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Cover Page Footnote

Appreciation is expressed to Dr. Kellie Hogan and Scott Webster, Trouw Nutrition USA, Highland, IL, for their technical and partial financial support.

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Evaluation of Elarom SES with or without Tri-basic Copper Chloride on Nursery Pig Growth Performance[1]

H.E. Williams, J.C. Woodworth, J.M. DeRouchey, S.S. Dritz,[2] M.D. Tokach, and R.D. Goodband

Summary

A total of 360 weanling pigs (DNA 200 × 400; initially 11.5 lb BW) were used in a 42-d study evaluating the effects of feeding Elarom SES in combination with increasing tri-basic copper chloride on nursery pig performance and fecal consistency. Elarom SES (Trouw Nutrition USA, Highland, IL) is a specialty feed ingredient containing a blend of active ingredients designed to enhance growth performance and gut health. Tri-basic copper chloride (TBCC, Intellibond C, Micronutrients USA, LLC., Indianapolis, IN) is a form of copper (Cu) that has the potential for improved bioavailability and enhanced growth performance. Pigs were weaned at approximately 21 d and allotted to pens based on initial BW in a completely randomized design. Experimental diets were fed in 3 phases (phase 1, d 0 to 7; phase 2, d 7 to 21; and phase 3, d 21 to 42 post-weaning) in meal form. Experimental treatments were arranged as a 2 × 3 factorial with main effects of Elarom SES (none vs. 0.2% in all phases) and TBCC (none, 108, or 183 ppm of Cu in phase 3 only). Fecal consistency was determined by visual appraisal of pen floors on d 0, 4,7, 14, 21, 28, 35, and 42 on a scale from 1-5. A score of 1 indicated hard, pellet type feces and a score of 5 indicated watery, liquid feces. Overall, there was no evidence for treatment differences observed for ADG, ADFI, or fecal consistency; however, a tendency for an Elarom SES × TBCC interaction was observed for F/G (quadratic, $P = 0.061$). This was the result of F/G improving at the intermediate level of TBCC without Elarom SES, yet F/G was improved at the highest level of TBCC when Elarom SES was present. Overall, no consistent benefit was observed from feeding Elarom SES or different levels of TBCC on growth performance or fecal consistency of weaned pigs.

Introduction

Elarom SES is a commercially available feed additive that combines medium chain fatty acids, phenolic compounds, long-chain carbohydrates, and organic acids into a single feed additive. It is suggested to improve gastrointestinal tract health and growth per-

[1] Appreciation is expressed to Dr. Kellie Hogan and Scott Webster, Trouw Nutrition USA, Highland, IL, for their technical and partial financial support.

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formance of pigs. However, Williams et al.[3] (2016) observed that feeding Elarom SES in combination with antimicrobials with or without added ZnO did not consistently improve nursery pig growth performance, and that feeding Elarom SES in combination with antimicrobial and/or ZnO had no effect in comparison to control and dietary treatments that only contained antimicrobials or ZnO.[3]

Supplementation of high levels of Cu is a feeding strategy considered in the nursery because of its antimicrobial effects that are potentially similar to that of antibiotics, and the ability of Cu to counter the effects of the post-weaning lag. Tri-basic copper chloride (TBCC, Micronutrients USA, LLC., Indianapolis, IN) is a form of Cu that has the potential for improved bioavailability and enhanced growth performance. Shelton et al. (2011) observed that the supplementation of 150 ppm TBCC during the nursery stage increased ADG and ADFI.[4] Also, Carpenter et al.[5] showed that increasing Cu linearly improved ADG and final BW in nursery pigs.[5] We are not aware of any previous research that describes the interactive effects of Elarom SES and TBCC when included in swine diets. Therefore, the objective of this study was to compare the growth performance and fecal consistency of nursery pigs fed diets containing Elarom SES with or without TBCC.

Procedures

The Kansas State University Institutional Animal Care and Use Committee approved the protocol for this experiment. The study was conducted at the Kansas State University Segregated Early Weaning Facility in Manhattan, KS.

A total of 360 nursery pigs (DNA 200 × 400; initially 13.2 lb BW) were used in a 42-d study with 5 pigs per pen and 12 replications per treatment. Each pen (4 × 4 ft.) had metal tri-bar flooring, one 4-hole self-feeder, and a cup waterer to provide ad libitum access to feed and water. Pigs were weaned at approximately 21 d of age and allotted to pens based on initial BW in a completely randomized design to 1 of 6 dietary treatments.

The treatments were arranged in a 2 × 3 factorial with main effects of added Elarom SES (none vs. 0.2% from d 0 to 42) and added Cu from TBCC (none, 108, or 183 ppm Cu from d 21 to 42;). The treatment ingredients were substituted for an equivalent amount of corn in the respective diets to form the experimental treatments (Table 1).

All diets were corn-soybean meal based and were formulated in 3 phases with decreasing nutrient concentration in each phase. Diets were fed in meal form and were pre-

[3] Williams, H.; Woodworth, J. C.; DeRouchey, J. M.; Dritz, S. S.; Tokach, M. D.; and Goodband, R. D. 2016. "Evaluation of Elarom SES in Nursery Diets with or without the Inclusion of High Zinc Oxide or Feed Antimicrobials," *Kansas Agricultural Experiment Station Research Reports*: Vol. 2: Iss. 8. https://dx.doi.org/10.4148/2378-5977.1296.

[4] Shelton, N.W., M. Tokach, J. Nelssen, R. Goodband, S. Dritz, J. DeRouchey, G. Hill. 2011. Effects of copper sulfate, tri-basic copper chloride, and zinc oxide on weanling pig performance. J. Anim. Sci. 89:2440-2451. doi:10.2527/jas.2010-3432.

[5] Carpenter, C. B.; Woodworth, J. C.; DeRouchey, J. M.; Tokach, M. D.; Goodband, R. D.; Dritz, S. S.; and Usry, J. 2016. "Effects of Increasing Copper from Tri-basic Copper Chloride or a Copper-Amino Acid Complex on Growth Performance of Nursery Pigs," *Kansas Agricultural Experiment Station Research Reports*: Vol. 2: Iss. 8. https://dx.doi.org/10.4148/2378-5977.1297.

pared at the Kansas State University O.H. Kruse Feed Technology Innovation Center, Manhattan, KS. Each diet contained 110 ppm of added Zn from ZnO and 17 ppm of added Cu from $CuSO_4$ from the trace mineral premix. All diets in phase 1 and phase 2 contained 2,890 and 1,890 ppm of added Zn from ZnO, respectively, in addition to the ZnO provided by the trace mineral premix. Diet samples were collected from every 5th bag at manufacturing, and a single pooled sample of each diet was submitted for analysis of DM, CP, calcium (Ca), phosphorus (P), and Cu (Ward Laboratories, Inc., Kearney, NE; Table 2).

Pigs and feeders were weighed every 7 d to determine ADG, ADFI, and F/G. Fecal scoring of pens occurred on d 0, 4, 7, 14, 21, 28, 35, and 42 by visual appraisal of the pen floor. Fecal scores were conducted before weighing on weigh days and were replicated by 3 individuals each day. Pens were scored on a scale from 1 to 5, with 1 indicating hard pellet type feces; 2 indicating firm, formed feces; 3 indicating soft, moist feces that retained shape; 4 indicating soft, unformed feces; and 5 indicating watery, liquid feces.

Growth data were analyzed as a randomized complete block design using the PROC GLIMMIX procedure of SAS version 9.4 (SAS Institute, Inc., Cary, NC) with pen as the experimental unit. The main effects of Elarom SES and linear and quadratic effects of TBBC, as well as their interactions, were evaluated using preplanned CONTRAST statements. Differences between treatments were determined by using least squares means. A P-value ≤ 0.05 was considered significant and 0.05 < P ≤ 0.10 was considered marginally significant.

Results and Discussion

Results of the diet analysis closely matched those of formulated levels. Analyzed diets confirmed diets manufactured with no added Cu closely matched formulated values, and phase 3 diets manufactured with added Cu from TBCC increased in a step-wise fashion as expected.

From d 0 to 21, 21 to 42, and overall, there was no evidence for differences in ADG or ADFI observed among pigs fed any of the dietary treatments. A tendency for an Elarom × TBCC interaction (P = 0.061) was observed for F/G (Table 3). The interaction was a result of F/G improving at the intermediary level of TBCC without Elarom SES; however, F/G was only improved at the highest TBCC concentration when Elarom SES was present. There were no treatment or treatment × day effects observed on fecal consistency, but a day effect was observed (P = 0.001, Table 4) resulting from pigs at d 0 exhibiting firmer stool that transitioned to a softer stool in the subsequent collection days.

In summary, these data suggests that feeding different levels of TBCC with or without the inclusion of Elarom SES has no effect on nursery pig growth performance. The absence of a Cu response in this study is in contrast with previous research that has showed improvements in nursery pig performance to added Cu. Further research should be conducted to improve the understanding of the feeding of Elarom SES with or without TBCC and at what periods of the nursery phase these additives should be fed to improve performance.

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

Ingredient, %	Phase 1	Phase 2	Phase 3
Corn	36.02	51.10	62.81
Soybean meal	20.67	27.30	34.99
Dairylac 80[2]	15.00	---	---
Corn DDGS, 6-9% oil[3]	5.00	---	---
HP 300[4]	5.00	5.00	---
Spray-dried whey	1.25	1.25	---
Fish meal	5.00	---	---
Monocalcium phosphate, 21% P	1.13	1.10	1.18
Limestone	1.03	1.00	1.08
Sodium chloride	0.30	0.60	0.35
Choice white grease	1.00	1.00	1.00
Sodium chloride	0.30	0.60	0.35
L-Lys HCl	0.30	0.38	0.28
DL-Met	0.17	0.20	0.14
L-Thr	0.10	0.16	0.13
L-Val	---	0.06	---
L-Trp	---	0.02	---
Vitamin premix	0.25	0.25	0.25
Trace mineral premix[5]	0.15	0.15	0.15
Zinc oxide	0.42	0.28	---
CombiAcid[6]	0.20	0.20	0.20
Choline chloride, 60% liquid	0.04	---	---
Phytase[7]	---	0.02	0.02
Elarom-F Plus[6,8]	+/-	+/-	+/-
Intellibond C[8]	---	---	+/-
Total	100	100	100

continued

Table 1, *continued*. Experimental diet composition (as-fed basis)[1]

Ingredient, %	Phase 1	Phase 2	Phase 3
Calculated analysis			
Standardized ileal digestible (SID) amino acids, %			
Lys	1.40	1.35	1.25
Met:Lys	33	37	35
Met and Cys:Lys	57	58	58
Thr:Lys	62	63	65
Trp:Lys	19.3	19.3	19.1
Val:Lys	68	69	69
Total Lys, %	1.58	1.50	1.40
ME, kcal/lb	1,535	1,512	1,498
CP, %	22.7	22.2	22.1
Calcium, %	0.80	0.76	0.71
Phosphorus, %	0.75	0.69	0.66
Available phosphorus, %	0.51	0.49	0.42

[1] Phase 1 diet was fed from d 0 to 7 (~13.2 to 14.7 lb BW), phase 2 diets from d 7 to 21 (~14.7 to 24.9 lb BW) and phase 3 diets from d 21 to 42 (~24.9 to 53.1 lb BW).

[2] International Ingredients, Inc., St. Louis, MO.

[3] Dried distillers grains with solubles.

[4] Hamlet Protein, Inc., Findlay, OH.

[5] Trace mineral premix containing 17 ppm copper (Cu) and 110 ppm zinc (Zn).

[6] Trouw Nutrition USA, LLC., Highland, IL.

[7] HiPhos 2700 (DSM Nutritional Products, Inc., Parsippany, NJ), provided 184 phytase units (FTU)/lb and an estimated release of 0.10% available phosphorus.

[8] Treatment diets contained Elarom SES (Trouw Nutrition USA, LLC., Highland IL) added at either 0 or 0.2% from d 0 to 42 and TBCC (Micronutrients USA, LLC., Indianapolis, IN) added at 0, 108, or 183 ppm Cu from d 21 to 42.

Table 2. Chemical analysis of experimental diets, %[1]

	– Elarom SES			+ Elarom SES[2]		
	TBCC, ppm[3]			TBCC, ppm[3]		
	0	108	183	0	108	183
Phase 1 diets						
DM	92.1	---	---	91.5	---	---
CP	22.1	---	---	21.5	---	---
Ca	1.18	---	---	1.02	---	---
P	0.77	---	---	0.74	---	---
Cu, ppm	28	---	---	26	---	---
Phase 2 diets						
DM	90.8	---	---	91.8	---	---
CP	22.4	---	---	23.2	---	---
Ca	0.83	---	---	0.97	---	---
P	0.67	---	---	0.78	---	---
Cu, ppm	20	---	---	33	---	---
Phase 3 diets						
DM	89.3	89.2	89.4	89.6	89.1	88.1
CP	21.6	22.1	23.1	22.1	22.9	22.8
Ca	0.78	0.67	0.88	0.79	0.83	0.89
P	0.59	0.58	0.70	0.65	0.68	0.72
Cu, ppm	18	111	169	27	87	202

[1] Complete diet samples were obtained from each dietary treatment during manufacturing. Samples of diets were then submitted for analysis of DM, CP, calcium (Ca), phosphorus (P), and copper (Cu) (Ward Laboratories, Inc., Kearney, NE).

[2] Trouw Nutrition USA, LLC., Highland, IL.

[3] Tri-basic copper chloride (Micronutrients USA, LLC., Indianapolis, IN) added at 0, 108, or 183 ppm Cu from d 21 to 42.

Table 3. Effect of Elarom SES and tri-basic copper chloride (TBCC) on nursery pig performance[1,2]

	– Elarom SES			+ Elarom SES[3]				Probability, $P <$		
	TBCC, ppm[4]			TBCC, ppm[4]				TBCC		
	0	108	183	0	108	183	SEM	Elarom SES	Linear	Quadratic
BW, lb										
d 0	13.2	13.2	13.2	13.2	13.2	13.2	0.30	0.521	---	---
d 21	24.4	25.4	25.1	24.6	25.0	24.6	0.77	0.555	---	---
d 42	51.0	54.4	53.3	52.2	53.4	54.4	1.17	0.834	0.140	0.204
d 0 to 21										
ADG, lb	0.53	0.58	0.56	0.54	0.56	0.55	0.03	0.595	---	---
ADFI, lb	0.69	0.71	0.71	0.68	0.71	0.68	0.03	0.509	---	---
F/G	1.30	1.22	1.27	1.26	1.27	1.24	0.02	0.966	---	---
d 21 to 42										
ADG, lb	1.34	1.37	1.35	1.33	1.39	1.41	0.03	0.346	0.129	0.460
ADFI, lb	2.02	2.04	2.06	2.00	2.07	2.07	0.05	0.970	0.101	0.620
F/G	1.51	1.49	1.53	1.50	1.49	1.47	0.02	0.108	0.983	0.581
d 0 to 42										
ADG, lb	0.94	0.97	0.96	0.93	0.97	0.98	0.02	0.729	0.114	0.329
ADFI, lb	1.35	1.38	1.38	1.33	1.39	1.37	0.03	0.798	0.128	0.440
F/G	1.44	1.42	1.44	1.43	1.43	1.40	0.01	0.153	0.543	0.392
Fecal consistency[6]										
	3.02	3.08	3.02	3.07	3.01	3.00	0.03	0.740	0.869	0.115

[1] A total of 360 pigs (DNA 200 × 400) were used in a 3-phase nursery trial with 5 pigs per pen and 12 replications per treatment. All experimental diets were fed in three phases (d 0 to 7, d 7 to 21, and d 21 to 42). Each diet received 17 ppm of copper (Cu) from $CuSO_4$ from the trace mineral premix.

[2] --- Indicates analysis was not conducted due to Intellibond C not being included in the diet during these phases.

[3] Elarom SES (Trouw Nutrition USA, LLC, Highland, IL) added at 0.2% of the diet in all phases (d 0-42).

[4] TBCC (Micronutrients USA, LLC, Indianapolis, IN) added at 0, 108, and 183 ppm Cu in phase 3 (d 21-42).

[5] A tendency for an Elarom SES × TBCC interaction ($P = 0.061$) was observed.

[6] Fecal consistency was categorized through scoring of consistency of feces from each pen (fecal scoring occurred on d 0, 4, 7, 14, 21, 28, 35, and 42). Pens were scored by 3 trained individuals; those 3 scores were then averaged and reported as pen means for overall and each collection day fecal consistency. Scoring scale guidelines: 1 = dry, firm pellet; 2 = firmly formed stool; 3 = soft stool that retains shape; 4 = soft, unformed stool; and 5 = watery liquid stool.

Table 4. Nursery pig fecal consistency over time

Day	Fecal score[1]
0	2.9
4	3.1
7	3.2
14	2.9
21	3.2
28	2.9
35	3.0
42	3.1

[1] Fecal consistency scores were categorized by the consistency of feces per pen (fecal scores collected on d 0, 4, 7, 14, 21, 28, 35, and 42). Pens were scored by 3 trained individuals; those scores were then averaged and reported as pen means for each collection day. Scoring scale guidelines: 1 = dry, firm pellet; 2 = firmly formed stool; 3 = soft stool that retains shape; 4 = soft, unformed stool; and 5 = watery liquid. Treatment × Day interaction ($P = 0.230$, SEM = 0.03) and day effect ($P < 0.001$, SEM = 0.04).