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Effect of dietary addition of dried whey and/or copper sulfate on starter pig performance

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EFFECT OF DIETARY ADDITION OF DRIED WHEY AND/OR COPPER SULFATE ON STARTER PIG PERFORMANCE

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Summary

Two 35-day trials involving 504 pigs were conducted to determine the efficacy of dietary supplementation of copper sulfate ($CuSO_4$) and/or dried whey to corn-soybean meal starter pig diets (1.25% lysine). Pigs were weaned at 21 ± 3 days and ranged in average initial weight from 8.1 to 19.2 lbs. In trial 1, $CuSO_4$ addition of either 0 or 250 ppm were made to diets containing 0, 10, and 20% extra-grade dried whey. At both 2 and 5 weeks, average daily gain (ADG), average daily feed intake (ADFI), and feed efficiency (F/G) improved linearly ($P<.05$) with increasing whey levels. Also, $CuSO_4$ additions of 250 ppm increased ADG and ADFI ($P<.05$) at 2 and 5 weeks. The six dietary treatments in trial 2 consisted of a negative control (no $CuSO_4$ or dried whey), and five other diets containing 250 ppm $CuSO_4$ with graded levels of dried whey (0, 5, 10, 15, and 20%). Dried whey additions linearly increased ADG and ADFI at both 2 and 5 weeks ($P<.05$), whereas F/G at 2 and 5 weeks was optimized at the 5% dried whey level. Copper sulfate supplementation improved ADG and F/G at 5 weeks ($P<.05$). These results suggest that $CuSO_4$ additions are beneficial for starter pig performance, and the 5% dried whey addition gave starter pig performance equal to that with 20% dried whey addition, when $CuSO_4$ was present in both diets.

Introduction

Producers are currently weaning pigs at 4 weeks of age or less in order to increase the number of pigs/sow/year. However, early weaning of pigs has been associated with such problems as decreased feed intake, decreased gain, and increased pig morbidity. One part of the problem is that grain-based diets aren't as palatable to the young pig as diets containing milk products. Current research has shown that weanling pigs will consume less of a cereal-based diet than they will of a diet containing dried whey. Another part of this postweaning "lag" or "check" may be attributed to the fact that the 3-4 week old pig's digestive system is better able to digest a milk-based diet than a grain-based diet. This may be due to enzymes present in the small intestine of pigs weaned at 17-21 d of age. Lactase, the enzyme that breaks down the milk sugar lactose, is present in a much greater concentration in the young pigs digestive tract than is amylase, the enzyme that breaks down starch in grain. This difference in enzyme concentrations, combined with a decreased feed intake, reduces utilizable calories available to the early-weaned pig on grain-based diets at a critical time when energy is needed for growth and thermoregulation. In order to alleviate this problem, most commercial diets for early-weaned pigs contain some form of milk products.

Dietary addition of 250 ppm of $CuSO_4$ has been shown to improve the young pig's growth rate and feed efficiency. Copper sulfate's growth-promoting abilities have been attributed to its antibacterial properties; it may also increase feed intake. Recent studies at the University of Illinois have shown that the $CuSO_4$ sulfate response is affected by the dried whey level present in starter diets. Although the response is additive, there is a greater $CuSO_4$ response at lower dried whey levels than at higher whey levels. Therefore, the objectives of the following studies were to further study the interactive effects of dried whey and $CuSO_4$, and to determine the optimum dried whey level in starter diets supplemented with $CuSO_4$.

Experimental Procedures

Two trials were conducted in environmentally controlled nurseries at the KSU Swine Research Center with 6 pigs/pen and feed and water offered ad libitum. The initial temperature of 95°F was decreased 5°F each week for the 35-day trials. Pig weights and feed intake were collected weekly. The dried whey used in all trials was an extra-grade edible whey, and its composition is shown in Table 1.

Trial 1

Trial 1 utilized 180 weanling pigs (21 $\pm$ 3 days) whose average pen weights ranged from 9.1 to 19.2 lbs. Diets consisted of two $CuSO_4$ levels (0 and 250 ppm) at each of the three dried whey levels (0, 10, and 20%) in a 2 x 3 factorial arrangement with each treatment replicated 5 times. Composition of the diets used in Trial 1 is shown in Table 2.

Trial 2

Trial 2 utilized 324 weanling pigs (21 $\pm$ 3 days), and average pen weight ranged from 8.1 to 18.0 lbs. Dietary treatments were a negative control diet (0 ppm $CuSO_4$ amd 0% dried whey) and five diets containing 250 ppm $CuSO_4$ with graded levels of dried whey (0, 5, 10, 15 and 20%) replicated 9 times. Composition of the diets used in Trial 2 is shown in Table 3.

Results and Discussion

During the first 2 weeks postweaning, ADG and ADFI increased linearly ($P<.01$) and feed efficiency linearly improved ($P<.05$) with increasing dried whey levels (Table 4.). $CuSO_4$ addition increased ADG and ADFI ($P<.01$) and tended to improve F/G ($P<.10$) during the first 14 days of the trial. At the end of the 35-day trial, dried whey addition still improved ADG, ADFI, and F/G. Although $CuSO_4$ had no affect on F/G, it increased ADG and ADFI for the 5-week period. The effects of $CuSO_4$ and dried whey on ADG at 2 and 5 weeks can be seen more clearly in Figure 1.[4] Both the linear whey effect and positive $CuSO_4$ effect are illustrated. As observed by the Illinois researchers, the $CuSO_4$ effect was more pronounced at the 0 and 10% whey levels than at the 20% level. Furthermore, the degree of improvement in ADG between the 0 and 20% whey levels at 2 weeks was less for diets containing 250 ppm $CuSO_4$ (.11 vs .15 lbs). It was also noted that at both 2

and 5 weeks, pigs receiving diets containing 10% dried whey and $CuSO_4$ performed as well as pigs receiving diets with 20% whey and no $CuSO_4$.

At both 2 and 5 weeks in Trial 2, dried whey addition linearly increased ($P<.05$) ADG and ADFI (Table 5.). Copper sulfate additions did not improve ($P>.05$) any performance criteria at 2 weeks, but did improve ($P<.05$) ADG and F/G at 5 weeks. Feed/gain was optimized at both 2 and 5 weeks by the 5% dried whey and 250 ppm $CuSO_4$ treatment. In Figure 2, the effect of $CuSO_4$ and dried whey additions on average daily gain at 2 and 5 weeks is shown. The bar on the extreme left represents the negative control diet. The other five bars to the right indicate diets containing 250 ppm $CuSO_4$. There is a $CuSO_4$ effect at 5 weeks, and a linear whey effect at both 2 and 5 weeks, which appears to plateau at the 5% dried whey level.

From these studies, the beneficial effects of dried whey and copper sulfate additions to starter diets can be seen. Dried whey improved the performance of starter pigs by improving feed intake and efficiency. However, the $CuSO_4$ response varied between the two trials. It appeared that the improvement in ADG was related to an increase in feed intake in Trial 1 and to an improvement in feed efficiency in Trial 2. It should be noted, though, that other researchers have observed inconsistencies in $CuSO_4$ effects.

In summarizing these two trials, the additive effects of $CuSO_4$ and dried whey can be seen, especially at the lower whey levels. Based on the greater $CuSO_4$ response at lower whey levels, these data suggest that decreasing the dried whey level from 20 to 5% will produce a more economical diet and not adversely affect starter pig performance if copper sulfate is present in the diet. It is imperative, however, that an excellent quality whey be used.

Table 1. Composition of Edible Dried Whey [a].

Item	%
Protein	11.17
Lysine	.82
Lactose	62.85
Salt	2.52
Ash	7.31
Moisture	10.37
Fiber	.09
Fat	.39

[a] On an as-fed basis.

Table 2. Percentage Diet Composition (Trial 1).[a]

Ingredients	Dried Whey (%)		
	0	10	20
Corn	55.21	48.49	41.45
Soybean meal (44% crude protein)	36.74	33.95	31.50
Soybean oil	4.00	4.00	4.00
Dried whey (edible grade)		10.00	20.00
Monocalcium phosphate	1.70	1.53	1.35
Limestone	1.00	.88	.75
Salt	.50	.30	.10
Trace mineral mix[b]	.10	.10	.10
Vitamin mix[c]	.25	.25	.25
L-Lysine HCL	.10	.10	.10
Selenium premix[d]	.15	.15	.15
Antibiotic mix[e]	.25	.25	.25

[a]Corn was replaced with 2 lbs copper sulfate in diets containing 250 ppm copper sulfate. Diets were calculated to contain 1.25% lysine, .90% calcium, and .70% phosphorus.

[b]Percentage composition was Fe, 10; Zn, 10; Cu, 1; I, .3; Co, .1.

[c]Compositon per lb premix: vitamin A, 800,000 IU; vitamin D_3, 60,000 IU; vitamin E, 4000 IU; riboflavin, 900 mg; menadione, 310 mg; pantothenic acid, 2400 mg; niacin, 5000 mg; choline chloride, 92,200 mg; vitamin B_{12}, 4.4 mg.

[d]Diet contains .3 ppm selenium.

[e]Antibiotic contained 20 g chlortetracycline, 20 g sulfamethazine and 10 g penicillin per lb.

Table 3. Percentage Diet Composition (Trial 2).[a]

Ingredients	Dried whey (%)					
	0	0	5	10	15	20
Corn	55.21	55.11	52.58	49.24	46.01	42.64
Soybean meal (44% crude protein)	36.74	36.74	34.82	33.40	31.92	30.50
Soybean oil	4.00	4.00	4.00	4.00	4.00	4.00
Dried whey (edible grade)			5.00	10.00	15.00	20.00
Monocalcium phosphate	1.70	1.70	1.46	1.37	1.27	1.18
Limestone	1.00	1.00	.79	.74	.69	.63
Salt	.50	.50	.40	.30	.20	.10
Trace mineral mix[b]	.10	.10	.10	.10	.10	.10
Vitamin mix[c]	.25	.25	.25	.25	.25	.25
L-Lysine HCL	.10	.10	.10	.10	.10	.10
Selenium premix[d]	.15	.15	.15	.15	.15	.15
Antibiotic mix[e]	.25	.25	.25	.25	.25	.25
Copper sulfate[f]		.10	.10	.10	.10	.10

[a]Diets were calculated to contain 1.25% lysine, .90% calcium, and .70% phosphorus.

[b]Percentage composition was Fe, 10; Zn, 10; Mn, 10; Cu, 1; I, .3; Co, .1.

[c]Composition per kg premix: vitamin A, 800,000 IU; vitamin D_3, 60,000 IU; vitamin E, 4000 IU; riboflavin, 900 mg; menadione, 310 mg; pantothenic acid, 2400 mg; niacin, 5000 mg; choline chloride, 92,200 mg; vitamin B_{12}, 4.4 mg.

[d]Diet contains .3 ppm selenium.

[e]Antibiotic contained 20 g chlortetracycline, 20 g sulfamethazine and 10 g penecillin per lb.

[f]Provided 250 ppm copper sulfate.

Table 4. Effect of Dried Whey and/or Copper Sulfate on Starter Pig Performance (Trial 1).

		Dried whey level (%) 0	10	20	Effect Of $CuSO_4$	SE
Week 2						
ADG[a,b]	control	.42	.44	.57	.48	.019
	+$CuSO_4$	.51	.57	.62	.57	
	Whey effect	.47	.51	.60		
ADFI[a,b]	control	.60	.57	.68	.62	.031
	+$CuSO_4$	.66	.68	.75	.70	
	Whey effect	.63	.63	.72		
F/G[c]	control	1.48	1.28	1.19	1.32	.068
	+$CuSO_4$	1.29	1.17	1.20	1.22	
	Whey effect	1.39	1.23	1.20		
Week 5						
ADG[a,b]	control	.84	.90	.93	.89	.023
	+$CuSO_4$	.88	.97	.99	.95	
	Whey effect	.86	.94	.96		
ADFI[a,b]	control	1.41	1.43	1.48	1.44	.033
	+$CuSO_4$	1.52	1.57	1.63	1.57	
	Whey effect	1.47	1.50	1.56		
F/G[c]	control	1.66	1.59	1.59	1.61	.033
	+$CuSO_4$	1.70	1.61	1.63	1.65	
	Whey effect	1.68	1.60	1.61		

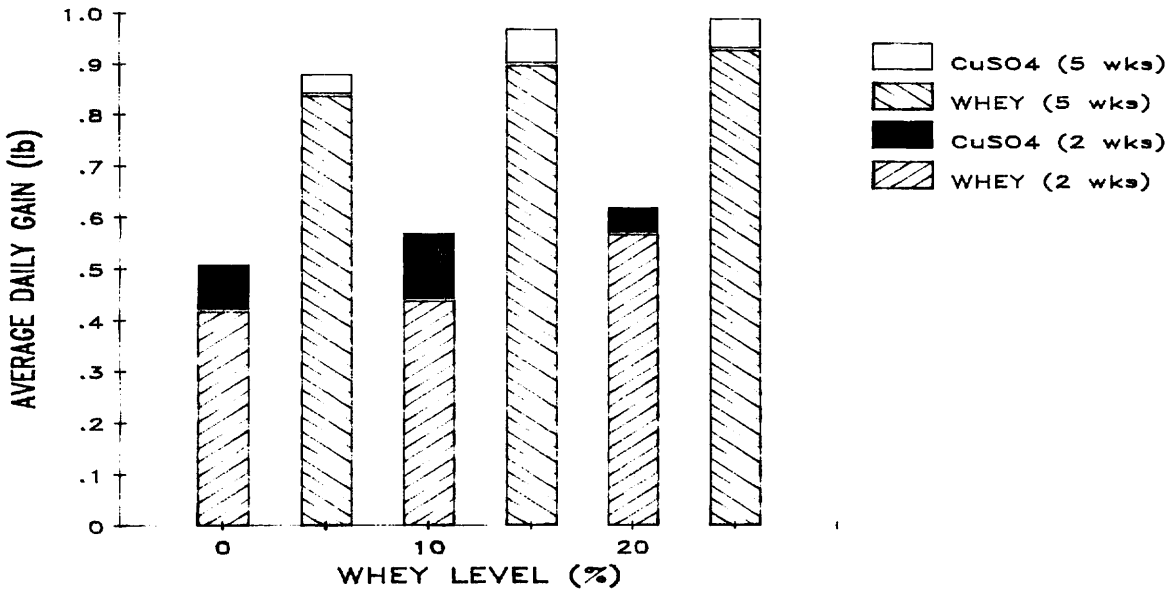
[a]Linear dried whey effect ($P<.01$).
[b]Copper sulfate effect ($P<.01$).
[c]Linear dried whey effect ($P<.05$).

Table 5. Effect of Dried Whey and/or Copper Sulfate on Starter Pig Performance (Trial 2.).

	Dried whey level (%)						
	0	0	5	10	15	20	
Copper sulfate (250 ppm)	-	+	+	+	+	+	SE
Week 2							
ADG[a]	.44	.47	.58	.54	.59	.60	.039
ADFI[b]	.58	.61	.68	.70	.74	.73	.036
F/G[c]	1.44	1.31	1.21	1.30	1.38	1.25	.051
Week 5							
ADG[b,c,d]	.81	.86	.94	.94	.92	.95	.020
ADFI[b,e]	1.30	1.31	1.41	1.46	1.46	1.47	.034
F/G[a,d]	1.61	1.48	1.46	1.50	1.57	1.52	.033

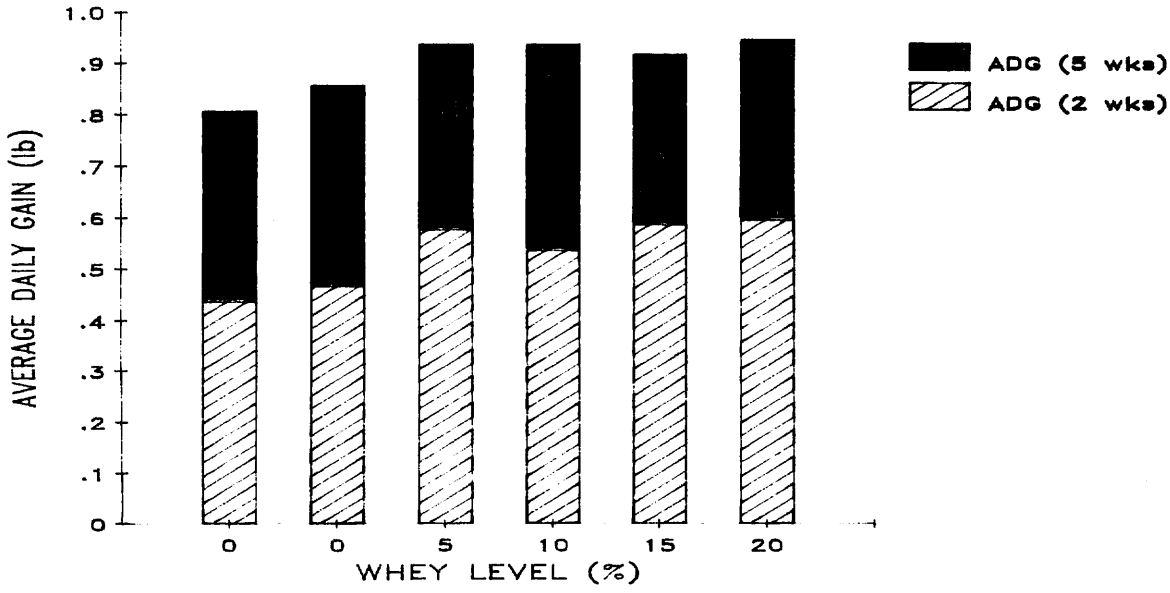
[a]Linear dried whey effect (P<.05)
[b]Linear dried whey effect (P<.01)
[c]Cubic dried whey effect (P<.01)
[d]Copper sulfate effect (P<.05)
[e]Quadratic dried whey effect (P<.05)

FIGURE 1. EFFECT OF COPPER SULFATE AND DRIED WHEY ON AVERAGE DAILY GAIN.



LINEAR WHEY AND CuSO4 EFFECT (P<.01).

FIGURE 2. EFFECT OF DRIED WHEY AND/OR COPPER SULFATE ADDITIONS ON AVERAGE DAILY GAIN.



LINEAR WHEY (2&5 wk) AND CuSO4 (5 wk) EFFECT (P<.01).