Kansas Agricultural Experiment Station Research Reports

Volume 1
Issue 7 *Swine Day*

Article 30

January 2015

Effects of Copper Sources and Levels on Nursery Pig Growth Performance

J. A. De Jong
Kansas State University, Manhattan, jadejong@k-state.edu

L. Bailey
Kansas State University, Manhattan

J. M. DeRouchey
Kansas State University, Manhattan, jderouch@k-state.edu

See next page for additional authors

Recommended Citation

De Jong, J. A.; Bailey, L.; DeRouchey, J. M.; Tokach, M. D.; Goodband, R. D.; and Dritz, S. S. (2015) "Effects of Copper Sources and Levels on Nursery Pig Growth Performance," *Kansas Agricultural Experiment Station Research Reports*: Vol. 1: Iss. 7. https://doi.org/10.4148/2378-5977.1135

Effects of Copper Sources and Levels on Nursery Pig Growth Performance

Abstract

A total of 225 pigs (PIC 327 × 1050, initially 25.5 lb) were used in a 21-d trial to evaluate the effects of copper source and level on nursery pig growth performance. Pens of pigs were balanced by initial BW and randomly allotted to 1 of 5 dietary treatments with 9 replications per treatment. The 5 corn and soybean meal-based diets were arranged in a 2 × 2 + 1 factorial with main effects of copper source — copper sulfate ($CuSO_4$) or tribasic copper chloride (TBCC) — and copper level (100 or 200 ppm) with a negative control. From weaning to 25 lb, pigs were fed a common phase 2 diet with added Zn and Cu levels of 1,965 and 17 ppm, respectively.

Overall (d 0 to 21), no copper source × level interactions ($P > 0.10$) were observed for any growth criteria. There were also no effects ($P > 0.10$) of copper, copper level, or copper source. These data suggest that adding high levels of copper from either $CuSO_4$ or TBCC to late nursery diets did not result in improved performance. Additional research should be conducted to determine if a late nursery Cu response is dependent on Zn concentrations in earlier diets.

Keywords

copper sulfate, nursery pig, tribasic copper chloride

Authors

J. A. De Jong, L. Bailey, J. M. DeRouchey, M. D. Tokach, R. D. Goodband, and S. S. Dritz

Effects of Copper Sources and Levels on Nursery Pig Growth Performance

J. A. De Jong, L. Bailey, J. M. DeRouchey, M. D. Tokach, R. D. Goodband, and S. S. Dritz[1]

Summary

A total of 225 pigs (PIC 327 × 1050, initially 25.5 lb) were used in a 21-d trial to evaluate the effects of copper source and level on nursery pig growth performance. Pens of pigs were balanced by initial BW and randomly allotted to 1 of 5 dietary treatments with 9 replications per treatment. The 5 corn and soybean meal-based diets were arranged in a 2 × 2 + 1 factorial with main effects of copper source — copper sulfate ($CuSO_4$) or tribasic copper chloride (TBCC) — and copper level (100 or 200 ppm) with a negative control. From weaning to 25 lb, pigs were fed a common phase 2 diet with added Zn and Cu levels of 1,965 and 17 ppm, respectively.

Overall (d 0 to 21), no copper source × level interactions ($P > 0.10$) were observed for any growth criteria. There were also no effects ($P > 0.10$) of copper, copper level, or copper source. These data suggest that adding high levels of copper from either $CuSO_4$ or TBCC to late nursery diets did not result in improved performance. Additional research should be conducted to determine if a late nursery Cu response is dependent on Zn concentrations in earlier diets.

Key words: copper sulfate, nursery pig, tribasic copper chloride

Introduction

Research has shown that adding high levels of copper (primarily from $CuSO_4$) to diets fed to nursery pigs will result in improved growth performance. It is thought that copper acts as an antimicrobial-like feed additive in the gut of the young pig, which influences the microflora in the intestine and leads to improvements in growth performance. Copper also has been shown to improve ADG and F/G during early finishing when fed as either $CuSO_4$ or tribasic copper chloride (TBCC) (Hastad et al., 2001)[2]. More recently, Coble et al. (2014)[3] has shown that TBCC can improve growth performance

[1] Department of Diagnostic Medicine/Pathobiology, College of Veterinary Medicine, Kansas State University.

[2] Hastad, C. W. 2002. Phosphorus requirements of grow-finish pigs reared in commercial environments. MS Thesis. Kansas State University, Manhattan.

[3] Coble, K. F., S. S. Dritz, M. D. Tokach, J. M. DeRouchey, J. L. Usry, R. D. Goodband. 2014. The effects of copper source (tribasic copper chloride or copper sulfate) on growth performance, carcass characteristics, and pen cleanliness in finishing pigs. J. Anim. Sci. 92(Suppl. 1): 82 (Abstr).

during early and late finishing. However, little data currently exists to compare the effects of $CuSO_4$ and TBCC on late nursery pig growth performance. Thus, the objective of this experiment was to compare the effects of added Cu from either $CuSO_4$ or TBCC on pigs fed from 25 to 50 lb.

Procedures

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

A total of 225 pigs (PIC 327 × 1050, initially 25.5 lb) were used in a 21-d growth trial. Pigs were allotted to pens by initial BW so pen initial average BW was similar among pens. Pens were then assigned to treatments in a completely randomized design with 5 pigs per pen and 9 replications per treatment. Before the start of the experiment, from approximately 15 to 25 lb, all pigs were fed a common phase 2 diet that contained added Zn and Cu levels of 1,965 and 17 ppm, respectively. The 5 treatment diets were arranged in a 2 × 2 + 1 factorial with main effects of copper source ($CuSO_4$ vs TBCC) and concentration (100 vs 200 ppm) with the addition of a negative control diet containing no additional copper (Table 1). All diets contained 17 ppm of Cu from $CuSO_4$ from the trace mineral premix and were formulated to a constant standardized ileal digestible (SID) lysine level. All diets were fed in meal form and were prepared at the O.H. Kruse Feed Technology and Innovation Center (Kansas State University, Manhattan, KS).

Pigs were housed in 2 separate but identical rooms. Each pen contained a 4-hole, dry self-feeder and a nipple waterer to provide ad libitum access to feed and water. Pens had wire-mesh floors and allowed approximately 3 ft^2/pig. Pig weight and feed disappearance were measured on d 0, 7, 14, and 21 of the trial to determine ADG, ADFI, and F/G.

Samples of corn and soybean meal, and complete diets were collected and submitted for analysis of DM, CP, ADF, NDF, crude fiber, fat, starch, Ca, and P (Ward Laboratories, Inc., Kearney, NE; Tables 2 and 3). In addition, complete diet samples were submitted for copper analysis to Cumberland Valley Analytical Services (Maugansville, MD).

Data were analyzed as a completely randomized design using the PROC GLIMMIX procedure of SAS (SAS Institute, Inc., Cary, NC), with pen as the experimental unit. Evaluation of residuals indicated heterogeneous variance among treatment groups. Establishing 2 residual variance groups resulted in the best model fit. Room was used as a random effect in the model. Pre-planned contrast statements were utilized to determine the interaction of copper source and level, the linear effect of copper, main effect of copper, and main effect of increasing copper. Treatment differences were considered significant at $P < 0.05$ and were considered tendencies between $P > 0.05$ and $P < 0.10$.

Results and Discussion

The chemical analysis of the corn and soybean meal revealed that most nutrients were similar to formulated values. Calcium levels were slightly higher for soybean meal than formulated values. As expected, analysis of the dietary treatments showed increasing amounts of copper when $CuSO_4$ or TBCC was added to the diet. All other nutrients were similar across treatments.

Overall (d 0 to 21), no copper source × copper level interactions ($P > 0.10$) were observed for any growth criteria (Table 4). There were also no effects ($P > 0.10$) of added copper, copper level, or copper source.

These data suggest that adding additional copper to phase 3 diets did not lead to improved growth performance. The lack of response may be related to the inclusion of high levels of Zn that was in the diet fed immediately prior to the study. High levels of Zn from ZnO are also known to have carryover effects, and other data suggest high levels of copper and zinc in nursery diets are not additive. Because we did not observe a Cu response, we also were unable to determine if the different Cu sources influenced growth performance differently. More research should be conducted to determine if a late nursery Cu response is dependent on the presence of high Zn concentrations in earlier diets.

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

		$CuSO_4$		TBCC	
	Copper level, ppm				
Item	0	100	200	100	200
Ingredient, %					
Corn	64.59	64.55	64.50	64.57	64.55
Soybean meal (46.5% CP)	32.04	32.04	32.05	32.04	32.04
Monocalcium phosphate (21% P)	1.10	1.10	1.10	1.10	1.10
Limestone	0.98	0.98	0.98	0.98	0.98
Salt	0.35	0.35	0.35	0.35	0.35
L-Lysine HCl	0.30	0.30	0.30	0.30	0.30
DL-methionine	0.12	0.12	0.12	0.12	0.12
L-threonine	0.12	0.12	0.12	0.12	0.12
Vitamin premix	0.15	0.15	0.15	0.15	0.15
Trace mineral premix[2]	0.25	0.25	0.25	0.25	0.25
Phytase[3]	0.02	0.02	0.02	0.02	0.02
Copper sulfate	---	0.04	0.08	---	---
TBCC[4]	---	---	---	0.02	0.03
Total	100.00	100.00	100.00	100.00	100.00
Calculated analysis					
Standard ileal digestible (SID) amino acids, %					
Lys	1.20	1.20	1.20	1.20	1.20
Ile:lys	63	63	63	63	63
Leu:lys	130	130	130	130	130
Met:lys	33	33	33	33	33
Met & cys:lys	57	57	57	57	57
Thr:lys	63	63	63	63	63
Trp:lys	18.6	18.6	18.6	18.6	18.6
Val:lys	69	69	69	69	69
Total lys, %	1.35	1.35	1.35	1.35	1.35
ME, kcal/lb[5]	1,484	1,483	1,483	1,484	1,484
NE, kcal/lb[5]	1,094	1,094	1,093	1,094	1,094
SID Lys:ME, g/Mcal	3.67	3.67	3.67	3.67	3.67
CP, %	21.0	21.0	21.0	21.0	21.0
Crude fiber %	2.5	2.5	2.5	2.5	2.5
Ca, %	0.70	0.70	0.70	0.70	0.70
P, %	0.63	0.63	0.63	0.63	0.63
Available P, %	0.41	0.41	0.41	0.41	0.41

[1] Treatment diets fed for 21 d.
[2] Trace mineral premix provided all diets with 17 ppm copper from copper sulfate.
[3] HiPhos 2700 (DSM Nutritional Products, Inc., Parsippany, NJ), providing 184.3 phytase units (FTU)/lb and an estimated release of 0.10% available P.
[4] Tribasic copper chloride (Micronutrients Inc., Indianapolis, IN).
[5] NRC. 2012. Nutrient Requirements of Swine, 10th ed. Natl. Acad. Press, Washington DC.

Table 2. Chemical analysis of corn and soybean meal (as fed basis)[1,2]

Item	Corn	Soybean Meal
DM, %	89.48	91.86
CP, %	8.4 (8.2)	46.5 (46.5)
ADF, %	2.1	9.6
NDF, %	14.4	9.3
Ca, %	0.03 (0.02)	0.42 (0.34)
P, %	0.23 (0.26)	0.67 (0.69)
Fat, %	3.3	1.2
Ash, %	1.08	5.98
Starch, %	64.9	2.8

[1] Values in parenthesis indicate those used in diet formulation.
[2] Values in parenthesis from NRC, 2012. Nutrient Requirements of Swine, 10th ed. Natl. Acad. Press, Washington DC.

Table 3. Chemical analysis of diets (as-fed basis)[1]

		$CuSO_4$		TBCC[2]	
	Copper level, ppm				
Item	0[3]	100	200	100	200
DM, %	89.55	90.00	89.36	89.53	90.13
CP, %	21.7	21.9	20.8	21.9	20.6
ADF, %	2.1	2.3	2.2	2.3	2.0
NDF, %	7.5	6.8	6.4	7.0	7.0
Crude fiber, %	1.5	1.6	1.2	1.3	1.2
Ca, %	0.81	0.84	0.84	0.81	0.85
P, %	0.60	0.62	0.58	0.61	0.61
Fat, %	2.5	2.2	2.2	2.1	2.2
Starch, %	38.5	37.2	40.5	38.5	40.5
Copper, ppm[4]	26	134	224	125	198

[1] A composite sample consisting of 6 subsamples was used for analysis.
[2] Tribasic copper chloride (Micronutrients Inc., Indianapolis, IN).
[3] Premix contained 17 ppm copper.
[4] Copper analysis was conducted at Cumberland Valley Analytical Services (Maugansville, MD).

Table 4. Effects of copper source and level on late nursery pig growth performance[1]

	$CuSO_4$			TBCC[2]			Probability, P <		
	Copper level, ppm						Copper source × copper level	Copper source main effect	Copper linear effect
Item	0	100	200	100	200	SEM[3]			
d 0 to 21									
ADG, lb	1.37	1.41	1.34	1.35	1.38	0.053	0.267	0.825	0.778
ADFI, lb	2.22	2.27	2.21	2.20	2.23	0.084	0.402	0.608	0.955
F/G	1.62	1.63	1.66	1.63	1.62	0.033	0.440	0.478	0.622
BW, lb									
d 0	25.56	25.58	25.57	25.57	25.55	0.522	0.988	0.981	0.993
d 21	54.31	55.69	54.12	54.21	54.33	1.344	0.454	0.576	0.941

[1] A total of 225 pigs (PIC 327 × 1050, initially 25.6 lb) were used in a 21-d trial with 5 pigs per pen and 9 replications per treatment.
[2] Tribasic copper chloride (Micronutrients Inc., Indianapolis, IN).
[3] Variance groupings were used to group the negative control and TBCC treatments, and the $CuSO_4$ treatments due to non-heterogeneous variance.