EFFECTS OF WATER-SOLUBLE AND IN-FEED ORGANIC ACIDS ON THE GROWTH PERFORMANCE OF WEANLING PIGS[1]

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Summary

A total of 360 weanling pigs (initially 11.5 lb and 18 ± 3 d of age, PIC) were used in a 42-d growth assay to determine the effects of water-soluble antimicrobials and organic acids in feed and/or water on nursery pig growth performance. Pigs were allotted to one of 9 experimental treatments: 1) control (no feed or water antimicrobials or acids); 2) water containing 38 mg/L neomycin sulfate; 3) water containing 0.06% Activate[3] WD; 4) water containing 0.12% Activate WD; 5) feed containing Neo-Terramycin[4] (140 g/ton neomycin sulfate, 140 g/ton oxytetracycline HCl; neo/oxy); 6) feed containing 0.50% Activate DA; 7) feed containing 0.45% Starter L; 8) feed containing 0.45% Multimax L; and 9) feed containing 0.50% Activate DA and 0.10% Mintrex[3] P. Overall (d 0 to 42 after weaning), pigs provided neo/oxy in the feed had greater (P<0.05) ADG, compared with pigs in all other treatments, except the pigs provided the combination of Activate DA and Mintrex P in the feed. Pigs provided neo/oxy in the feed had greater ADFI (P<0.02) than did pigs provided the control treatment. There were no differences in feed efficiency between any of the treatments. These data demonstrate that pigs provided in-feed antimicrobials had improved growth, whereas those provided organic acids in feed and water did not.

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

Introduction

Methionine hydroxyl analogs (MHA) are L-methionine precursors used in swine diets. In addition, MHA is chemically an organic acid, which may influence pig performance by modulating the growth of the microflora population in the gastrointestinal tract, and potentially improving nutrient utilization. Activate WD (water dispersible), DA (dry acid), Starter L (liquid), and Multimax L (liquid) organic acid blends are combinations of MHA and butyric, propionic, and/or lactic acids with methionine activity ranging from 29% to 31%. Mintrex P is a mixture of organic trace minerals, including zinc, copper, and manganese, with some residual methionine activity as a result of having MHA as the carrier. Although these Activate products are thought to improve growth performance in weanling pigs, antimicrobials such as neomycin sulfate, alone in the water, or in combination with oxytetracycline HCl in the feed, have been shown to improve growth performance and feed effi-

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[2]Food Animal Health and Management Center, College of Veterinary Medicine.

[3]Activate and Mintrex are registered trademarks of Novus International, Inc.

[4]Neo-Terramycin is a registered trademark of Phibro Animal Health Ltd., Regina, Saskachewan, Canada.

ciency in weanling pigs through research at Kansas State University. Thus, the objective of this experiment was to evaluate the effectiveness of organic acid blends in the water and feed, in comparison with in-feed Neo-Terramycin and neomycin sulfate in the water, in improving the growth performance of weanling pigs.

Procedures

A total of 360 weanling pigs (initially 11.5 lb and 18 ± 3 d of age, PIC) were used to determine the effects of water-soluble organic acid blends in a water medication and in-feed antibiotic program on nursery pig growth performance. Individual pens were the experimental units, and water was supplied by an individual line and bowl drinker in each pen. There were 5 pigs per pen and 8 pens per treatment.

Pigs were given 1 of 9 experimental treatments: 1) negative control (no feed or water antimicrobials or acids); 2) water containing 38 mg/L neomycin sulfate; 3) water containing 0.06% Activate WD; 4) water containing 0.12% Activate WD; 5) feed containing Neo-Terramycin (140 g/ton neomycin sulfate, 140 g/ton oxytetracycline HCl); 6) feed containing 0.50% Activate DA; 7) feed containing 0.45% Starter L; 8) feed containing 0.45% Multimax L, and; 9) feed containing 0.50% Activate DA and 0.10% Mintrex P. Pigs were provided treatments in two phases: d 0 to 14 and d 14 to 28. All pigs were then fed a common diet from d 28 to 42. Pigs that received water-based treatments (Treatments 2, 3, and 4) were fed the negative control diet. Pigs that received feed-based treatments (Treatments 5, 6, 7, 8, and 9) were provided the control water. The trial was conducted in the environmentally controlled Segregated Early Weaning nursery facility at Kansas State University. Each pen (5 × 5 ft) contained one self-feeder and one bowl waterer to provide *ad libitum* access to feed and water.

Water-based treatments were administered through SelectDoser™ peristaltic pumps (Genesis Instruments; Elmwood, WI). This type of doser is powered by electricity, and siphons a concentrated, pre-mixed stock solution through a tube and doses the medication into the existing water supply. Concentrated stock solutions were made as needed throughout the experiment, and were dosed into the existing water line at a ratio of 1:100 to achieve the desired level of treatment.

Dietary treatments were fed in meal form (Tables 1, 2, and 3). Phase 1 (d 0 to 14 after weaning) diets were formulated to contain 1.41% true ileal digestible (TID) lysine, 0.90% Ca, and 0.50% available phosphorus. Phase 2 (d 14 to 28 after weaning) diets were formulated to contain 1.31% TID lysine, 0.80% Ca, and 0.40% available phosphorus. The Phase 3 (d 28 to 42 after weaning) common diet was formulated to contain 1.24% TID lysine, 0.77% Ca, and 0.37% available phosphorus. Average daily gain (ADG), average daily feed intake (ADFI), and feed efficiency (F/G) were determined by weighing pigs and feeders on d 0, 14, 28, and 42 after weaning.

Data were analyzed as a randomized complete-block design, with pen as the experimental unit. Analysis of variance was performed by using the MIXED procedure of SAS. Contrasts were used to determine the effects of antibiotics, compared with the control and with the mean of pigs provided one of the organic acid treatments.

Results and Discussion

From d 0 to 14, pigs provided the water-based antimicrobial had greater ($P<0.05$) ADG and ADFI than those of pigs provided control feed and water and those of pigs provided water-soluble organic acids. Pigs provided the water-based antimicrobial also had greater ($P<0.05$) ADG than did pigs provided

feed containing Activate DA and Starter L, whereas in-feed Multimax L and DA plus Mintrex P treatments were intermediate. Pigs provided the water-based antimicrobial had greater (P<0.05) ADFI than that of pigs provided in-feed Activate DA, Starter L, or Multimax L, whereas DA plus Mintrex P and in-feed antimicrobial treatments were intermediate. Pigs provided feed containing Multimax L or DA plus Mintrex P had improved F/G, compared with that of pigs provided control feed and water, Activate WD, DA, or Starter L organic acids, whereas water-based and in-feed antimicrobial treatments were intermediate. Pigs provided antimicrobials had greater (P<0.01) ADG and ADFI than did pigs provided organic acids or pigs provided the control treatment. Pigs provided antimicrobials also had improved (P<0.01) F/G, compared with pigs provided the control.

From d 14 to 28, pigs provided in-feed antimicrobials had greater (P<0.05) ADG than that of all other pigs. In addition, pigs provided antimicrobials in the water or feed had greater ADG (P<0.01) and ADFI (P<0.05) than did pigs provided organic acids.

From d 28 to 42, pigs were provided a common diet, and there were no differences in growth performance and feed efficiency.

Overall (d 0 to 42), pigs provided in-feed antimicrobials had greater (P<0.05) ADG than that of all other pigs, except those provided diets containing Activate DA plus Mintrex P. Pigs provided antimicrobials had greater (P<0.03) ADG than did pigs provided organic acids or pigs provided control feed and water. Pigs provided antimicrobials also had improved (P<0.02) F/G, compared with that of pigs provided organic acids.

The use of organic acids in the feed or water in this experiment did not improve growth performance or feed efficiency over the control treatment during the 42-d nursery phase. In this experiment, antimicrobials provided in the feed or water yielded a significant improvement in average daily gain over all other treatments.

Table 1. Phase 1 Diet Composition (As-fed Basis)[a]

Ingredient, %	Control	Neo Terra	Activate DA	Activate Starter L	Activate Multimax L	Activate DA + Mintrex P
Corn	51.03	51.03	51.03	51.03	51.03	51.03
Soybean meal (46.5% CP)	30.16	30.16	30.16	30.16	30.16	30.16
Spray dried whey	10.00	10.00	10.00	10.00	10.00	10.00
Select menhaden fish meal	3.75	3.75	3.75	3.75	3.75	3.75
Soy oil	1.00	1.00	1.00	1.00	1.00	1.00
Monocalcium phosphate (21% P)	1.20	1.20	1.20	1.20	1.20	1.20
Limestone	0.75	0.75	0.75	0.75	0.75	0.75
Salt	0.35	0.35	0.35	0.35	0.35	0.35
Vitamin premix	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-lysine HCl	0.30	0.30	0.30	0.30	0.30	0.30
L-threonine	0.15	0.15	0.15	0.15	0.15	0.15
Corn starch	0.73	0.21	0.41	0.43	0.43	0.31
Neo-Terramycin[b]	---	0.70	---	---	---	---
MHA-Ca[c]	0.18	---	---	0.03	0.03	---
Activate DA[d]	---	---	0.50	---	---	0.50
Activate Starter L[e]	---	---	---	0.45	---	---
Activate Multimax L[e]	---	---	---	---	0.45	---
Activate DA + Mintrex P[f]	---	---	---	---	---	0.10
Total	100.00	100.00	100.00	100.00	100.00	100.00
Calculated Analysis						
Total lysine, %	1.55	1.55	1.55	1.55	1.55	1.55
True Digestible Amino Acids						
Lysine, %	1.41	1.41	1.41	1.41	1.41	1.41
Isoleucine:lysine ratio, %	60	60	60	60	60	60
Leucine:lysine ratio, %	118	118	118	118	118	118
Methionine:lysine ratio, %	35	35	35	35	35	35
Met & cys:lysine ratio, %	58	58	58	58	58	62
Threonine:lysine ratio, %	64	64	64	64	64	64
Tryptophan:lysine ratio, %	17	17	17	17	17	17
Valine:lysine ratio, %	66	66	66	66	66	66
ME, kcal/lb	1,502	1,502	1,502	1,502	1,502	1,502
CP, %	22.4	22.4	22.4	22.4	22.4	22.4
Ca, %	0.90	0.90	0.90	0.90	0.90	0.90
P, %	0.79	0.79	0.79	0.79	0.79	0.79
Available P, %	0.50	0.50	0.50	0.50	0.50	0.50

[a]Fed from d 0 to 14 after weaning.
[b]Neo-Terramycin (140 g/ton neomycin sulfate, 140 g/ton oxytetracycline HCl).
[c]Methionine hydroxy analog with calcium, 84% L-methionine activity.
[d]Activate dry organic acid blend, 31% L-methionine activity.
[e]Activate liquid acid blend, 29% L-methionine activity.
[f]Activate Mintrex P, 55% L-methionine activity.

Table 2. Phase 2 Diet Composition (As-fed Basis)[a]

Ingredient, %	Control	Neo Terra	Activate DA	Activate Starter L	Activate Multimax L	Activate DA + Mintrex P
Corn	59.00	59.00	59.00	59.00	59.00	59.00
Soybean meal (46.5% CP)	35.10	35.10	35.10	35.10	35.10	35.10
Soy oil	1.00	1.00	1.00	1.00	1.00	1.00
Monocalcium phosphate (21% P)	1.50	1.50	1.50	1.50	1.50	1.50
Limestone	1.10	1.10	1.10	1.10	1.10	1.10
Salt	0.35	0.35	0.35	0.35	0.35	0.35
Vitamin premix	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-lysine HCl	0.30	0.30	0.30	0.30	0.30	0.30
L-threonine	0.15	0.15	0.15	0.15	0.15	0.15
Corn starch	0.92	0.92	0.60	0.62	0.62	0.52
Neo-Terramycin[b]	---	1.10	---	---	---	---
MHA-Ca (84%)[c]	0.18	---	---	0.03	0.03	---
Activate DA[d]	---	---	0.50	---	---	0.50
Activate Starter L[e]	---	---	---	0.45	---	---
Activate Multimax L[e]	---	---	---	---	0.45	---
Activate DA plus Mintrex P[f]	---	---	---	---	---	0.10
Total	100.00	100.00	100.00	100.00	100.00	100.00
Calculated Analysis						
Total lysine, %	1.45	1.45	1.45	1.45	1.45	1.45
True Digestible Amino Acids						
Lysine, %	1.31	1.31	1.31	1.31	1.31	1.31
Isoleucine:lysine ratio, %	62	62	62	62	62	62
Leucine:lysine ratio, %	128	128	128	128	128`	128
Methionine:lysine ratio, %	35	35	35	35	35	39
Met & cys:lysine ratio, %	60	60	60	60	60	64
Threonine:lysine ratio, %	65	65	65	65	65	65
Tryptophan:lysine ratio, %	18	18	18	18	18	18
Valine:lysine ratio, %	69	69	69	69	69	69
ME, kcal/lb	1,500	1,500	1,500	1,500	1,500	1,500
CP, %	21.7	21.7	21.7	21.7	21.7	21.7
Ca, %	0.80	0.80	0.80	0.80	0.80	0.80
P, %	0.72	0.72	0.72	0.72	0.72	0.72
Available P, %	0.40	0.40	0.40	0.40	0.40	0.40

[a]Fed from d 14 to 28 after weaning.
[b]Neo-Terramycin (140 g/ton neomycin sulfate, 140 g/ton oxytetracycline HCl).
[c]Methionine hydroxy analog with calcium, 84% L-methionine activity.
[d]Activate dry organic acid blend, 31% L-methionine activity.
[e]Activate liquid acid blend, 29% L-methionine activity.
[f]Activate Mintrex P, 55% L-methionine activity.

Table 3. Phase 3 Diet Composition (As-fed Basis)[a]

Ingredient, %	Common
Corn	61.13
Soybean meal (46.5% CP)	33.00
Soy oil	2.00
Monocalcium phosphate (21% P)	1.40
Limestone	1.00
Salt	0.50
Vitamin premix	0.25
Trace mineral premix	0.15
L-lysine HCl	0.28
L-threonine	0.13
MHA-Ca (84%)[b]	0.16
Total	100.00
Calculated Analysis	
Total lysine, %	1.38
True Digestible Amino Acids	
Lysine, %	1.24
Isoleucine:lysine ratio, %	63
Leucine:lysine ratio, %	131
Methionine:lysine ratio, %	35
Met & cys:lysine ratio, %	60
Threonine:lysine ratio, %	65
Tryptophan:lysine ratio, %	18
Valine:lysine ratio, %	70
ME, kcal/lb	1,538
CP, %	20.9
Ca, %	0.77
P, %	0.69
Available P, %	0.37

[a]Fed from d 28 to 42 after weaning.
[b]Methionine hydroxy analog with calcium, 84% L-methionine activity.

Table 4. Growth Performance of Nursery Pigs Provided Organic Acid Blends[a]

				Activate Organic Acid Blended Products							Probability , P<		
				Activate WD, %[h]								Antimicrobial vs	
Item,	Control	Water Med[f]	Neo Terra[g]	0.06	0.12	DA[i]	Starter L[j]	Multimax L[j]	DA + Mintrex P[k]	SE	Trt	Control[m]	Organic Acids
d 0 to 14													
ADG, lb	0.42[b]	0.52[e]	0.50[de]	0.45[bcd]	0.46[cd]	0.42[bc]	0.41[bc]	0.48[cde]	0.50[de]	0.027	0.01	0.01	0.01
ADFI, lb	0.49[b]	0.57[d]	0.55[cd]	0.50[b]	0.52[bc]	0.48[b]	0.48[b]	0.51[bc]	0.53[cd]	0.027	0.02	0.01	0.01
F/G	1.19[d]	1.09[bc]	1.09[bc]	1.13[cd]	1.15[cd]	1.15[cd]	1.17[d]	1.08[b]	1.07[b]	0.030	0.01	0.01	0.11
d 14 to 28													
ADG, lb	1.06[b]	1.03[b]	1.18[c]	1.03[b]	1.07[b]	1.05[b]	1.04[b]	1.04[b]	1.04[b]	0.035	0.01	0.16	0.01
ADFI, lb	1.51	1.50	1.64	1.49	1.53	1.52	1.52	1.49	1.49	0.050	0.21	0.19	0.05
F/G	1.43	1.46	1.39	1.44	1.44	1.45	1.46	1.43	1.43	0.023	0.50	0.85	0.42
d 28 to 42													
ADG, lb	1.48	1.45	1.47	1.41	1.47	1.44	1.48	1.47	1.50	0.032	0.62	0.68	0.98
ADFI, lb	2.23	2.20	2.26	2.19	2.31	2.22	2.32	2.25	2.36	0.057	0.22	0.97	0.28
F/G	1.51	1.51	1.54	1.55	1.57	1.55	1.57	1.53	1.58	0.026	0.54	0.65	0.14
d 0 to 42													
ADG, lb	0.98[b]	1.00[b]	1.05[c]	0.96[b]	1.00[b]	0.96[b]	0.97[b]	1.00[b]	1.01[bc]	0.024	0.01	0.03	0.01
ADFI, lb	1.40	1.42	1.48	1.38	1.45	1.40	1.42	1.42	1.46	0.037	0.13	0.13	0.16
F/G	1.44	1.42	1.41	1.44	1.46	1.45	1.47	1.42	1.45	0.018	0.20	0.34	0.02

[a]A total of 360 weanling pigs (initially 11.5 lb, 18 ± 3d of age), with 5 pigs per pen and 8 pens per treatment.
[b,c,d,e]Means in the same row with different superscripts differ (P<0.05).
[f]Pigs provided water containing 38 mg/L neomycin sulfate.
[g]Neo-Terramycin® (140 g/ton neomycin sulfate, 140 g/ton oxytetracycline HCl).
[h]Water-dispersible organic acid blend, 29% L-methionine activity.
[i]Activate dry organic acid blend, 31% L-methionine activity.
[j]Activate liquid organic acid blend, 29% L-methionine activity.
[k]Activate Mintrex P, 55% L-methionine activity.
[m]Each P-value represents the contrast between the mean of all antimicrobial treatments and either the control or the mean of all organic acid treatments.