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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 in Nursery Diets with or without the Inclusion of High Zinc Oxide or Feed Antimicrobials[1]

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Summary

A total of 360 weaned 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 high levels of ZnO and/or antimicrobials on nursery pig performance and fecal consistency. Elarom SES (Trouw Nutrition USA, Highland, IL) is a commercially available blend of short chain fatty acids (SCFAs), medium chain fatty acids (MCFAs) and slow release organic acids designed to enhance growth performance and gut health. Pigs were weaned at approximately 21 d and allotted to pens based on initial BW in a completely randomized design. Experimental treatments were arranged as a 2 × 2 × 2 factorial. The 8 treatment diets included: Elarom SES (none vs. 4 lb/ton), additional ZnO (none vs. 3,000 ppm in phase 1, 2,000 ppm in phase 2, and none in phase 3), and antimicrobial regimen (none vs. 400 g/ton CTC and 35 g/ton Denagard in Phase 1 and 50 g/ton Mecadox in Phases 2 and 3). 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) and fed in meal form. Overall, an Elarom SES × ZnO × antimicrobial interaction was observed for ADG ($P = 0.043$) and F/G ($P = 0.009$). The ADG interaction was the result of poorer ADG when Elarom SES or ZnO were added alone compared to when feed antimicrobials were added alone or when Elarom SES was added in combination with ZnO or ZnO was added in combination with antimicrobials. The F/G interaction was a result of the poorest F/G observed when all three additives were added in combination, compared to the control diet with Elarom SES or antimicrobials only and the diet with Elarom SES and ZnO in combination or the diet with ZnO and antimicrobial in combination. Adding antibiotics to the diet increased ($P < 0.013$) ADG and ADFI, but there were no main effects of ZnO or Elarom SES observed. There were no individual or overall treatment effects ($P > 0.100$), or treatment × day interactions ($P = 0.53$) observed for fecal consistency. Overall, we observed some benefits in performance when adding combinations of ingredients compared to including them as stand alone products. More research should be conducted to confirm this response.

Key words: antimicrobial, Elarom SES, growth performance, nursery, zinc

[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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Introduction

With the introduction of new veterinary feed directive rules limiting the use of antimicrobials in swine feed, a need has arisen to find new alternatives that can replace the growth performance effects of feed grade antimicrobials. Elarom SES (Trouw Nutrition USA, Highland, IL) is a technology that combines the use of short chain fatty acids (SCFAs), medium chain fatty acids (MCFAs) and slow release organic acids that was developed and is sold by Trouw Nutrition. Initial research has shown that when Elarom SES is included in nursery pig diets, increased average daily gain and improved feed efficiency is observed compared to control diets without feed antibiotics. The effects of other feed additives on nursery growth performance such as dietary antibiotics and high levels of ZnO are well understood; however the effect of Elarom SES included in diets with or without these additives has not been characterized.

The objective of this study was to compare the growth performance and fecal consistency of nursery pigs fed diets containing antimicrobials, ZnO, and/or Elarom SES.

Methods

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

A total of 360 nursery pigs (DNA 200 × 400; initially 11.5 lb BW) were used in a 42-d study with 5 pigs per pen and 9 replications per treatment. Each pen had metal tri-bar flooring, one 4-hole self-feeder (4 ft. × 4 ft.) 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 8 dietary treatments.

The 8 dietary treatments were based on a corn-soybean meal diet and arranged in a 2 × 2 × 2 factorial with main effects of added zinc from zinc oxide (ZnO; none vs. 3,000 ppm Zn from d 0 to 7, 2,000 ppm Zn from d 7 to 21, and no additional Zn above that provided in the trace mineral premix from d 21 to 42), feed antimicrobial (none vs. 400 g/ton CTC (Zoetis Services, LLC., Florham Park, NJ) and 35 g/ton Denagard (Elanco Animal Health, Greenfield, IN) from d 0 to 7 and 50 g/ton carbadox (Phibro Animal Health, Teaneck, NJ) from d 7 to 42), or Elarom SES (none vs. 4 lb/ton from d 0 to 42; Trouw Nutrition USA, LLC, Highland, IL). The treatment ingredients were substituted for an equivalent amount of corn in the respective diets to form the experimental treatments (Table 1). 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.

All diets were fed in meal form and were prepared at the Kansas State University O.H. Kruse Feed Technology Innovation Center in Manhattan, KS. Each diet contained 110 ppm of added Zn from ZnO from the trace mineral premix. Diet samples were collected at manufacturing, and pooled samples of each diet were submitted for analysis of DM, CP, Ca, P, and Zn (Ward Laboratories, Inc., Kearney, NE; Table 2). Analyzed diets confirmed diets manufactured with no added ZnO contained approximately 110 ppm ZnO from the trace mineral premix, and diets manufactured with added ZnO contained approximately 3,000 ppm ZnO in Phase 1 and approximately 2,000 ppm in Phase 2.

Growth data were analyzed as a randomized complete block design using the PROC GLIMMIX procedure of SAS (SAS Institute, Inc., Cary, NC) with pen as the experimental unit. The main effects of Zn, Elarom SES, and antimicrobial, as well as their interactions, were evaluated using preplanned CONTRAST statements. The main effects of Zn, Elarom SES, and antimicrobial, as well as day and treatment interactions were tested using preplanned CONTRAST statements. Fecal consistency scores were analyzed using PROC MIXED in SAS with pen as the experimental unit. The main effects of Zn, Elarom SES, and antibiotic, as well as day and treatment interactions were tested 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

From d 0 to 7, an Elarom SES × ZnO interaction (P = 0.016) was observed for F/G (Table 3 and 4). The interaction occurred because pigs fed Elarom SES in combination with ZnO had improved F/G comparative to pigs fed diets containing only Elarom SES or ZnO with the control diet intermediate. Pigs fed diets containing feed antimicrobials had improved ADG (P = 0.047) compared to those without.

From d 7 to 21, ADG tended to be greater (P = 0.091) when diets contained Elarom SES, but ADFI and F/G were not influenced. Including ZnO in the diets increased (P < 0.001) ADG, ADFI, and d 21 BW and marginally improved (P = 0.074) F/G. Diets containing feed antimicrobials had improved (P < 0.001) ADG, ADFI, F/G, and d 21 wt.

From d 0 to 21, an Elarom SES × ZnO interaction was observed for F/G (P = 0.026) and ADG (P = 0.053). The greatest improvement in ADG and F/G was observed when both Elarom SES and ZnO were included in the diets compared to when either was added alone. Including ZnO in the diets increased (P <0.001) ADG, ADFI, and tended to improve (P = 0.071) F/G. Diets containing feed antimicrobials had improved (P < 0.001) ADG, ADFI, and F/G.

From d 21 to 42, an Elarom SES × ZnO × antimicrobial interaction tended to be observed (P = 0.055) for ADG and was observed (P = 0.006) for F/G. This interaction occurred because ADG and F/G was poorest when all three feed additives were added in combination compared to all other treatments. There was an Elarom SES × antimicrobial interaction for ADFI (P = 0.013) that was the result of ADFI being similar to control values when both additives were included; however, when only the antimicrobial was added to the diet, ADFI was increased.

Overall (from d 0 to 42), an Elarom SES × ZnO × antibiotic interaction was observed for ADG (P = 0.043) and F/G (P = 0.009). The ADG interaction was the result of poorer ADG when Elarom SES or ZnO were added alone compared to when antibiotic was added alone or when Elarom SES was added in combination with ZnO or ZnO was added in combination with antibiotic. The F/G interaction was a result of the poorest F/G being reported when all three additives were added in combination, compared to the control, diets with Elarom SES or antibiotic only and the diet with Elarom SES and ZnO in combination or the diet with ZnO and medication in combination. Overall, ADFI was increased (P < 0.001) when antibiotic was included in the diets.

While there was no treatment effect on fecal consistency, there was a day effect observed (P = 0.001; Table 5) resulting from d 0, 4, and 7 pigs exhibiting softer stool that improved to a firmer stool in the subsequent collection days.

In summary, these data suggest feeding combinations of different feed additives may influence growth performance in a manner that is different than their individual performance would indicate. For instance, the combination of Elarom SES and high ZnO had performance similar to the medication treatment, even though Elarom SES or high ZnO treatments fed alone had poorer performance than the medication treatment. The main effect of medication or ZnO during the Zn feeding phase was similar to previous studies. However, we unexpectedly observed poorer performance in some diets once ZnO was removed from the diet, which warrants further investigation. Also, further research should be considered to improve the understanding of feeding Elarom SES in combination with high ZnO and medication and at what periods of the nursery phase these additives should be fed to improve growth performance.

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

Ingredient, %	Phase 1	Phase 2	Phase 3
Corn	36.25	51.80	62.81
Soybean meal	20.65	27.25	32.57
Corn DDGS, 6-9% oil[2]	5.00	---	---
Blood plasma	4.00	---	---
Fish meal	1.25	1.25	---
Milk, whey powder	8.00	5.00	---
HP 300[3]	5.00	5.00	---
Dairylac 80[4]	15.00	---	---
CombiAcid[5]	0.20	0.20	---
Choice white grease	1.00	1.00	1.00
Limestone	1.03	1.00	1.08
Monocalcium phosphate, 21%	1.13	1.00	1.18
Sodium chloride	0.30	0.30	0.35
L-Lys HCl	0.30	0.38	0.35
DL-Met	0.17	0.20	0.14
L-Thr	0.10	0.15	0.13
L-Val	---	0.05	---
Elarom SES[5,6]	---	---	---
Zinc oxide[6]	---	---	---
Denagard[6]	---	---	---
CTC-50[6]	---	---	---
Mecadox-2.5[6]	---	---	---
Choline chloride, 60% liquid	0.04	---	---
Phytase[7]	---	0.02	0.02
Trace mineral premix[8]	0.15	0.15	0.15
Vitamin premix	0.25	0.25	0.25
Total	100	100	100

continued

Table 1. 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	34
Met and Cys:Lys	57	58	57
Thr:Lys	62	63	62
Trp:Lys	19.3	17.8	18.1
Val:Lys	68	69	66
Total Lys, %	1.58	1.51	1.40
ME, kcal/lb	1,542	1,522	1,503
CP, %	22.8	22.2	21.2
Ca, %	0.80	0.74	0.7
P, %	0.75	0.67	0.65
Available P, %	0.51	0.47	0.42

[1]Phase 1 diet was fed from d 0 to 7 (~11.5 to 13.5 lb BW), Phase 2 diets from d 7 to 21 (~13.5 to 22.5 lb BW) and Phase 3 diets from d 21 to 42 (~ 22.5 to 46 lb BW).
[2]Dried distillers grains with solubles.
[3]Hamlet Protein, Inc., Findlay, OH.
[4]International Ingredients, Inc., St. Louis, MO.
[5]Trouw Nutrition USA, LLC., Highland, IL.
[6]Treatment diets contained zinc oxide added at 0 or 3,000 ppm from d 0 to 7 and at 0 or 2,000 ppm from d 7 to 21, Elarom SES (Trouw Nutrition USA, LLC., Highland, IL) added at either 0 or 0.2%, and medication regimen with 8 lb/ton CTC-50 (Zoetis Services, LLC., Florham Park, NJ) and 3.5 lb/ton Denagard (Elanco Animal Health, Greenfield, IN) added from d 0 to 7 and from d 7 to 42, 20 lb/ton Mecadox-2.5 (Phibro Animal Health, Teaneck, NJ). Additions of treatment ingredients were made in place of an equivalent amount of corn in respective experimental diets.
[7]HiPhos 2700 (DSM Nutritional Products, Inc., Parsippany, NJ), provided 184.3 phytase units (FTU)/lb and an estimated release of 0.10% available P.
[8]Trace mineral premix containing 17 ppm Cu and 110 ppm Zn.

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

Elarom SES:	-	+	-	-	+	+	-	+
Added ZnO:	-	-	+	-	+	-	+	+
Antimicrobial:	-	-	-	+	-	+	+	+
Phase 1 diets								
DM	91.0	91.2	91.4	91.2	91.0	91.1	91.0	91.4
CP	22.3	21.9	22.4	22.6	22.6	22.5	22.4	22.6
Ca	1.07	0.98	0.94	1.01	1.11	1.06	1.04	1.11
P	0.82	0.78	0.76	0.76	0.83	0.78	0.79	0.81
Zn, ppm	122	113	2,998	165	2,263	148	3,109	2,921
Phase 2 diets								
DM	89.0	88.4	89.7	88.9	89.5	89.3	90.0	88.8
CP	20.3	20.7	21.9	21.1	21.5	20.9	21.8	21.7
Ca	0.93	0.96	0.87	1.07	0.96	1.00	1.04	0.96
P	0.67	0.69	0.64	0.64	0.65	0.69	0.67	0.65
Zn, ppm	101	120	1,627	237	1,603	314	1,503	1,551
Phase 3 diets								
DM	88.1	88.1	88.1	87.6	88.1	88.2	87.6	88.2
CP	21.7	20.5	21.7	20.7	20.5	21.0	20.7	21.0
Ca	0.83	0.91	0.83	0.97	0.91	0.96	0.97	0.96
P	0.63	0.62	0.63	0.61	0.62	0.62	0.61	0.62
Zn, ppm	135	136	135	100	136	95	100	136

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

Table 3. Effects of Elarom SES, ZnO, and/or antimicrobials on nursery pig performance [1]

Elarom SES[3]:	-	+	-	-	+	+	-	+	
Added ZnO[4]:	-	-	+	-	+	-	+	+	
Antimicrobial[5]:	-	-	-	+	-	+	+	+	SEM
BW, lb									
d 0	11.5	11.5	11.5	11.5	11.5	11.5	11.6	11.6	0.081
d 7	13.4	13.2	13.4	13.7	13.5	13.3	13.7	13.5	0.143
d 21	21.1^{ef}	20.6^{f}	22.0^{ed}	23.0^{bc}	22.8^{bcd}	22.7^{cd}	23.7^{ab}	24.0^{a}	0.337
d 42	45.7^{cd}	44.9^{d}	44.4^{d}	48.4^{ab}	47.4^{abc}	46.2^{abcd}	48.6^{a}	46.0^{bcd}	0.882
d 0 to 7									
ADG, lb	0.26	0.24	0.27	0.31	0.28	0.26	0.30	0.28	0.02
ADFI, lb	0.29	0.29	0.33	0.31	0.29	0.30	0.32	0.31	0.015
F/G	1.10^{ab}	1.26^{a}	1.24^{a}	1.03^{b}	1.06^{b}	1.19^{ab}	1.05^{a}	1.12^{ab}	0.065
d 7 to 21									
ADG, lb	0.55	0.52	0.61	0.64	0.66	0.67	0.70	0.75	0.022
ADFI, lb	0.68	0.65	0.75	0.74	0.79	0.79	0.81	0.84	0.022
F/G	1.25	1.25	1.23	1.16	1.20	1.17	1.15	1.13	0.023
d 0 to 21									
ADG, lb	0.45^{de}	0.43^{e}	0.49^{cd}	0.53^{c}	0.53^{bc}	0.53^{bc}	0.57^{ab}	0.59^{a}	0.015
ADFI, lb	0.55	0.53	0.61	0.60	0.62	0.62	0.64	0.66	0.016
F/G	1.21^{ab}	1.24^{a}	1.23^{a}	1.13^{c}	1.17^{bc}	1.17^{bc}	1.13^{c}	1.12^{c}	0.02
d 21 to 42									
ADG, lb	1.17^{a}	1.16^{a}	1.05^{b}	1.21^{a}	1.18^{a}	1.12^{ab}	1.19^{a}	1.05^{b}	0.033
ADFI, lb	1.65^{bc}	1.64^{bc}	1.55^{c}	1.79^{a}	1.68^{ab}	1.68^{ab}	1.74^{ab}	1.66^{b,c}	0.042
F/G	1.41^{d}	1.42^{d}	1.48^{bc}	1.48^{bc}	1.44^{cd}	1.50^{b}	1.46^{bcd}	1.59^{a}	0.022
d 0 to 42									
ADG, lb	0.81^{bc}	0.79^{c}	0.77^{c}	0.86^{ab}	0.85^{ab}	0.82^{abc}	0.88^{a}	0.82^{abc}	0.02
ADFI, lb	1.10	1.09	1.08	1.18	1.15	1.14	1.18	1.16	0.026
F/G	1.36^{c}	1.37^{bc}	1.40^{ab}	1.37^{bc}	1.35^{c}	1.39^{abc}	1.35^{c}	1.42^{a}	0.015
Fecal consistency[2]	2.81	2.80	2.80	2.76	2.79	2.83	2.74	2.74	0.043

^{a,b,c} Means within the same row with different superscripts differ ($P \leq 0.05$).

[1]A total of 360 pigs (DNA 200 × 400) were used in a 3-phase nursery trial with 5 pigs per pen and 9 replications per treatment.

[2]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. There was no overall or individual treatment effect ($P > 0.100$).

[3]Elarom SES (Trouw Nutrition USA, LLC, Highland, IL) added at 0.2% of the diet.

[4]Zinc oxide fed at 3,000 ppm in Phase 1 (d 0 to 7) and 2,000 ppm in Phase 2 (d 7 to 21).

[5]Phase 1: (400 g/ton CTC and 35 g/ton Denagard and 50 g/ton); Phases 2 and 3: (Mecadox 50 g/ton) (Phibro Animal Health, Teaneck, NJ).

Table 4. Main and interactive effects of Elarom SES, added ZnO, and antimicrobials on nursery pig growth performance[1,2]

	Probability, $P <$						
	Elarom SES	ZnO	Antimicrobial	Elarom SES × ZnO	Elarom SES × Antimicrobial	ZnO × Antimicrobial	Elarom SES × ZnO × Antimicrobial
BW, lb							
d 0	0.944	0.742	0.888	0.832	0.655	0.814	0.906
d 7	0.183	0.219	0.076	0.224	0.201	0.773	0.890
d 21	0.687	0.001	0.001	0.043	0.700	0.240	0.407
d 42	0.302	0.638	0.001	0.171	0.005	0.648	0.090
d 0 to 7							
ADG, lb	0.112	0.210	0.047	0.192	0.211	0.642	0.922
ADFI, lb	0.238	0.164	0.244	0.451	0.666	0.580	0.199
F/G	0.249	0.533	0.122	0.016	0.165	0.909	0.169
d 7 to 21							
ADG, lb	0.091	0.001	0.001	0.139	0.428	0.338	0.218
ADFI, lb	0.170	0.001	0.001	0.347	0.322	0.234	0.168
F/G	0.448	0.07	0.001	0.339	0.911	0.718	0.858
d 0 to 21							
ADG, lb	0.283	0.001	0.001	0.053	0.744	0.273	0.240
ADFI, lb	0.318	0.001	0.001	0.546	0.256	0.217	0.357
F/G	0.950	0.071	0.001	0.026	0.299	0.760	0.434
d 21 to 42							
ADG, lb	0.186	0.04	0.968	0.352	0.001	0.885	0.055
ADFI, lb	0.573	0.30	0.001	0.133	0.013	0.934	0.373
F/G	0.070	0.01	0.001	0.309	0.002	0.689	0.006
d 0 to 42							
ADG, lb	0.560	0.599	0.013	0.145	0.007	0.871	0.043
ADFI, lb	0.996	0.376	0.001	0.160	0.117	0.774	0.304
F/G	0.221	0.356	0.136	0.718	0.004	0.754	0.009

[1]A total of 360 pigs (DNA 200 x 400) were used in a 3-phase nursery trial with 5 pigs per pen and 9 replications per treatment.
[2]All experimental diets were fed in three phases (d 0 to 7, d 7 to 21, and d 21 to 42). All diets contained 110 ppm of Zn from the trace mineral premix.

Table 5. Nursery pig fecal consistency over time

Day	Fecal score[1]
0	3.4
4	3.4
7	3.3
14	2.3
21	2.1
28	2.4
35	2.6
42	2.8

[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 ($P = 0.53$) and day effect ($P < 0.01$).