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EFFECTS OF DIETARY CALCIUM FORMATE AND MALIC ACID ON NURSERY PIG GROWTH PERFORMANCE

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Summary

A total of 180 weanling pigs (initially 14.1 lb and 18 ± 3 d of age, PIC) were used to determine the effects of dietary calcium formate or malic acid on nursery pig growth performance. Treatments were arranged in a 2×3 factorial, with or without an antimicrobial, and with or without calcium formate or malic acid, for a total of six dietary treatments: 1) negative control (no organic acids or antimicrobials); 2) positive control (feed containing 140 g/ton neomycin sulfate, 140 g/ton oxytetracycline; neo/oxy); 3) negative control feed containing malic acid; 4) positive control feed containing malic acid; 5) negative control feed containing calcium formate; 6) positive control feed containing calcium formate. There were no interactions ($P > 0.10$) between the antimicrobial and the organic acids. Overall, pigs fed diets containing neo/oxy had greater ADG and ADFI ($P < 0.04$) than did pigs fed diets without an antimicrobial. There were no differences in growth performance between pigs fed the control diet and pigs fed diets containing organic acids. These data suggest that neo/oxy increases ADG and ADFI of weanling pigs. Neither malic acid nor calcium formate are suitable replacements for neo/oxy for growth performance in nursery pigs.

(Key Words: Nursery Pig, Antibiotics, Organic Acids, Water, Growth.)

Introduction

Recent concern over antimicrobial usage in livestock diets has prompted research for antimicrobial alternatives for nursery pig diets. One such alternative is the addition of organic acids to the feed. Research at Kansas State University in 1990 and 1996 evaluated organic acids in semi-complex nursery pig diets containing one or more antimicrobial additives. This research indicated that organic acids did not improve growth performance in nursery pigs when used in combination with an antimicrobial. Since this research was conducted, the general objective of diet acidification has taken secondary interest to antimicrobial replacement for growth performance enhancement. Many alternatives such as organic acids have received renewed interest as potential replacements for antimicrobials, but few have been proven effective. The two most commonly researched organic acids are citric and fumaric acid, neither of which have been shown to effectively replace antimicrobials in nursery pig diets. Two other organic acids that have shown potential for antimicrobial replacement are formic and malic acid. Although pure formic acid is not legal for use in animal feeds in the United States, salts of this acid are available. Salts of formic acid are typically used in food and feed preservation, and have limited availability for use in swine diets, but show the greatest potential for im-

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proving growth performance, according to European research. One such salt, potassium formate, has been effective in nursery pig diets in Europe and Canada, but is not yet available for use in the United States. Another salt, calcium formate, is available, but little research exists on its effectiveness. Another organic alternative, malic acid, is a naturally occurring substance in apples and other fruits, but is commercially produced as a fruit drink additive and food preserver. Malic acid has been briefly evaluated in beef cattle diets, with little or no effect on gastrointestinal pH, and in nursery pig diets, with a negative effect on feed intake. But little recent research exists for these organic acids as antimicrobial alternatives in nursery pig diets. Therefore, the objective of this experiment was to determine the effects of calcium formate and malic acid, and the interactive effects of these acids with an in-feed antimicrobial (neomycin/oxytetracycline), on the growth performance of weanling pigs.

Procedures

A total of 180 weanling pigs (initially 14.1 lb and 18 ± 3 d of age, PIC) were placed 5 pigs per pen in 36 pens, allowing 6 pens per treatment. Dietary treatments were arranged in a 2×3 factorial design for a total of 6 experimental diets: 1) negative control (no organic acids or antimicrobials); 2) positive control (feed containing 140 g/ton neomycin sulfate, 140 g/ton oxytetracycline; neo/oxy); 3) negative control feed containing malic acid; 4) positive control feed containing malic acid; 5) negative control feed containing calcium formate; 6) positive control feed containing calcium formate. Pigs remained on the same dietary treatments throughout the experiment.

Dietary treatments were fed in meal form (Table 1). Phase 1 (d 0 to 14 after weaning) diets were formulated to contain 1.41% true ileal digestible (TID) lysine, 0.92% Ca, and 0.55% available P. Phase 2 (d 14 to 28 after weaning) diets were formulated to contain

1.31% TID lysine, 0.80% Ca, and 0.38% available P. In diets containing calcium formate, this organic acid was used as the sole source of calcium, and no limestone was used. The trial was conducted at the Segregated Early Weaning nursery facility at Kansas State University. Each pen (5 $\times$ 5 ft) contained one self-feeder and one bowl waterer to provide *ad libitum* access to feed and water. Pigs and feeders were weighed on d 0, 14, and 28 after weaning to determine ADG, ADFI, and F/G.

Data were analyzed as a 2×3 factorial, with pen as the experimental unit. Analysis of variance was performed by using the MIXED procedure of SAS. Contrasts were used to determine treatment mean differences, main effects of antimicrobials or organic acids, and the antimicrobial $\times$ organic acid interaction. Data were also analyzed as two separate 2×2 factorial structures for each organic acid to further determine possible interactions between each organic acid and the antimicrobial.

Results

Interactions between organic acids and the antimicrobial were evaluated in the original 2×3 factorial arrangement and as two separate 2×2 factorials with each organic acid. In both analyses, there were no significant interactions during any phase of the experiment.

From d 0 to 14 after weaning, there were no differences ($P > 0.17$) between pigs fed the control diets and those fed the neo/oxy for ADG or F/G, but pigs fed neo/oxy tended ($P = 0.10$) to have greater ADFI than those fed the control diet. Furthermore, addition of organic acid to the diet (with or without neo/oxy) had no effect on ADG, ADFI, or F/G.

From d 14 to 28 after weaning, pigs fed the diets containing neo/oxy had greater ($P < 0.04$) ADG and ADFI than did pigs fed the diets with no antimicrobial; there was no change ($P > 0.50$) in F/G. As observed from d 0 to 14, there were no improvements ($P > 0.14$)

in growth performance when either malic acid or calcium formate was added to the diet.

Overall (d 0 to 28), pigs fed diets containing neo/oxy had greater ($P<0.04$) ADG and ADFI than did pigs fed non-medicated feed. No differences among pigs fed either organic acid were observed for the overall treatment period.

Discussion

In general, organic acids or their salts are thought to lower gastric pH, resulting in improved nutrient digestion and reduced bacteria concentration in the gut. Adding organic acids to the diet has been shown to be most effective during the first 2 weeks after weaning, with the benefit decreasing thereafter. Acidification of starter diets is also thought to be more effective in simple corn-soybean meal diets than

in diets containing high amounts of dried whey and specialty protein sources. Perhaps the effect of organic acids in our experiment could have been improved if less complex diets were used. Pigs in this study also weighed more than 14 lb at weaning, which also may have reduced a response to acidification.

As observed in previous studies conducted at our research farm, pigs fed nursery diets containing neo/oxy had greater ADG and ADFI than did pigs fed the control diet with no medication during the first 28 days after weaning. Studies have shown that dietary organic acids can enhance the effects of antibiotics by improving their absorption, but this was not true in our study. These data suggest that neo/oxy increases ADG and ADFI of weanling pigs. Neither malic acid nor calcium formate are suitable replacements for neo/oxy for growth performance in nursery pigs.

Table 1. Diet Composition (As-fed Basis)

Ingredient, %	Phase 1 ^a	Phase 2 ^b
Corn ^c	43.06 to 44.68	55.63 to 57.25
Soybean meal, 46.5%	28.59 to 28.71	35.25 to 35.37
Spray dried whey	15.00	---
Select menhaden fish meal	5.00	---
Soy oil	3.00	3.00
Monocalcium phos, 21% P	1.15	1.45
Limestone ^d	0.00 to 0.60	0.00 to 1.05
Vitamins, minerals, & salt	0.75	0.75
Lysine HCl	0.25	0.30
DL -Methionine	0.15	0.13
L-Threonine	0.13	0.13
Test ingredient ^e	0.00 to 1.50	1.35 to 1.50
Total	100.00	100.00
Calculated Analysis		
True ileal digestible lysine, %	1.41	1.31
Total lysine, %	1.55	1.45
ME, kcal/lb	1,537 to 1,563	1,541 to 1,567
CP, %	22.4	21.6
Ca, %	0.92	0.80
P, %	0.82	0.71
Available P, %	0.55	0.38

^aPhase 1 diets fed from d 0 to 14 after weaning.

^bPhase 2 diets fed from d 14 to 28 after weaning.

^cCorn and soybean meal contents fluctuated to accommodate various additions of organic acids, while maintaining amino acid values across treatments within phases.

^dDiets containing calcium formate did not contain limestone; it was replaced as the source of calcium by this organic acid.

^eContaining 0.70% cornstarch or antimicrobial (140 g neomycin sulfate and 140 g oxytetracycline HCl per ton of complete feed) and either 0% organic acids, 1.50% malic acid (Phases 1 and 2), 0.75% calcium formate (Phase 1) or 1.35% calcium formate (Phase 2).

Table 2. Effects of In-feed Antimicrobials and Organic Acids on Weanling Pig Growth Performance^a

Item,	Without Antimicrobial			Antimicrobial ^b			SE	Probability, P<		
	Negative Control	Malic Acid	Calcium Formate	Positive Control	Malic Acid	Calcium Formate		Anti-microbial	Malic Acid	Calcium Formate
d 0 to 14										
ADG, lb	0.29	0.27	0.27	0.28	0.33	0.34	0.039	0.17	0.80	0.63
ADFI, lb	0.37	0.33	0.34	0.36	0.38	0.41	0.029	0.10	0.82	0.72
F/G	1.38	1.27	1.30	1.29	1.23	1.21	0.093	0.31	0.39	0.45
d 14 to 28										
ADG, lb	1.05	1.14	1.05	1.14	1.21	1.15	0.058	0.04	0.15	0.93
ADFI, lb	1.55	1.64	1.50	1.65	1.72	1.65	0.087	0.03	0.23	0.64
F/G	1.48	1.44	1.43	1.45	1.42	1.43	0.041	0.53	0.39	0.39
d 0 to 28										
ADG, lb	0.66	0.70	0.65	0.70	0.75	0.75	0.047	0.04	0.28	0.65
ADFI, lb	0.94	0.97	0.91	0.99	1.03	1.03	0.057	0.02	0.35	0.94
F/G	1.44	1.41	1.40	1.41	1.37	1.38	0.039	0.35	0.28	0.38

^aA total of 180 pigs, initially 14.1 lb and 18 ± 3 d of age, with six replications per treatment. There were no interactions ($P>0.10$) between organic acids and the antimicrobial (2×3 factorial) or between the individual organic acids and the antimicrobial (2×2 factorial) during any phase of the experiment.

^bProvided 140 g neomycin sulfate and 140 g oxytetracycline HCl (neo/oxy) per ton of complete feed.