thank DSM for providing the VevoVitall and CRINA used in this study, as well as for financial support.

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The Effects of Feeding Benzoic Acid and Essential Oils on Growth Performance, Survivability and Fecal Characteristics of Grower Pigs[1]

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Summary

A total of 200 pigs (DNA Line 200 × 400) with an initial body weight of 81 lb were used to determine the effects of feeding benzoic acid and an essential oil blend (Vevo-Vitall and CRINA Piglets AF, DSM Nutritional Products, Parsippany, NJ) to grower pigs. There were 10 pigs per pen and 10 pens per treatment in this 28-d grower trial. Pigs were allotted by BW and randomly assigned to 1 of 2 dietary treatments. Dietary treatments included a control diet, or the control diet with added benzoic acid (6.00 lb/ton) paired with an essential oil blend (0.20 lb/ton). For overall growth performance (d 0 to 28), adding benzoic acid and an essential oil blend to the grower diet did not affect ($P > 0.05$) ADG, ADFI, or F/G. Throughout the duration of this study, a trend ($P = 0.06$) was found for an increased loss from death and removals in pigs fed the control diet compared to pigs fed a diet containing an acidifier and essential oil blend. *Lawsonia* was detected in all d 28 fecal samples collected, except for one, whereas *Salmonella* was not detected in any of the fecal samples. Although there was no hemolytic *Escherichia coli* detected, there were other coliforms that were sporadic in occurrence. When comparing fecal samples collected on d 14, there was a tendency ($P = 0.10$) for pigs fed the control diet to have greater amounts of *E. coli* detected than those pigs fed the diet containing benzoic acid and an essential oil blend. More research is needed to confirm the reduced death loss found for pigs fed benzoic acid and an essential oil blend compared to pigs fed a control diet.

Introduction

Alternative feed ingredients with growth-promoting properties are becoming more important than ever in the swine industry. One such alternative being studied is a class of phytogenic feed additives known as essential oils. Essential oils are extracted from plants, or synthetically made to be "naturally identical," and are known to sometimes have beneficial properties including flavoring, stimulation of enzyme secretion, anti-

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oxidant, and/or microbiome-altering activities.[4] These benefits have the potential to improve digestive efficiency. Another alternative being studied is benzoic acid for acidification. Benzoic acid is considered by some to be a growth-promoting feed additive because it has been seen to relieve the animal from immune defense stress and increase nutrient absorption, allowing the animal to grow better within its genetic potential.[5] In poultry, Weber et al.[3] fed diets with a blend of essential oils and found an improvement in body weight on d 21 ($P = 0.002$) and d 42 ($P = 0.02$). They also reported a significant increase ($P = 0.02$) in ADG for the entire poultry starter and grower trial period. A study feeding benzoic acid to weaned pigs showed benefits, including improved final body weight and improved ADG and G:F, from days 15 to 42 postweaning and the entire trial period.[6] The objective of this study was to determine if feeding benzoic acid (VevoVitall, DSM Nutritional Products, Parsippany, NJ) and an essential oil blend (CRINA Piglets AF, DSM Nutritional Products, Parsippany, NJ) can change growth rate and reduce diarrhea for grower pigs at a farm with an existing history of enteric challenges.

Procedures

The protocol for this experiment was approved by the Kansas State University Institutional Animal Care and Use Committee. The study was conducted at the K-State Swine Teaching and Research Center, Manhattan, KS.

A total of 200 pigs (DNA Line 200 × 400) with an initial BW of 81 lb were used in a 28-d grower trial. They were housed 10 pigs per pen and 10 replicates per treatment with pen as the experimental unit. The pigs were allotted by BW to pen and then pens were randomly assigned 1 of 2 dietary treatments in a completely randomized design. The two dietary treatments included a control grower diet without any growth-promoting feed additives, and a diet containing benzoic acid and essential oil blend (VevoVitall and CRINA Piglets AF, DSM Nutritional Products, Parsippany, NJ) at an inclusion of 6.00 lb/ton and 0.20 lb/ton, respectively. All diets were formulated to meet or exceed the Swine NRC dietary requirements.[7] Pigs were provided ad libitum access to water and feed in meal form.

Pigs and feeders were weighed on a weekly basis including d 0, 7, 14, 21, and 28 of the trial to determine ADG, ADFI, and F/G. The average total for pen live gain, pen feed disappearance, and pen live F/G were determined for d 0 to 28. Pen weights were collected after the initial allotment weigh period on d 0. Pigs were fed the dietary treatments for d 0 to 28. Feed was distributed and recorded by a robotic feeding system (FeedPro; Feedlogic Corp., Wilmar, MN) 4 times a day. Diet samples were taken from

[4] Weber, G. M., M. Michalczuk, G. Huyghebaert, H. Juin, C. Kwakernaak, and M. I. Gracia. 2012. Effects of a blend of essential oil compounds and benzoic acid on performance of broiler chickens as revealed by a meta analysis of 4 growth trials in various locations. Poult Sci. 91:2820-2828. doi:10.3382/ps.2012-02243.

[5] Windisch, W., K. Schedle, C. Plitzner, and A. Kroismayr. 2008. Use of phytogenic products as feed additives for swine and poultry. J. Anim. Sci. 86:E140-E148. doi: 10.2527/jas.2007-0459.

[6] Chen, J. L., P. Zheng, C. Zhang, B. Yu, J. He, J. Yu, J. Q. Luo, X. B. Mao, Z. Q. Huang, and D. W. Chen. 2016. Benzoic acid beneficially affects growth performance of weaned pigs which was associated with changes in gut bacterial populations, morphology indices and growth factor gene expression. J Anim Physiol Anim Nutr (Berl). doi: 10.111/jpn.12627

[7] NRC. 2012. Nutrient Requirements of Swine, 11th ed. Natl. Acad. Press, Washington DC.

all 20 feeders, pooled, subsampled, and stored at -20°C. Table 1 contains both diet formulations and the calculated analysis for each grower diet. All diets were prepared at the K-State O.H. Kruse Feed Technology Innovation Center, Manhattan, KS. Fecal samples were collected from 3 barrows per pen on d 1, 14, and 28. Samples were sent to the Iowa State Veterinary Diagnostic Lab in Ames, IA, where they were pooled before being analyzed for *Lawsonia*, *Salmonella*, and *Escherichia coli*.

Growth performance data were analyzed using the GLIMMIX procedure in SAS version 9.4 (SAS Institute, Inc., Cary, NC). The experiment was a completely randomized design with repeated measures. Pigs were assigned to mixed-gender pens based on individual initial weights, with the pens as the experimental units for the dietary treatments. The dietary treatment was considered as the fixed factor. The pens were randomly assigned to 1 of 2 dietary treatments. Time points were the repeated measure factor at which the pens were measured repeatedly over time. The covariance structure for repeated measure factor was chosen to be autoregressive model of order 1 (AR(1)) as the best fit based on Bayesian Information Criterion. The *E. coli* data were analyzed consistent with the previously mentioned description using binary data measuring the probability of presence with the default logit link function. The death/removal rate data were analyzed using the Fisher's Exact Test to test the relationship between deaths/removals and feed categorical variables. Statistical significance of above analyses was determined at $P < 0.05$ and trends at $P < 0.10$.

Results and Discussion

For overall growth performance (d 0 to 28), adding benzoic acid and an essential oil blend to the grower diet did not affect ($P > 0.05$) ADG, ADFI, or F/G (Table 2).

For total pen live performance from d 0 to 28, pigs fed the benzoic acid and essential oil diet tended ($P > 0.05$) to have improved ADG and F/G compared with pigs fed the control diet (Table 3).

Over the entire course of this study, death/removal losses in the control fed pigs tended ($P = 0.06$) to be greater compared to the benzoic acid and essential oil fed pigs (Table 2). All fecal samples collected on d 28, except one, tested PCR positive for *Lawsonia.* Five of the 20 pens had *Lawsonia* CT values <20, which gives a high likelihood of clinical significance. *Salmonella* was not detected in any of the samples. Although there was no hemolytic *E. coli* detected, there were other coliforms that were sporadic in occurrence and the numbers present. When comparing fecal samples from collection on day 14, pigs fed VevoVitall and CRINA tended ($P = 0.10$) to have fewer *E. coli* detected than those fed a control diet.

In conclusion, adding benzoic acid and an essential oil blend to the grower diet did not affect overall growth performance in this study. However, the higher losses from deaths and removals in the control pigs warranted further testing of the fecal samples collected. The presence of *Lawsonia* was only determined for d 28 samples, and was found to be present in every pen. Although the cause of reduced death loss in pigs fed the combination of VevoVitall and CRINA, compared to pigs fed the control diet, could not be elicited in the experiment, further research is needed to understand this experimental response.

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

Ingredient	%
Corn	71.51
Soybean meal	25.70
Monocalcium P (21% P)	0.55
Limestone	1.125
Salt	0.35
L-Lys-HCL	0.305
DL-Met	0.06
L-Thr	0.085
Trace mineral premix	0.15
Vitamin premix	0.15
Phytase[2]	0.015
Benzoic acid[3]	---
Essential oil blend[4]	---
Total	100.00
Calculated analysis[5]	
SID lysine, %	1.05
NE, kcal/lb	1,117
CP, %	18.50
Ca, %	0.60
Available P, %	0.28
Standardized digestible P, %	0.34

[1] Diets were fed from d 0 to 28.

[2] Ronozyme Hiphos (GT) 2700 (DSM Nutritional Products, Parsippany, NJ), with a release of 0.10% available P.

[3] VevoVitall (DSM Nutritional Products, Parsippany, NJ) is an ultra-pure source of benzoic acid added at 6.0 lb/ton.

[4] CRINA Piglets AF (DSM Nutritional Products, Parsippany, NJ) is a blend of essential oils added at 0.20 lb/ton.

[5] NRC. 2012. Nutrient Requirements of Swine, 11th ed. Natl. Acad. Press, Washington D.C.

Table 2. Effects of feeding benzoic acid and an essential oil blend on growth performance[1]

	Diet[2]			
	Control	Benzoic acid[3] and essential oil blend[4]	SEM	Probability, $P <$
d 0 to 28				
ADG, lb	1.77	1.89	0.0855	0.2387
ADFI, lb	4.47	4.48	0.0579	0.9424
F/G	2.58	2.39	0.1273	0.2155
Mortality and removals, %[5]	7.00	1.00	---	0.0649
BW, lb				
d 0	80.84	81.18	1.1758	0.8520
d 28	127.84	133.72	1.1758	0.6942

[1] A total of 200 grower pigs (DNA Line 200 × 400, initially 81 lb BW) were used in a 28-d growth trial with 10 pigs per pen and 10 pens per treatment.

[2] Diets were fed from d 0 to 28.

[3] VevoVitall (DSM Nutritional Products, Parsippany, NJ) is an ultra-pure source of benzoic acid added at 6.0 lb/ton.

[4] CRINA Piglets AF (DSM Nutritional Products, Parsippany, NJ) is a blend of essential oils added at 0.20 lb/ton.

[5] The mortality and removal data were analyzed using the Fisher's Exact Test to test the relationship between deaths/removals and feed categorical variables.

Table 3. Effects of feeding benzoic acid and an essential oil blend on total pen live performance[1]

	Diet[2]			
	Control	Benzoic acid[3] and essential oil blend[4]	SEM	Probability, $P <$
Average pigs per pen				
d 0	10	10	---	---
d 28	9.3	9.9	---	---
d 0 to 28				
Average total pen live gain, lb	470.0	525.4	26.034	0.1497
Average total pen feed disappearance, lb	1223.2	1249.5	19.979	0.3635
Average total pen live F/G	2.71	2.41	0.1424	0.1582

[1] A total of 200 grower pigs (DNA Line 200 × 400, initially 81 lb BW) were used in a 28-d growth trial with 10 pigs per pen and 10 pens per treatment.

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