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C W. Hastad

Jim L. Nelssen

Michael D. Tokach

See next page for additional authors

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Evaluation of different copper sources as a growth promoter in swine finishing diets

Authors

C W. Hastad, Jim L. Nelssen, Michael D. Tokach, Robert D. Goodband, and Steven S. Dritz

EVALUATION OF DIFFERENT COPPER SOURCES AS A GROWTH PROMOTER IN SWINE FINISHING DIETS [1]

C. W. Hastad, S. S. Dritz [2], J. L. Nelssen, M. D. Tokach, and R. D. Goodband

Summary

Two trials were conducted to determine the effects of added copper from copper sulfate or copper chloride on performance of growing-finishing pigs. A total of 2,277 pigs with an initial weight of 71.6 lb were used in a commercial research facility in southwest Minnesota. Adding copper to the diet improved performance during the first two weeks in the finishing barn regardless of copper source or level. The results of these experiments indicate that low levels of copper chloride or copper sulfate (50 to 100 ppm) can be an effective and economical growth promoter when fed for the first two weeks to growing-finishing pigs.

(Key Words: Growth Promoter, Copper Sulfate, Copper Chloride, Grower-Finisher Pigs.)

Introduction

Many swine production systems have used copper sulfate as a growth promoter in growing and finishing diets. Recent research indicates that tribasic copper chloride is as effective as copper sulfate as a growth promoter in nursery pig diets. Previous trials have shown that low levels of tribasic copper chloride yield similar results as higher levels of copper sulfate. Because of the lower inclusion rate, adding copper chloride may be more cost effective than copper sulfate for growth promotion. The lower inclusion rate also would result in less copper excretion in swine waste. In addition, copper chloride is thought to be less oxidative and thus, should result in less corrosion to feeders and gating. Therefore, the objective of these trials was to evaluate low levels of copper chloride and copper sulfate as growth promoters in growing-finishing diets.

Procedures

Both experiments were conducted in a commercial research facility in southwest Minnesota. Pigs were randomly allotted to the dietary treatments in a randomized complete block design in both experiments. Each pen contained one self-feeder and nipple waterer to allow ad libitum access to feed and water. There were approximately 28 pigs per pen with the same number of pigs per pen within each block. Pigs were weighed and feed disappearance was determined approximately every 14 days to calculate ADG, ADFI, and feed efficiency.

Experiment 1. A total of 1,100 pigs (initially 74.2 lb) were used. Pigs were allotted to one of five dietary treatments with 8 replications (pens) per treatment (4 per gender). Diets were fed in four phases in order to more closely match nutrient requirements of the pigs. The phases were from d 0 to 31, 31 to 59, 59 to 86, and 86 to 115 (Table 1). Within each phase, treatment diets consisted of a control diet with no added copper, three diets with 50, 100, and 200 ppm of added

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[2]Food Animal Health and Management Center.

copper from copper chloride and a single diet with 200 ppm of added copper from copper sulfate. Copper replaced corn in the control diet.

Experiment 2. A total of 1,177 gilts (initially 68.9 lb) were used in this experiment. Pigs were allotted to one of seven dietary treatments in a randomized complete block design with six pens per treatment. Diets were provided in two phases from d 0 to 27 and d 27 to 56. Diets consisted of a control diet with no added copper and control plus 50, 100, or 200 ppm of added copper from either copper chloride or copper sulfate (Table 2).

Results and Discussion

Experiment 1. Adding either copper source to the diet reduced (P<0.02) ADFI and improved (P<0.05) F/G during phase 1 (d 0 to 31). When copper chloride was added to the diet, the greatest improvement in ADFI and F/G occurred with the addition of the first 50 ppm of copper. Adding copper to the diet caused a similar reduction (P<0.05) in ADFI during phase 3. Copper did not consistently influence ADG; however, there was a trend (P<0.12) for improved ADG during phase 2 and 4 when copper was added to the diet.

For the overall experiment, ADG was improved as either copper source was added to the diet (linear, P<0.07 for copper chloride and P<0.003 for copper sulfate). Pigs fed either copper source had reduced (P<0.06) ADFI and improved (P<0.003) F/G for the overall trial. The feed intake and feed efficiency response to increasing copper chloride was quadratic; the maximal response was observed in pigs fed 50 ppm, with no further improvement through the higher levels.

Experiment 2. Pigs fed either copper source had greater (P<0.01) ADG during the first two weeks of the experiment compared to pigs fed the control diet. There were no differences between copper sources and no response to copper level indicating that the maximal response was achieved with the inclusion of the first 50 ppm of copper. Adding copper sulfate to the diet reduced (P<0.03) ADFI and copper chloride tended to improve (P<0.07) feed efficiency from d 0 to 14.

From d 14 to 27, pigs fed copper sulfate had greater (P<0.04) ADG than pigs fed copper chloride. However, ADG for pigs fed either copper source was not different from pigs fed the control diet. Neither copper source nor level had any affect on ADFI or F/G.

From d 27 to 42, pigs fed diets containing copper chloride had decreased (P<0.03) ADFI but improved (P<0.04) F/G compared with pigs fed the diets containing copper sulfate. Similar to the response from d 14 to 27, neither copper source influenced ADG, ADFI, or F/G compared to the control diet. Neither copper source nor level influenced performance from d 27 to 56.

For the overall experiment, ADG was greater (P<0.05) for pigs fed copper sulfate compared to those fed the control diet. They also tended to have greater (P<0.08) ADG than pigs fed the diets containing copper chloride. Pigs fed diets containing copper sulfate had greater (P<0.02) ADFI than pigs fed diets containing copper chloride; however, neither source influenced ADFI compared to pigs fed the control diet. Also, neither copper source influenced F/G compared to the control diet; however, there was a level by source interaction (P<0.05). The reason for the interaction is that F/G improved with increasing levels of copper chloride while no distinct pattern was found with increasing levels of copper sulfate.

In conclusion, adding low levels of copper to diets during the first four weeks of the growing-finishing phase appears to provide an advantage in gain and feed efficiency. There is not an advantage to use copper chloride as a replacement for copper sulfate. Because of the low cost of copper and the improvements in ADG and feed efficiency, this practice may offer an economic benefit for the producer. Added copper during the late finishing phase does not appear to provide any significant advantage in gain or feed conversion.

Table 1. Composition of Diets in Experiment 1				
Ingredient	d 0 to 31	d 31 to 59	d 59 to 86	d 86 to 115
Corn	58.98	64.43	75.43	87.75
Soybean meal (46.5%)	32.41	26.97	16.09	10.07
Choice white grease	6.00	6.00	6.00	0.00
Monocalcium phosphate (21% P)	1.08	1.02	1.02	0.75
Limestone	0.84	0.87	0.81	0.85
Salt	0.35	0.35	0.35	0.35
Vitamin premix	0.09	0.07	0.06	0.04
Trace mineral premix	0.10	0.12	0.10	0.05
Lysine@HCl	0.15	0.15	0.15	0.15
Copper chloride or sulfate[a]	- - -	- - -	- - -	- - -
TOTAL	100.00	100.00	100.00	100.00
Calculated Analysis				
Desired lysine, %	1.25	1.10	.80	
Isoleucine:lysine ratio	67%	68%	65%	
Leucine:lysine ratio	142%	148%	167%	
Methionine:lysine ratio	25%	26%	30%	
Met & Cys:lysine ratio	54%	56%	62%	
Threonine:lysine ratio	62%	62%	65%	
Tryptophan:lysine ratio	20%	19%	19%	
Valine:lysine ratio	77%	78%	82%	
ME, kcal/lb	1,628	1,629	1,633	
Protein, %	20.10	18	13.9	
Calcium, %	0.65	0.63	0.57	
Phosphorus, %	0.61	0.58	0.54	
Available phosphorus, %	0.30	0.28	0.27	
Lysine:calorie ratio, g/Mcal ME	3.48	3.06	2.22	

[a]Copper source replaced corn in the control diets.

Table 2. Composition of Diets in Experiment 2		
Ingredient, %	d 0 to 27	d 27 to 56
Corn	59.29	66.85
Soybean meal (46.5%)	32.04	24.84
Choice white grease	6.00	6.00
Monocalcium phosphate (21% P)	1.05	0.85
Limestone	0.90	0.80
Salt	0.35	0.35
Vitamin premix	0.08	0.06
Trace mineral premix	0.15	0.10
Copper chloride or sulfate	- - -	- - -
Lysine@HCl	0.15	0.15
TOTAL	100.00	100.00
Calculated Analysis		
Lysine, %	1.25	1.05
Isoleucine:lysine ratio	67%	66%
Leucine:lysine ratio	141%	151%
Methionine:lysine ratio	25%	27%
Met & cys:lysine ratio	54%	57%
Threonine:lysine ratio	62%	63%
Tryptophan:lysine ratio	20%	19%
Valine:lysine ratio	77%	79%
ME, kcal/lb	1,627	1,634
Protein, %	20.1	17.36
Calcium, %	0.66	0.57
Phosphorus, %	0.61	0.54
Available phosphorus, %	0.29	0.24
Lysine:calorie ratio, g/Mcal ME	3.48	2.91

[a]Copper source replaced corn in the control diets.

Table 3. Growth Performance of Finishing Pigs fed Various Copper Sources (Exp. 1)[a]

		CuCl			$CuSO_4$		CuCl		Control vs. $CuSO_4$
Item	Control	50	100	200	200	SEM	Linear	Quadratic	
Period I, d 0 to 31									
ADG, lb	1.83	1.84	1.78	1.89	2.02	0.073	0.58	0.44	0.08
ADFI, lb	4.05	3.76	3.72	3.76	3.77	0.067	0.02	0.01	0.01
F/G	2.25	2.09	2.13	2.00	1.88	0.075	0.05	0.70	0.002
Period II, d 31 to 59									
ADG, lb	1.69	1.68	1.70	1.78	1.77	0.036	0.08	0.47	0.12
ADFI, lb	4.10	3.81	3.88	3.92	4.02	0.103	0.44	0.13	0.57
F/G	2.43	2.28	2.29	2.22	2.28	0.081	0.11	0.50	0.20
Period III, d 59 to 86									
ADG, lb	1.64	1.75	1.67	1.78	1.65	0.047	0.09	0.95	0.92
ADFI, lb	5.31	5.18	5.05	4.99	5.01	0.107	0.04	0.45	0.05
F/G	3.24	2.96	3.02	2.81	3.06	0.106	0.02	0.61	0.26
Period IV, d 86 to 115									
ADG, lb	1.05	1.14	1.20	1.03	1.16	0.047	0.57	0.01	0.12
ADFI, lb	3.98	4.03	3.97	4.01	3.93	0.106	0.92	0.96	0.70
F/G	3.84	3.61	3.33	3.91	3.48	0.177	0.70	0.02	0.16
Overall, d 0 to 115									
ADG, lb	1.56	1.61	1.59	1.63	1.66	0.022	0.07	0.58	0.003
ADFI, lb	4.34	4.17	4.13	4.15	4.16	0.063	0.06	0.08	0.05
F/G	2.79	2.59	2.59	2.55	2.51	0.047	0.003	0.05	0.001
Final Wt.	254.86	257.9	258.4	260.0	262.3	1.70	0.05	0.51	0.004

[a]A total of 1,100 pigs (20 pens of barrows and 20 pens of gilts with 26 to 28 pigs per pen and with eight replications, four per gender for each treatment) with an average initial weight of 74.4 lb were used for this experiment.

Table 4. Growth Performance of Pigs Fed Increasing Copper Chloride or Copper Sulfate (Exp. 2)[a]

	Control	Copper Chloride			Copper Sulfate			
Item	No Cu	50	100	200	50	100	200	SEM
D 0 to 14								
ADG, lb	1.83	2.00	1.91	2.04	2.01	1.99	2.02	0.04
ADFI, lb	3.29	3.42	3.39	3.35	3.48	3.41	3.53	0.07
F/G	1.80	1.72	1.78	1.65	1.73	1.71	1.75	0.04
D 14 to 27								
ADG, lb	2.10	2.05	2.08	2.10	2.13	2.19	2.15	0.04
ADFI, lb	4.34	4.35	4.26	4.38	4.36	4.37	4.46	0.07
F/G	2.07	2.12	2.05	2.08	2.05	2.01	2.08	0.05
D 27 to 42								
ADG, lb	1.82	1.81	1.84	1.80	1.86	1.72	1.81	0.04
ADFI, lb	4.55	4.54	4.52	4.42	4.59	4.64	4.62	0.07
F/G	2.50	2.51	2.47	2.46	2.48	2.70	2.55	0.06
D 27 to 56								
ADG, lb	1.87	1.75	1.82	1.86	1.85	1.84	1.88	0.04
ADFI, lb	4.45	4.32	4.32	4.48	4.39	4.48	4.44	0.09
F/G	2.38	2.49	2.38	2.41	2.37	2.44	2.36	0.06
Overall, d 0 to 56								
ADG, lb	1.90	1.90	1.91	1.95	1.96	1.93	1.96	0.02
ADFI, lb	4.16	4.16	4.13	4.16	4.21	4.23	4.26	0.04
F/G	2.19	2.19	2.17	2.14	2.15	2.19	2.17	0.02

[a]A total of 1,177 gilts with an average initial wt of 68.9 lb were used in the experiment. The values represent the means of six pens per treatment and 28 pigs per pen.

Table 5. Probability Values for Growth Performance of Pigs Fed Increasing Copper Chloride or Copper Sulfate (Exp. 2)[a]

		P-Value			Control vs.	
Item		Level	Source	Level* Source	Copper Chloride	Copper Sulfate
D 0 to 14						
ADG		0.11	0.36	0.39	0.007	0.001
ADFI		0.79	0.19	0.58	0.24	0.03
F/G		0.47	0.61	0.12	0.07	0.13
D 14 to 27						
ADG		0.63	0.04	0.82	0.73	0.19
ADFI		0.34	0.25	0.78	0.91	0.46
F/G		0.61	0.45	0.84	0.84	0.70
D 27 to 42						
ADG		0.41	0.55	0.14	0.93	0.59
ADFI		0.65	0.03	0.54	0.50	0.41
F/G		0.23	0.04	0.08	0.76	0.24
D 27 to 56						
ADG		0.29	0.14	0.56	0.20	0.79
ADFI		0.53	0.40	0.51	0.49	0.91
F/G		0.76	0.45	0.37	0.49	0.90
Overall, d 0 to 56						
ADG		0.26	0.08	0.55	0.52	0.05
ADFI		0.68	0.02	0.75	0.79	0.12
F/G		0.36	0.65	0.05	0.17	0.30

[a]A total of 1,177 gilts with an average initial wt of 68.9 lb were used in the experiment. The values represent the means of six pens per treatment and 28 pigs per pen.