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Abstract

Results of these studies suggest that experimental high molecular weight, whey protein concentrate can be an effective replacement for spray-dried animal plasma in diets for weanling pigs. Increasing spray-dried animal plasma improved ADG and ADFI quadratically, with the maximum response observed with 2.5% in 21-d-old pigs or 5.0% in 12-d-old pigs. The specialty whey protein concentrate fed from d 0 to 14 after weaning resulted in similar responses as spray-dried animal plasma fed during the same period and may be an effective alternative.; Swine Day, Manhattan, KS, November 19, 1998

Keywords

Swine day, 1998; Kansas Agricultural Experiment Station contribution; no. 99-120-S; Report of progress (Kansas State University. Agricultural Experiment Station and Cooperative Extension Service); 819; Swine; Starter pigs; Spray-dried animal plasma; High-protein whey protein concentrate

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EVALUATION OF A HIGH-PROTEIN WHEY PROTEIN CONCENTRATE AND SPRAY-DRIED ANIMAL PLASMA ON GROWTH PERFORMANCE OF WEANLING PIGS[1]

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Summary

Results of these studies suggest that experimental high molecular weight, whey protein concentrate can be an effective replacement for spray-dried animal plasma in diets for weanling pigs. Increasing spray-dried animal plasma improved ADG and ADFI quadratically, with the maximum response observed with 2.5% in 21-d-old pigs or 5.0% in 12-d-old pigs. The specialty whey protein concentrate fed from d 0 to 14 after weaning resulted in similar responses as spray-dried animal plasma fed during the same period and may be an effective alternative.

(Key Words: Starter Pigs, Spray-Dried Animal Plasma, High-Protein Whey Protein Concentrate.)

Introduction

Whey protein concentrate has been established as an excellent protein source in diets for weanling pigs. Specialty high molecular weight, whey protein concentrate (Foremost Farms) contains twice the protein and amino acids as conventional whey protein concentrate. In addition, the manufacturing process also concentrates the immunoglobulin fraction. Because of the immunoglobulins contained in spray-dried animal plasma may be responsible for its positive effects on weanling pig growth, specialty whey protein concentrate may be a potential alternative.

In the 1997 Kansas State University Swine Day Report of Progress, we evaluated the use of specialty whey protein concentrate in weanling pig diets. However, we observed few positive responses to increasing high molecular weight, whey protein concentrate or spray-dried animal plasma, possibly suggesting that our control diet was already adequate for the age, weight, and health status of the pigs. Therefore, the objective of these experiments was to revaluate experimental whey protein concentrate as a replacement for spray-dried animal plasma in younger pigs with less complex diets.

Procedures

Animals and Housing. For Exps. 1 and 2, pigs were blocked by weight, equalized for sex and ancestry, and allotted randomly to one of five experimental treatments. Each treatment had six pigs per pen and six pigs per treatment. The trials were divided into two phases with the pelleted, experimental diets fed from d 0 to 14 after weaning. All diets were formulated to contain 1.5% or 1.4% lysine (Exps. 1 and 2, respectively), .9% Ca, .8% P. Additional DL-methionine was used to maintain a constant level of methionine in all diets. From d 14 to 35 after weaning, a common corn-soybean meal diet

[1]The authors thank Foremost Farms USA, Sauk City, WI for providing the high molecular weight, whey protein concentrate used in these experiments and Adam McNess and Eichman Brothers, St. George, KS for the use of facilities and animals in Exps. 3 and 4.

[2]Northeast Area Extension Office, Manhattan, KS.

[3]Foremost Farms USA, Sauk City, WI.

containing 10% dried whey and 2.5% spray-dried blood meal was fed in a meal form. The common diet was formulated to contain 1.35% lysine, .9% Ca, and .8% P (Table 2). Pigs were housed at the Kansas State University Swine Teaching and Research Center in an environmentally controlled nursery in 5 x 5 ft. pens and were provided ab libitum access to feed and water. Average daily gain, ADFI, and F/G were determined by weighing pigs and measuring feed disappearances on d 7,14, 21, 28, and 35 after weaning.

In Exps. 3 and 4, pigs were blocked by initial weight and allotted randomly to one of five dietary treatments. Each treatment had eight or nine pigs per pen and seven replications per treatment. The trials were divided into two phases with the pelleted experimental diets fed from d 0 to 14 after weaning. All diets fed during this period contained at least 2.5% spray-dried animal plasma and were formulated to contain 1.7% lysine, .9% Ca, .8% P, and .48% methionine. From d 14 to 28 after weaning, the same diet from Exps. 1 and 2 was used. Pigs were housed on a commercial operation in an environmentally controlled nursery in 5 × 5 ft pens and were provided ad libitum access to feed and water.

Chemical compositions of the experimental specialty whey protein concentrate and spray-dried animal plasma are presented in Table 1.

Experiment 1. A total of 180 weanling pigs with an average weight of 12.8 lb and 18 to 21 days of age was used. Dietary treatments were based on a corn-soybean meal control diet containing 20% dried whey and 2.5% spray-dried blood meal. Spray-dried animal plasma (2.5 or 5.0%) or specialty whey protein concentrate (2.5 or 5.0%) was substituted for soybean meal, on an equal lysine basis, in the control diet to create the additional experimental treatments (Table 2). Diets were formulated using the analyzed values of the specialty whey protein concentrate and spray-dried animal plasma.

Experiment 2. A total of 180 weanling pigs with an initial average weight of 11.1 lb and 16 to 18 d of age was used. Diets fed in this experiment were based on a corn-soybean meal control diet that contained less specialty protein sources than the basal diet of Exp. 1. They contained 15% dried whey compared to 20% dried whey in Exp.1. Spray-dried animal plasma (2.5 or 5.0%) or high protein, whey protein concentrate (2.5 or 5.0%) was substituted for soybean meal, on an equal lysine basis, in the control diet to create the additional experimental treatments (Table 3).

Table 1. Compositions of High Protein, Whey Protein Concentrate and Spray-Dried Animal Plasma[a]

Item , %	Whey Protein Concentrate	Animal Plasma
Protein	73.18	70.00
Fat	6.00	2.00
Ash	6.50	13.00
Amino acids		
Arginine	2.32	5.30
Cystine	1.68	2.50
Histidine	1.49	2.80
Isoleucine	4.15	1.96
Leucine	7.43	5.56
Lysine	6.81	6.80
Methionine	1.52	0.53
Phenylalanine	2.67	4.10
Threonine	4.64	4.13
Tryptophan	1.63	1.33
Tyrosine	2.34	3.90
Valine	4.42	4.12

[a]Analyzed values expressed on an as-fed basis.

Experiment 3. A total of 305 weanling pigs with an average initial weight of 9.0 lb and 12 to 13 d of age was used. Dietary treatments were based on a corn-soybean meal control diet containing 25% dried whey, 6.0% fish meal, 5.0% lactose, 2.5% spray-dried animal plasma, and 1.75% spray-dried blood meal. Additional spray-dried animal plasma (2.5 or 5.0%) or specialty whey protein concentrate (2.5 or 5.0%) was substituted for soybean meal, on an equal lysine basis, in the control diet to create the additional experimental treatments (Table 4).

Experiment 4. A total of 320 weanling pigs with an average initial weight of 9.2 lb and 12 to 13 d of age was used. This experiment was designed to compare pig performance when experimental whey protein concentrate replaced increasing amounts of spray-dried animal plasma fed from d 0 to 14 after weaning. Dietary treatments were based on a corn-soybean meal control diet containing 25% dried whey, 6.0% fish meal, 5.0% lactose, 6.7% spray-dried animal plasma, and 1.75% spray-dried blood meal. High protein, whey protein concentrate was substituted for spray-dried animal plasma on an equal lysine basis. It replaced 25, 50, 75, and 100% of the spray-dried animal plasma in the control diet to provide the additional experimental treatments (Table 5).

Results and Discussion

In Exp. 1, from d 0 to 7 after weaning, no differences in ADG, ADFI, or F/G were observed for pigs fed any of the experimental treatments (Table 6). However, ADFI tended to increase numerically then decrease with increasing spray-dried animal plasma (quadratic, P = .12). From d 7 to 14 and d 0 to 14 after weaning, no differences were observed for pigs fed either of the experimental treatments.

From d 14 to 35 after weaning (pigs were fed a common diet) and for cumulative performance, F/G tended to increase numerically then decrease with increasing spray-dried animal plasma fed from d 0 to 14 (quadratic, P=.10, Table 6). However, no differences in ADG or ADFI were observed in pigs fed any of the different protein sources from d 0 to 14.

As with our previous experiment reported in the 1997 Kansas State University Swine Day Report of Progress, we believe that because of the high-health status, weight, and age of the pigs at weaning, the diets were likely too complex. Thus, we observed few benefits from the increasing spray-dried animal plasma or high molecular weight, whey protein concentrate. Therefore, we conducted a second experiment, in which we further reduced the complexity of the control diet and decreased the age at weaning.

In Exp. 2, from d 0 to 7 after weaning, ADG increased with increasing spray-dried animal plasma and specialty whey protein concentrate (linear, P=.002 and .02, respectively, Table 7). Average daily feed intake also increased (linear, P=.04) with increasing spray-dried animal plasma but was unchanged for pigs fed specialty whey protein concentrate. Feed efficiency was improved for pigs fed increasing spray-dried animal plasma (linear, P=.007) or specialty whey protein concentrate (linear, P =.002). Pigs fed specialty whey protein concentrate had the best feed efficiency during this period.

From d 0 to 14 after weaning, ADG, ADFI, and F/G improved (linear, P=.002, .04, and .02 respectively) with increasing spray-dried animal plasma (Table 7). Increasing specialty whey protein concentrate improved ADG (linear, P=.001) and F/G, (linear, P=.003), but ADFI was unchanged. From d 14 to 35 or d 0 to 35 after weaning, no differences were observed in pigs previously fed any of the experimental treatments.

Based on the results in Exp.2, with younger and lighter pigs, we conducted Exps. 3 and 4 on a commercial facility to further validate our findings. In Exp. 3, from d 0 to 7 after weaning, ADG tended to increase then decrease with increasing spray-dried animal plasma (quadratic, P=.16, Table 8). This response to ADG also was observed with increasing specialty whey protein concentrate (quadratic, P=.04). Average daily feed intake increased linearly with increasing spray-dried animal plasma (P=.04), although actual intake values were identical. Feed efficiency was not affected by spray-dried animal plasma. Increasing specialty whey protein concentrate increased then decreased ADFI and F/G (quadratic, P=.05 and .09, respectively).

From d 0 to 14 after weaning, ADG, ADFI, and F/G increased quadratically with increasing spray-dried animal plasma (P=.003, .04, and .02, respectively), with pigs fed 5.0% spray-dried animal plasma having

the best ADG. Average daily gain (quadratic, P=.07) tended to increase then decrease, whereas ADFI (linear, P=.09) tended to increase with increasing specialty whey protein concentrate. Feed efficiency was not affected.

From d 14 to 28 after weaning, ADG (P=.11) and ADFI (P=.04) tended to numerically decrease linearly in pigs fed increasing spray-dried animal plasma fed from d 0 to 14 after weaning. However, feed efficiency was not affected. No differences in ADG, ADFI, or F/G were observed from d 14 to 28 after weaning in pigs fed the specialty whey protein concentrate.

For the cumulative period, d 0 to 28 after weaning, no differences in ADG or ADFI were observed in pigs fed either increasing spray-dried animal plasma or high molecular weight, whey protein concentrate from d 0 to 14 after weaning. Pigs previously fed increasing specialty whey protein concentrate from d 0 to 14 after weaning had improved F/G (quadratic, P=.03).

In Exp. 4 from d 0 to 7 after weaning, as specialty whey protein concentrate replaced increasing amounts of spray-dried animal plasma, ADG increased then decreased (quadratic, P<.10, Table 9). Average daily feed intake and F/G was not affected by increasing specialty whey protein concentrate. However, pigs fed 3.35% specialty whey protein concentrate and 3.35% spray-dried animal plasma had numerically the greatest ADG and the best feed efficiency during the first week after weaning.

From d 0 to 14 after weaning, ADG and ADFI increased then decreased with increasing specialty whey protein concentrate (quadratic, P<.04, and .09, respectively). Feed efficiency was not affected by specialty whey protein concentrate. During this period, pigs fed the diet containing 5.0% specialty whey protein concentrate and 1.7% spray-dried animal plasma had numerically the highest ADG and ADFI of any experimental treatments.

From d 14 to 28 after weaning, no differences in ADG, ADFI, or F/G were observed when pigs were fed a common diet. This pattern also was observed for cumulative performance, d 0 to 28 after weaning.

Evaluation of all four studies showed that increasing spray-dried animal plasma from 2.5 to 5.0% in 21-d-old pigs or from 5.0 to 7.5% in 12-d-old pigs did not further improve growth performance. We also can conclude that pigs fed specialty whey protein concentrate demonstrated similar growth performance compared to pigs fed similar amounts of spray-dried animal plasma. Therefore, specialty whey protein concentrate can be an effective replacement for spray-dried animal plasma in diets for early-weaned pigs.

Table 2. Compositions of Diets (Exp.1)

Ingredients, %	Control[a]	Spray-Dried Animal Plasma, %[a] 2.5	5.0	Whey Protein Concentrate, %[a] 2.5	5.0	Day 14-35[b]
Corn	37.86	41.27	44.68	41.24	44.62	51.87
Soybean meal	29.87	23.94	18.01	23.94	18.00	26.85
Dried whey	20.00	20.00	20.00	20.00	20.00	10.00
Soybean oil	5.00	5.00	5.00	5.00	5.00	4.00
Monocalcium phosphate	1.62	1.59	1.60	1.74	1.85	1.65
Whey protein concentrate	--	--	--	2.50	5.00	--
Spray-dried animal plasma	--	2.50	5.00	--	--	--
Spray-dried blood meal	2.50	2.50	2.50	2.50	2.50	2.50
Antibiotic [c]	1.00	1.00	1.00	1.00	1.00	1.00
Limestone	.89	.94	.98	.84	.79	.98
Zinc oxide	.38	.38	.38	.38	.38	.25
Vitamin premix	.25	.25	.25	.25	.25	.25
Salt	.20	.20	.20	.20	.20	.25
Trace mineral premix	.15	.15	.15	.15	.15	.15
L-Lysine HCl	.15	.15	.15	.15	.15	.15
DL-Methionine	.14	.14	.15	.12	.11	.10
Total	100.00	100.00	100.00	100.00	100.00	100.00

[a]Diets were formulated to contain 1.5% lysine, .42% methionine, .9% Ca, .8% P and fed from d 0 to 14 after weaning.
[b]Diet was formulated to contain 1.35% lysine .38% methionine, .9% Ca, .8% P and fed to all pigs from d 14 to 35, or 14 to 28 after weaning in Exps.1, 2, 3, and 4.
[c]Provided 50 g/ton carbadox.

Table 3. Compositions of Diets (Exp. 2)

Ingredients, %	Control[a]	Spray-Dried Animal Plasma, %[a] 2.5	5.0	Whey Protein Concentrate, %[a] 2.0	5.0
Corn	40.84	44.24	47.65	44.22	47.59
Soybean meal	34.36	28.43	22.50	28.42	22.49
Dried whey	15.00	15.00	15.00	15.00	15.00
Soybean oil	5.00	5.00	5.00	5.00	5.00
Monocalcium phosphate	1.66	1.64	1.60	1.77	1.88
Whey protein concentrate	--	--	--	2.50	5.00
Spray-dried animal plasma	--	2.50	5.00	--	--
Spray-dried blood meal	--	--	--	--	--
Antibiotic [b]	1.00	1.00	1.00	1.00	1.00
Limestone	.95	1.00	1.05	.90	.85
Zinc oxide	.38	.38	.38	.38	.38
Vitamin premix	.25	.25	.25	.25	.25
Salt	.20	.20	.20	.20	.20
Trace mineral premix	.15	.15	.15	.15	.15
L-Lysine HCl	.15	.15	.15	.15	.15
DL-methionine	.06	.08	.10	.06	.06
Total	100.00	100.00	100.00	100.00	100.00

[a]Diets were formulated to contain 1.4% lysine, .42% methionine, .9% Ca, .8% P and fed from d 0 to 14 after weaning.
[b]Provided 50 g/ton carbadox.

Table 4. Compositions of Diets (Exp. 3)

Ingredients, %	Control [a]	Spray-Dried Animal Plasma, % [a]		Whey Protein Concentrate, % [a]	
		5.0	7.5	2.5	5.0
Corn	27.82	31.23	34.65	31.20	34.59
Dried whey	25.00	25.00	25.00	25.00	25.00
Soybean meal	22.44	16.51	10.57	16.50	10.56
Soybean oil	6.00	6.00	6.00	6.00	6.00
Fish meal	6.00	6.00	6.00	6.00	6.00
Lactose	5.00	5.00	5.00	5.00	5.00
Spray-dried animal plasma	2.50	5.00	7.50	2.50	2.50
Whey protein concentrate	--	--	--	2.50	5.00
Spray-dried blood meal	1.75	1.75	1.75	1.75	1.75
Antibiotic [b]	1.00	1.00	1.00	1.00	1.00
Monocalcium phosphate	.82	.78	.75	.93	1.05
Limestone	.40	.45	.49	.35	.30
Zinc oxide	.38	.38	.38	.38	.38
Vitamin premix	.25	.25	.25	.25	.25
Salt	.20	.20	.20	.20	.20
Trace mineral premix	.15	.15	.15	.15	.15
L-Lysine HCl	.15	.15	.15	.15	.15
DL-Methionine	.15	.16	.16	.14	.13
Total	100.00	100.00	100.00	100.00	100.00

[a]Diets were formulated to contain 1.7% lysine, .48% methionine, .9% Ca, .8% P and fed from d 0 to 14 after weaning.
[b]Provided 50 g/ton carbadox.

Table 5. Compositions of Diets (Exp. 4)

Ingredients, %	Animal Plasma:Whey Protein Concentrate, % [a]				
	6.7:0	5.0:1.7	3.35:3.35	1.7:5.0	0:6.7
Corn	33.56	33.55	33.52	33.50	33.48
Soybean meal	12.47	12.47	12.47	12.47	12.47
Dried whey	25.00	25.00	25.00	25.00	25.00
Soybean oil	6.00	6.00	6.00	6.00	6.00
Fish meal	6.00	6.00	6.00	6.00	6.00
Lactose	5.00	5.00	5.00	5.00	5.00
Whey protein concentrate	--	1.70	3.35	5.00	6.70
Spray-dried animal plasma	6.70	5.00	3.35	1.70	--
Spray-dried blood meal	1.75	1.75	1.75	1.75	1.75
Antibiotic [b]	1.00	1.00	1.00	1.00	1.00
Monocalcium phosphate	.76	.86	.96	1.06	1.16
Limestone	.47	.41	.35	.28	.22
Zinc oxide	.38	.38	.38	.38	.38
Vitamin premix	.25	.25	.25	.25	.25
Salt	.20	.20	.20	.20	.20
Trace mineral premix	.15	.15	.15	.15	.15
L-Lysine HCl	.15	.15	.15	.15	.15
DL-methionine	.15	.13	.12	.11	.10
Total	100.00	100.00	100.00	100.00	100.00

[a]Diets were formulated to contain 1.7% lysine, .48% methionine, .9% Ca, .8% P and fed from d 0 to 14 after weaning.
[b]Provided 50 g/ton carbadox.

Table 6. Effects of Increasing High Molecular Weight, Whey Protein Concentrate and Animal Plasma Fed from d 0 to 14 after Weaning on Pig Performance (Exp. 1)[a]

Item	Control	Added Spray-Dried Animal Plasma, %		Whey Protein Concentrate, %		SEM	Animal Plasma		Whey Protein	
		2.5	5.0	2.5	5.0		Linear	Quad	Linear	Quad
Day 0 to 7										
ADG, lb	.68	.74	.70	.74	.72	.029	.65	.22	.42	.27
ADFI, lb	.62	.68	.63	.65	.63	.028	.83	.12	.95	.44
F/G	.91	.93	.90	.88	.87	.024	.79	.57	.25	.69
Day 7 to 14										
ADG, lb	.93	.94	.97	.92	.92	.039	.49	.78	.83	.99
ADFI, lb	1.07	1.10	1.12	1.08	1.01	.030	.26	.88	.16	.24
F/G	1.16	1.18	1.17	1.18	1.11	.047	.82	.82	.44	.40
Day 0 to 14										
ADG, lb	.81	.84	.83	.83	.82	.026	.44	.63	.77	.54
ADFI, lb	.85	.89	.88	.87	.82	.023	.39	.30	.37	.22
F/G	1.05	1.07	1.06	1.05	1.00	.024	.90	.71	.16	.55
Day 14 to 35										
ADG, lb	1.34	1.36	1.33	1.34	1.31	.030	.85	.59	.42	.77
ADFI, lb	2.04	2.12	2.01	2.05	2.01	.049	.70	.13	.68	.76
F/G	1.52	1.56	1.51	1.53	1.54	.023	.76	.10	.54	.98
Day 0 to 35										
ADG, lb	1.13	1.15	1.13	1.13	1.11	.025	.85	.55	.63	.64
ADFI, lb	1.56	1.63	1.56	1.57	1.53	.035	.92	.12	.56	.55
F/G	1.39	1.42	1.37	1.39	1.38	.018	.63	.10	.83	.84

[a]A total of 180 weanling pigs (initially 12.8 lb and 18 to 20 d of age) with six pigs per pen and six replications per treatment.

Table 7. Effects of Increasing High Molecular Weight, Whey Protein Concentrate and Animal Plasma Fed from d 0 to 14 after Weaning on Pig Performance (Exp. 2)[a]

Item	Control	Added Spray-Dried Animal Plasma, %		Whey Protein Concentrate, %		SEM	Animal Plasma		Whey Protein	
		2.5	5.0	2.5	5.0		Linear	Quad	Linear	Quad
Day 0 to 7										
ADG, lb	.38	.47	.53	.49	.50	.031	.002	.72	.02	.19
ADFI, lb	.49	.52	.59	.52	.52	.031	.04	.68	.50	.78
F/G	1.32	1.12	1.10	1.05	1.05	.052	.007	.22	.002	.05
Day 7 to 14										
ADG, lb	.62	.68	.74	.68	.72	.034	.02	.98	.05	.82
ADFI, lb	.83	.87	.91	.87	.82	.036	.14	.89	.82	.29
F/G	1.36	1.27	1.23	1.29	1.15	.067	.17	.81	.04	.70
Day 0 to 14										
ADG, lb	.50	.58	.64	.59	.61	.027	.002	.84	.009	.35
ADFI, lb	.66	.70	.75	.67	.67	.027	.04	.75	.82	.40
F/G	1.34	1.21	1.17	1.19	1.11	.047	.02	.48	.003	.51
Day 14 to 35										
ADG, lb	1.31	1.23	1.28	1.19	1.31	.036	.64	.16	.90	.01
ADFI, lb	1.81	1.83	1.86	1.76	1.83	.038	.35	.89	.68	.18
F/G	1.39	1.48	1.45	1.49	1.39	.044	.32	.23	.92	.09
Day 0 to 35										
ADG, lb	.97	.95	1.01	.94	1.02	.028	.27	.32	.22	.12
ADFI, lb	1.32	1.35	1.39	1.31	1.34	.030	.13	.82	.70	.50
F/G	1.37	1.42	1.37	1.40	1.32	.037	.96	.38	.32	.23

[a]A total of 180 weanling pigs (initially 11.1 lb and 16 to 18 d of age) with six pigs per pen and six replications per treatment.

Table 8. Effects of Increasing High Molecular Weight, Whey Protein Concentrate and Animal Plasma Fed from d 0 to 14 after Weaning on Pig Performance (Exp. 3) [a]

		Added Spray-Dried Animal Plasma, %		Whey Protein Concentrate, %			Animal Plasma		Whey Protein	
Item	Control	2.5	5.0	2.5	5.0	SEM	Linear	Quad	Linear	Quad
Day 0 to 7										
ADG, lb	.22	.26	.25	.28	.25	.02	.25	.16	.44	.04
ADFI, lb	.27	.31	.31	.32	.30	.01	.04	.14	.23	.05
F/G	1.32	1.23	1.27	1.16	1.24	.06	.63	.39	.57	.09
Day 7 to 14										
ADG, lb	.57	.64	.55	.60	.61	.02	.42	.002	.33	.44
ADFI, lb	.61	.65	.60	.65	.67	.02	.83	.08	.14	.51
F/G	1.07	1.02	1.12	1.08	1.10	.03	.20	.02	.58	.98
Day 0 to 14										
ADG, lb	.39	.45	.40	.44	.43	.01	.87	.003	.27	.07
ADFI, lb	.44	.48	.46	.48	.48	.01	.41	.04	.09	.14
F/G	1.12	1.07	1.16	1.10	1.14	.02	.24	.02	.61	.34
Day 14 to 28										
ADG, lb	.77	.75	.71	.78	.77	.03	.11	.71	.56	.57
ADFI, lb	1.08	1.08	.98	1.07	1.08	.04	.04	.27	.51	.88
F/G	1.42	1.44	1.40	1.39	1.41	.03	.65	.49	.79	.42
Day 0 to 28										
ADG, lb	.59	.60	.56	.62	.61	.02	.26	.17	.79	.20
ADFI, lb	.77	.78	.72	.78	.79	.02	.13	.14	.79	.64
F/G	1.32	1.30	1.29	1.27	1.30	.02	.25	.85	.81	.03

[a]A total of 305 weanling pigs (initially 9.0 lb and 12 to 13 d of age) with seven or eight pigs per pen and eight replications per treatment.

Table 9. Effects of Replacing Spray-Dried Animal Plasma with High Molecular Weight, Whey Protein Concentrate when Fed from d 0 to 14 after Weaning on Pig Performance (Exp. 4)[a]

	Animal Plasma:Whey Protein Concentrate,%						P <		
Item	6.7:0	5.0:1.7	3.35:3.35	1.7:5.0	0:6.7	SEM	Linear	Quad.	Cubic
Day 0 to 7									
ADG, lb	.26	.28	.29	.27	.25	.03	.62	.10	.83
ADFI, lb	.29	.32	.30	.30	.28	.02	.57	.22	.69
F/G	1.13	1.15	1.06	1.15	1.21	.02	.56	.39	.70
Day 7 to 14									
ADG, lb	.46	.50	.52	.57	.49	.08	.14	.08	.63
ADFI, lb	.56	.61	.56	.65	.60	.02	.17	.30	.46
F/G	1.34	1.27	1.11	1.15	1.22	.02	.30	.43	.64
Day 0 to 14									
ADG, lb	.34	.39	.40	.42	.37	.09	.47	.04	.84
ADFI, lb	.42	.46	.43	.48	.44	.02	.46	.09	.74
F/G	1.22	1.21	1.08	1.14	1.18	.01	.48	.35	.86
Day 14 to 28									
ADG, lb	.97	1.00	.94	1.00	1.02	.05	.91	.77	.49
ADFI, lb	.98	1.04	.97	1.03	1.02	.03	.47	.78	.30
F/G	1.10	1.12	1.11	1.16	1.05	.03	.88	.48	.54
Day 0 to 28									
ADG, lb	.66	.69	.68	.71	.70	.01	.56	.34	.66
ADFI, lb	.70	.75	.70	.75	.73	.02	.35	.74	.50
F/G	1.11	1.13	1.09	1.12	1.07	.02	.96	.83	.69

[a]A total of 320 weanling pigs (initially 9.2 lb and 12 to 13 d of age) with eight or nine pigs per pen and seven replications per treatment.