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Summary

A total of 299 pigs (DNA 400 × 200; initial BW 33.6 lb) were used in a 14-d study to determine the effects of two separate commercial formaldehyde products (Termin-8; Anitox Corp, Lawrenceville, GA and SalCURB; Kemin Industries, Inc., Des Moines, IA) on nursery pig performance. Dietary treatments were arranged in a 3 × 2 factorial design with three formaldehyde inclusions: none vs. 6.5 lb/ton SalCURB vs. 6.0 lb/ton Termin-8 and 2 Lys levels: Standard (1.25% SID Lys) vs. Low (1.10% SID Lys). Formaldehyde treatments were established based on supplier recommendations and diets were treated with supplier-specific equipment. Pens of pigs were balanced by initial BW and randomly allotted to one of six treatments with five pigs per pen and 10 pens per treatment. Overall, there was a tendency ($P < 0.10$) for a formaldehyde source × Lys level interaction to affect ADG and F/G, but not ADFI. Pigs fed diets with standard Lys levels, regardless of formaldehyde source, tended to have similar ($P > 0.10$) ADG to one another, but greater ($P < 0.10$) ADG than pigs fed low Lys levels treated with either formaldehyde source. Furthermore, pigs fed standard Lys levels treated with no formaldehyde or SalCURB tended to have improved ($P < 0.10$) F/G compared to pigs fed standard Lys levels treated with Termin-8 or low Lys levels treated with no formaldehyde or SalCURB. Pigs fed diets with low Lys and treated with Termin-8 tended to have poorer ($P < 0.10$) F/G than all other treatments. Regardless of source or Lys level, the inclusion of formaldehyde in nursery pig diets tended to reduce ($P < 0.10$) ADG and resulted in poorer ($P < 0.05$) F/G. Furthermore, the main effect of formaldehyde source affected ($P < 0.05$) ADG, F/G, and tended to affect ($P < 0.10$) ADFI, with pigs fed Termin-8 performing poorer than those fed SalCURB or no formaldehyde. As expected, Lys level affected ($P < 0.05$) ADG and F/G, but did not alter ADFI ($P > 0.10$).

In summary, SalCURB inclusion did not alter nursery pig growth performance compared to the untreated basal diet, regardless of Lys level. However, the inclusion of Termin-8 tended to result in poorer F/G in standard Lys diets and poorer ADG and F/G in low Lys diets compared to an untreated control.

Key words: formaldehyde, lysine, nursery pigs

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Introduction

Commercial formaldehyde products, such as Termin-8 (Anitox Corp, Lawrenceville, GA) and SalCURB (Kemin Industries, Inc., Des Moines, IA) are approved to prevent *salmonella* contamination in animal feed. These products are commonly used for bacterial control in the poultry industry. Also, their use is increasing in the swine industry due to reports of efficacy in reducing Porcine Epidemic Diarrhea Virus (PEDV) infectivity in contaminated feed. However, formaldehyde is known to bind proteins and amino acids. Thus, inclusion in diets may reduce the availability of dietary amino acids in pigs, which may influence growth performance and nutrient utilization. Therefore, the objective of this study was to observe the effects of formaldehyde source inclusion and Lys level on nursery pig growth performance.

Procedures

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

Two basal diets (low and standard Lys) were manufactured at a commercial mill. Each diet was divided and either left untreated, treated with 6.0 lb/ton Termin-8 in the same mill, or transported to a separate commercial mill and treated with 6.5 lb/ton SalCURB to make a total of six dietary treatments arranged in a 2×3 factorial with 2 Lys levels (1.10 vs. 1.25% SID Lys) and three formaldehyde sources (none vs. SalCURB vs. Termin-8). Formaldehyde inclusion levels and application methods were conducted according to manufacturers' recommendations, with inclusion occurring in the mixer. All diets were then transported back to the O.H. Kruse Feed Technology Innovation Center in Manhattan, KS where they were bagged and transported to the Kansas State University Swine Teaching and Research Center.

A total of 299 pigs (initially 33.6 lb) were used in a 14-d study. Pens of pigs were allotted by initial BW and then randomly allotted to one of six treatments with five pigs per pen and 10 pens per treatment. Each pen was equipped with a 4-hole, dry-self feeder and a nipple waterer to provide ad libitum access to feed and water. Pigs and feeders were weighed on d 0, 7, and 14 of the trial to calculate average daily gain, average daily feed intake, and feed efficiency.

Data were analyzed as a completely randomized design using PROC GLIMMIX in SAS (SAS Institute, Inc., Cary, NC) with pen as the experimental unit. Results were considered significant at $P \leq 0.05$ and marginally significant at $P > 0.05$ and $P \leq 0.10$. Pre-planned contrasts were utilized to compare the interaction between formaldehyde source and Lys level, the main effects of formaldehyde or Lys level, and formaldehyde inclusion, regardless of source, compared to none.

Results and Discussion

There were no significant formaldehyde source \times Lys level interaction detected for BW on d 0, 7, and 21 or any growth performance response measured from d 0 to 7 (Table 2). For the day 7 to 14 and overall (d 0 to 14) periods, formaldehyde source \times Lys level interactions were marginally significant ($P < 0.10$) for ADG and F/G. From

d 7 to 14, ADG for pigs fed diets with standard Lys levels, regardless of formaldehyde inclusion, and pigs fed the Low Lys level diets without formaldehyde were similar and pigs fed the low Lys diets with Termin-8 had lower ($P < 0.05$) ADG compared to pigs fed these diets. The pigs fed SalCURB had intermediate growth rate between pigs fed the Termin-8 and those fed the other diets. From d 7 to 14, pigs fed the standard Lys level without formaldehyde or SalCURB had better F/G than those fed the low Lys Level and either SalCURB or Termin-8. Those pigs fed the high Lys level and Termin-8 or those fed the low Lys without formaldehyde had intermediate growth rates. Also, the pigs fed the low Lys level and Termin-8 had poorer ($P < 0.05$) feed efficiency compared to those pigs fed all other treatments.

From d 0 to 14, ADG for pigs fed high Lys regardless of formaldehyde treatment had better ($P < 0.05$) ADG compared to those fed the low Lys diet treated with Termin-8. Those pigs fed the low Lys diet without formaldehyde treatment or SalCURB had intermediate ADG compared to pigs fed the other treatments. The ADG was marginally better ($P = 0.07$) for pigs fed SalCURB than for those pigs fed the Termin-8 during the overall d 0 to 14 period. For the d 0 to 14 period pigs fed the high Lys diet without formaldehyde or with SalCURB had better ($P < 0.05$) feed efficiency compared to those fed the other treatments. Those pigs fed low Lys diets treated with Termin-8 had poorer ($P < 0.001$) F/G than any other treatment from d 0 to 14.

Pre-planned contrasts revealed that formaldehyde inclusion, regardless of source, reduced ($P < 0.05$) F/G from d 7 to 14 and overall, and tended to reduce ($P < 0.10$) ADG overall, but otherwise did not influence ADFI or early growth performance.

Formaldehyde inclusion did not affect the main effects of BW or ADG from d 7 to 14. However, from d 0 to 7 pigs fed diets without formaldehyde or those treated with SalCURB had greater ($P < 0.05$) ADG and better ($P < 0.05$) F/G than those fed diets treated with Termin-8. Pigs fed diets treated with SalCURB had lower ($P < 0.05$) ADFI than those fed untreated diets or diets treated with Termin-8. From d 7 to 14, formaldehyde inclusion did not affect ADG but pigs fed Termin-8 treated diets had greater ($P < 0.05$) ADFI than those fed untreated diet. For the d 7 to 14 period pigs fed Termin-8 had the poorer ($P < 0.05$) F/G compared to those fed SalCURB or the diets without formaldehyde. Overall in the d 0 to 14 period, pigs fed diets treated with Termin-8 had poorer ($P < 0.05$) ADG and F/G, than those fed the diets without formaldehyde or the SalCURB-treated diets. Pigs fed Termin-8 had greater ($P < 0.05$) ADFI compared to those fed SalCURB while those fed the diets without formaldehyde had intermediate feed intake.

As expected, Lys level impacted ($P < 0.05$) ADG and F/G in each phase and overall. Pigs fed the Lys-deficient diet were nearly 2 lbs lighter at the end of the 14-day experiment due to a 7% reduction in overall F/G.

In summary, SalCURB inclusion did not alter nursery pig growth performance compared to the untreated basal diet, regardless of Lys level. However, the inclusion of Termin-8 tended to result in poorer F/G in standard Lys diets and poorer ADG and F/G in low Lys diets compared to pigs fed an untreated control diet.

Table 1. Composition of experimental diets (as-fed basis)¹

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Item	Low Lys	Standard Lys
Ingredient, %		
Corn	68.80	63.74
Soybean meal	26.80	31.73
Monocalcium phosphate	0.93	0.83
Limestone	1.23	1.20
Base mix ²	2.35	2.50
Total	100.00	100.00
Calculated analysis		
Standard ileal digestible (SID) amino acids, %		
Lys	1.10	1.25
Ile:lys	61	60
Leu:lys	130	124
Met:lys	32	31
Met & cys:lys	56	54
Thr:lys	62	61
Trp:lys	17.7	17.7
Val:lys	67	65
SID lysine:ME, g/Mcal	3.37	3.84
ME, kcal/lb	1,480	1,477
Total lysine, %	1.23	1.39
CP, %	19.0	20.9
Ca, %	0.73	0.72
P, %	0.61	0.61
Available P, %	0.41	0.41

¹Treatment diets were either untreated or treated with 6.5 lb/ton SalCURB or 6.0 lb/ton Termin-8 according to manufacturers' recommendations.

²Base mix was formulated to contain 25.72% corn, 7.30% monocalcium phosphate, 20% salt, 14.88% L-lysine HCl, 4.24% DL-methionine, 4.72% L-threonine, 1.40% choline chloride 60%, 0.74% Phytase (HiPhos 2700, DSM Nutritional Products, Inc., Parsippany, NJ, provided 9,091 FYT/lb of basemix), 1% tribasic copper chloride, and 20% vitamin and trace mineral premix.

Table 2. Interactive effects of Lys level and formaldehyde source on nursery pig growth performance¹

Formaldehyde ³ :	Standard Lys level ²			Low Lys level			SEM	<i>P</i> =	
	None	SalCURB	Termin-8	None	SalCURB	Termin-8		Formaldehyde source × Lys level	Form. inclusion vs. none
BW, lb									
d 0	33.8	33.6	33.6	32.8	33.8	33.6	0.63	0.588	0.456
d 7	45.3	45.6	44.7	43.6	44.4	43.9	0.77	0.801	0.770
d 14	57.2	57.8	56.9	55.4	55.8	54.9	0.89	0.994	0.949
d 0 to 7									
ADG, lb	1.66	1.72	1.58	1.58	1.51	1.47	0.04	0.243	0.188
ADFI, lb	2.50	2.47	2.51	2.51	2.37	2.51	0.04	0.326	0.312
F/G	1.51	1.43	1.60	1.59	1.58	1.71	0.03	0.667	0.251
d 7 to 14									
ADG, lb	1.69 ^{ab}	1.73 ^a	1.74 ^a	1.72 ^a	1.63 ^{ab}	1.56 ^b	0.05	0.086	0.334
ADFI, lb	2.82	2.94	3.04	2.99	2.95	3.07	0.07	0.423	0.123
F/G	1.68 ^a	1.70 ^a	1.75 ^{ab}	1.74 ^{ab}	1.80 ^b	1.97 ^c	0.04	0.073	0.003
d 0 to 14									
ADG, lb	1.67 ^a	1.73 ^a	1.66 ^a	1.65 ^{ab}	1.57 ^{bc}	1.52 ^c	0.03	0.053	0.096
ADFI, lb	2.65	2.70	2.78	2.75	2.66	2.79	0.04	0.292	0.431
F/G	1.59 ^a	1.57 ^a	1.67 ^b	1.66 ^b	1.69 ^b	1.84 ^c	0.02	0.085	0.0003

¹ Basal diets were manufactured at a commercial mill and 1/3 of the diet was treated with Termin-8. The remaining basal diet remained untreated (control) or was transported to a separate commercial mill for treatment with SalCURB. All diets were then transported back to the O.H. Kruse Feed Technology Innovation Center in Manhattan, Kansas where they were bagged and transported to the Kansas State University Swine Teaching and Research Center.

² Diets were formulated to contain Lys level at assumed requirement for a phase 3 nursery diet (1.25% SID Lys) and 90% of the requirements (1.10 % SID Lys).

³ Formaldehyde product was added to the mixer in a commercial mill according to the manufacturer's inclusion instructions. This included 6.5 lb/ton SalCURB and 6 lb/ton Termin-8.

^{a,b,c} Means within a row lacking a common superscript differ *P* < 0.04.

Table 3. Main effects of Lys level and formaldehyde source on nursery pig growth performance¹

Item	Formaldehyde source ²					Lys level ³			
	None	SalCURB	Termin-8	SEM	<i>P</i> =	Low	Standard	SEM	<i>P</i> =
BW, lb									
d 0	33.3	33.7	33.6	0.44	0.744	33.4	33.7	0.36	0.625
d 7	44.5	45.0	44.3	0.55	0.621	44.3	45.2	0.45	0.055
d 14	56.9	56.8	55.9	0.63	0.577	55.4	57.3	0.52	0.012
d 0 to 7									
ADG, lb	1.62 ^a	1.62 ^a	1.52 ^b	0.03	0.043	1.52	1.65	0.02	0.001
ADFI, lb	2.50 ^a	2.42 ^b	2.51 ^a	0.03	0.044	2.49	2.46	0.02	0.386
F/G	1.55 ^b	1.51 ^b	1.66 ^a	0.02	< 0.0001	1.63	1.51	0.02	< 0.0001
d 7 to 14									
ADG, lb	1.71	1.68	1.65	0.03	0.498	1.64	1.72	0.03	0.039
ADFI, lb	2.90 ^b	2.94 ^{ab}	3.05 ^a	0.05	0.090	3.00	2.93	0.04	0.226
F/G	1.71 ^b	1.75 ^b	1.86 ^a	0.03	0.001	1.84	1.71	0.02	< 0.001
d 0 to 14									
ADG, lb	1.66 ^a	1.65 ^a	1.59 ^b	0.02	0.038	1.58	1.69	0.02	< 0.0001
ADFI, lb	2.70 ^{ab}	2.68 ^a	2.78 ^b	0.03	0.054	2.73	2.71	0.03	0.556
F/G	1.63 ^b	1.63 ^b	1.76 ^a	0.01	< 0.001	1.73	1.61	0.01	< 0.0001

¹ Basal diets were manufactured at a commercial mill and 1/3 of the diet was treated with Termin-8. The remaining basal diet remained untreated (control) or was transported to a separate commercial mill for treatment with SalCURB. All diets were then transported back to the O.H. Kruse Feed Technology Innovation Center in Manhattan, KS where they were bagged and transported to the Kansas State University Swine Teaching and Research Center.

² Formaldehyde product was added to the mixer in a commercial mill according to the manufacturer's inclusion instructions. This included 6.5 lb/ton SalCURB and 6 lb/ton Termin-8.

³ Diets were formulated to contain Lys level at an assumed requirement for a phase 3 nursery diet (1.25% SID Lys) and 90% of the requirements (1.10 % SID Lys).

^{ab} Means within a row lacking a common superscript differ *P* < 0.05.