THE EFFECTS OF EXPERIMENTAL POTATO PROTEIN ON STARTER PIG GROWTH PERFORMANCE [1]

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Summary

This study suggested that experimental potato protein can be an effective replacement for a portion of spray-dried animal plasma in starter diets. Pigs fed combinations of experimental potato protein and spray-dried plasma had greater ADG than those fed either protein source alone. In phase II diets, pigs fed experimental potato protein had similar ADG and F/G compared with those fed spray-dried blood meal and select menhaden fish meal.

(Key Words: Starter Pig Performance, Potato Protein.)

Introduction

Swine producers have continually decreased the age at weaning in order to increase the number of pigs weaned per sow and ultimately improve profitability. However, the age at weaning is dependent on good management factors including nutrition, environmental regulation, and health status. Because of improvements in technology in these areas, weaning ages below 21 days are now commonplace throughout the U.S. swine industry. Important developments facilitating early weaning are the use of high nutrient dense diets and the concept of phase feeding. These practices involve the use of highly digestible ingredients such as dried whey, spray-dried animal plasma and blood meal, and select menhaden fish meal. Because of the relatively high cost of these ingredients, research has continually focused on examining other ingredients to improve pig growth performance and lower feed costs per unit of gain. Potato protein is one such ingredient that may be a cost-effective replacement for the more commonly used animal protein sources in starter diets. In the 1994 Kansas State University Swine Day Report of Progress, we evaluated the use of potato protein in starter diets. These trials demonstrated that high levels of potato protein (5 to 7.5%) can result in decreased feed intake and growth of weanling pigs. This may have been the result of a bitter off-flavor stemming from the presence of glycoalkaloids contained in potato and potato protein. Complaints from the feed industry about the off-flavor of potato protein have led to the development of an experimental potato protein with improved palatability. By including a special refinery step in the production process, bitter components can be removed. Therefore, the objective of this experiment was to evaluate the use of an experimental potato protein as a replacement for spray-dried animal plasma in high nutrient density phase I diets for weanling pigs and to compare pigs fed experimental potato protein, conventional potato protein, spray-dried blood meal, and select menhaden fish meal in phase II diets.

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Procedures

Experiment 1. A total of 180 weanling pigs (PIC C15 x L 326) with an average initial weight of 12.98 lb and 20 +/- 2 days of age was used in a 35-d growth assay to determine the effects of replacing spray-dried animal plasma with experimental potato protein on starter pig growth performance. Pigs were blocked by initial weight, randomized across treatments by sex and ancestry, and allotted to each of five dietary treatments. Each treatment had six pigs per pen and six replications (pens). The control diet (Table 1) was a high nutrient density diet containing 20% dried whey, 4% select menhaden fish meal, and 7% spray-dried animal plasma and formulated to 1.5% total lysine (1.26% apparent digestible lysine) and at least .42% total methionine (.35% apparent digestible methionine). The apparent digestible lysine values were 5.18% for experimental potato protein and 5.92% for spray-dried animal plasma. Other amino acid requirements were balanced on a total amino acid basis to meet or exceed NRC (1988) estimates as well as meet or exceed ARC (1981) digestible amino acid estimates based on a ratio relative to lysine. Additional diets consisted of experimental potato protein replacing 25, 50, 75, or 100% of the spray-dried animal plasma on a digestible lysine basis. Thus, the five experimental diets contained the following blends of spray-dried animal plasma and experimental potato protein: 7.0:0, 5.25:2.0, 3.50:4.0, 1.75:6.0, or 0:8.0%, respectively. The experimental diets were fed from d 0 to 14 postweaning (phase I). Diets were pelleted and offered ad libitum. No creep feed was offered to pigs prior to weaning. From d 14 to 35 postweaning, all pigs were fed a common corn-soybean meal diet containing 10% dried whey and 2.5% spray dried blood meal and formulated to 1.35% total lysine and .38% total methionine. Pigs were weighed and feed disappearance was determined weekly for the 35-day trial to calculate ADG, ADFI, and feed efficiency (F/G).

Experiment 2. Two hundred fifty-five weanling pigs (PIC C15 x L 326), initially 11.72 lb and 17+/- 2 days of age, were used to compare the effects of spray-dried blood meal, select menhaden fish meal, experimental potato protein, and conventional potato protein in phase II diets (d 7 to 28 postweaning) on growth performance. Pigs were blocked by initial weight, randomized across treatments by sex, and allotted to each of five dietary treatments. Eight, nine, or 10 pigs per pen within weight block and six replications (pens) per treatment were used. Pigs were all fed the same pelleted, high nutrient density diet (20% dried whey and 9% animal plasma) from d 0 to 7 postweaning. On day 7 postweaning, pigs were switched to experimental diets containing 2.5% spray dried blood meal, 5.51% select menhaden fish meal, 4.17% conventional potato protein, 4.17% experimental potato protein, or 8.34% experimental potato protein (Table 3). All diets contained 10% dried whey with experimental protein sources substituted on an apparent digestible lysine basis with the exception of the 8.34% experimental potato protein diet, which also replaced a portion of the soybean meal on a digestible lysine basis. The apparent digestible lysine values were 8.64% for spray-dried blood meal, 3.93% for select menhaden fish meal, and 5.18% for both experimental and commercial potato proteins. Diets were formulated to contain 1.05% apparent digestible lysine (at least 1.25% total lysine) and at least .30% apparent digestible methionine (.34% total methionine). Other amino acid requirements met or exceeded NRC (1988) estimates for total amino acids and met or exceeded ARC (1981) digestible amino acid estimates based on a ratio relative to lysine. Pigs were weighed and feed disappearance was determined weekly for the 28-d trial to calculate ADG, ADFI, and F/G.

Experiment 3. Two hundred ten weanling pigs (PIC C15 x L 326), with an average initial weight of 12.21 lb and 20 +/- 3 d of age, were used in a 35-d growth assay to determine the effects of increasing experimental potato protein or spray-dried animal plasma on starter pig growth performance. A second objective was to compare growth performance of pigs fed either the original experimental potato protein or a second experimental potato protein. Pigs were blocked by initial weight, randomized across treatments by sex and ancestry, and allotted to each of six dietary treatments. Each treatment had seven pigs per pen and five replications (pens). The control diet (Table 3) was a high nutrient density diet containing 20% dried whey, 17.5% dried skim milk, and 4% select menhaden fish meal and formulated to at least 1.46% total lysine (1.26% apparent digestible lysine) and at least .42% total methionine (.35% apparent digestible methionine). Additional diets consisted of either 3.5 and 7.0% spray-dried animal plasma or 4.0 and 8.0% experimental potato protein and lactose added at the expense of dried skim milk. Experimental potato protein and spray-dried animal plasma were substituted on an equal digestible lysine basis. In diet formulation, apparent digestibilities of amino acids and requirement estimates were similar to those outlined for Exp. 1. The sixth dietary treatment was provided by replacing 8.0% experimental potato protein with 8.0% of a second experimental potato protein.

Samples of the individual protein sources used in these experiments were collected and analyzed for amino acid concentrations (Table 4). In addition, potato protein samples were analyzed for glycoalkaloid concentration.

Results and Discussion

The amino acid profiles of the individual protein sources used in Exp. 1, 2, and 3 are consistent with previously published values for spray-dried blood meal and select menhaden fish meal. Amino acid values for conventional potato protein also were within analytical variation for published values, and most of those for experimental potato protein were slightly higher compared with conventional potato protein. Total glycoalkaloids of the new experimental potato protein were reduced considerably compared to the conventional potato protein. Little difference in glycoalkaloid concentrations occurred between the two new experimental potato proteins.

In Exp. 1, from d 0 to 7 postweaning, ADG and ADFI increased then decreased with increasing experimental potato protein (quadratic, $P<.01$). Feed efficiency also improved (quadratic, $P<.05$) with increasing potato protein. Pigs fed any of the blends of spray-dried animal plasma and experimental potato protein had greater ADG, ADFI, and better F/G than pigs fed either of the two protein sources alone (Table 5). From d 0 to 14 postweaning, ADG tended (linear and quadratic, $P<.11$) to increase with increasing experimental potato protein. Average daily feed intake increased then decreased (quadratic, $P<.05$) while F/G improved (linear, $P<.05$) with increasing experimental potato protein. However, pigs fed 8% experimental potato protein had greater ADG and better F/G than those fed 7% spray-dried animal plasma from d 0 to 14 postweaning (individual contrast, $P<.05$) From d 14 to 35 when all pigs were fed a common diet containing 10% dried whey and 2.5% spray-dried blood meal and for the overall trial (d 0 to 35), no differences in growth performance resulted from experimental diets fed from d 0 to 14 postweaning.

In Exp. 2, when all pigs were fed the same high nutrient density diet from d 0 to 7 postweaning, ADG, ADFI, and F/G were .39 lb, .48 lb, and 1.20, respectively. This resulted in pigs averaging 14.47 lb when switched to the experimental diets. Throughout the experiment, no differences ($P>.10$) were observed in growth performance among pigs fed any of the protein sources (Table 6). However, throughout the trial, pigs fed the experimental potato protein had numerically greater ADG and better F/G than those fed conventional potato protein. Pigs fed the other protein sources had intermediate ADG compared with those fed either potato protein source. Pig performance was not improved by feeding 8.34% experimental potato protein compared with 4.17% experimental potato protein.

Because of the excellent growth performance of pigs fed experimental potato protein compared with those fed spray-dried animal plasma in Exp. 1, we felt it necessary to confirm these results in a third experiment. In addition, a second experimental potato protein was evaluated. From d 0 to 7 postweaning, ADG and ADFI increased (linear, $P<.05$) with increasing animal plasma. However, ADG and ADFI increased then decreased (quadratic, $P<.10$ and $P<.05$, respectively) with increasing experimental potato protein. Feed efficiency (F/G) was not affected by animal plasma level and was poorer for pigs fed increasing amounts of experimental potato protein. Average daily gain and ADFI for pigs fed either 3.5% spray-dried animal plasma or 4.0% potato protein were similar and greater than those for pigs fed the control diet; however, adding 8.0% experimental potato protein decreased ADFI compared with that of pigs fed 4.0% experimental potato protein. The reduction in ADFI coupled with poorer F/G of pigs fed the 8.0% experimental potato protein resulted in decreased daily gains. No differences in performance occurred between pigs fed either of the experimental potato protein sources. From d 0 to 14 postweaning, increasing spray-dried animal plasma had no effect on ADG, ADFI, or F/G. However, ADG increased then decreased (quadratic, $P<.10$) as experimental potato protein increased. This response was similar to that observed from d 0 to 7 postweaning, in that 4.0% added potato protein improve ADG compared with that of pigs fed the control diet; however, adding 8.0% experimental potato protein decreased ADG.

From d 14 to 28 when pigs were fed a common diet, no differences were observed in ADG or ADFI. However, F/G improved then worsened (quadratic, $P<.10$) for pigs fed increasing animal plasma from d 0 to 14 postweaning. For the cumulative study (d 0 to 28 postweaning), no differences in ADG resulted from protein source or level fed from d 0 to 14 postweaning. Average daily feed intake decreased then increased (quadratic, $P<.05$), whereas F/G improved then worsened (quadratic, $P<.10$) with increasing spray-dried animal plasma fed from d 0 to 14 postweaning. No differences in performance throughout the trial occurred among pigs fed the two experimental potato protein source.

The response observed to added potato protein from d 0 to 14 postweaning in Exp. 3 is contradictory to results of Exp. 1, in which pigs fed 8.0% experimental potato protein had increased ADG compared with those fed 7.0% spray-dried animal plasma. However, pigs fed an intermediate level of potato protein (4.0%) had similar growth performance to those fed 3.5% spray-dried animal plasma. Perhaps variation in processing of spray-dried animal plasma and(or) potato protein could account for the differences in growth performance between the two studies. Regardless, these results suggest that experimental potato protein can be a cost-effective replacement for a portion of the spray-dried animal plasma in diets for early-weaned pigs.

Table 1. Composition of Diets (Exp. 1)[a]

	Animal Plasma, %:Experimental Potato Protein, %				
Ingredient, %	7.0:0	5.25:2.0	3.50:4.0	1.75:6.0	0:8.0
Ground corn	45.12	44.82	44.51	44.20	43.89
Soybean meal (46.5%)	15.19	15.19	15.19	15.19	15.19
Dried whey	20.00	20.00	20.00	20.00	20.00
Animal plasma, spray-dried	7.00	5.25	3.50	1.75	—
Potato protein	—	2.00	4.00	6.00	8.00
Soybean oil	5.00	5.00	5.00	5.00	5.00
Select menhaden fish meal	4.00	4.00	4.00	4.00	4.00
Medication[b]	1.00	1.00	1.00	1.00	1.00
Monocalcium phosphate	.98	1.11	1.23	1.35	1.47
Limestone	.63	.58	.52	.47	.41
Zinc oxide	.38	.38	.38	.38	.38
Vitamin premix	.25	.25	.25	.25	.25
Trace mineral premix	.15	.15	.15	.15	.15
L-lysine HCL	.10	.10	.10	.10	.10
Salt	.10	.10	.10	.10	.10
DL-methionine	.09	.08	.07	.06	.05
Total	100.00	100.00	100.00	100.00	100.00

[a]Experimental diets were fed from d 0 to 14 postweaning and were formulated to contain 1.5% total lysine (1.26% apparent digestible lysine), at least .42% total methionine (.35% apparent digestible methionine), 90% Ca, and .80% P.
[b]Provided 150 g/ton apramyacin.

Table 2. Composition of Diets (Exp. 2)[a]

Ingredient, %	Spray-Dried Blood Meal	Select Menhaden Fish Meal	Potato[b] Protein	Exp. Potato[c] Protein
Ground corn	53.41	51.47	51.77	56.10
Soybean meal (46.5%)	26.40	26.50	26.40	17.70
Dried whey	10.00	10.00	10.00	10.00
Spray-dried blood meal	2.50	—	—	—
Select menhaden fish meal	—	5.51	—	—
Potato protein	—	—	4.17	8.34
Soybean oil	3.00	3.00	3.00	3.00
Monocalcium phosphate	1.88	1.10	1.94	2.14
Medication[d]	1.00	1.00	1.00	1.00
Limestone	.84	.42	.81	.82
Zinc oxide	.25	.25	.25	.25
Vitamin premix	.25	.25	.25	.25
Salt	.25	.25	.25	.25
Trace mineral premix	.15	.15	.15	.15
DL-methionine	.07	.01	.01	—

[a]Experimental diets were fed from d 7 to 28 postweaning and were formulated to contain at least 1.25% total lysine and .34% total methionine (1.05% and .30% apparent digestible lysine and methionine, respectively). Protein sources (except exp. potato protein, 8.34%) were substituted on an equal digestible lysine basis.
[b]Potato protein and experimental potato protein were included at 4.17% to provide two experimental diets.
[c]Experimental potato protein was added at twice the inclusion rate for digestible lysine of other protein sources.
[d]Provided 50 g/ton carbadox.

Table 3. Composition of Diets (Exp. 3)[a]

Ingredient, %	Dried Skim Milk	Animal Plasma, % 3.5	Animal Plasma, % 7.0	Potato Protein, % 4.0	Potato Protein, % 8.0[b]
Ground corn	34.72	35.18	35.65	34.57	34.42
Soybean meal (46.5%)	15.84	15.84	15.84	15.84	15.84
Dried whey	20.00	20.00	20.00	20.00	20.00
Dried skim milk	17.50	8.75	—	8.75	—
Lactose	—	4.38	8.75	4.38	8.75
Animal plasma, spray-dried	—	3.50	7.00	—	—
Potato protein	—	—	—	4.00	8.00
Soybean oil	5.00	5.00	5.00	5.00	5.00
Select menhaden fish meal	4.00	4.00	4.00	4.00	4.00
Medication[c]	1.00	1.00	1.00	1.00	1.00
Monocalcium phosphate	.73	.91	1.08	1.16	1.58
Limestone	.12	.38	.58	.27	.36
Zinc oxide	.38	.38	.38	.38	.38
Vitamin premix	.25	.25	.25	.25	.25
Trace mineral premix	.15	.15	.15	.15	.15
L-lysine HCL	.10	.10	.10	.10	.10
Salt	.10	.10	.10	.10	.10
DL-methionine	.05	.08	.12	.06	.07
Total	100.00	100.00	100.00	100.00	100.00

[a]Experimental diets were fed from d 0 to 14 postweaning and were formulated to contain at least 1.46% total lysine (1.26% apparent digestible lysine), at least .42% total methionine (.35% apparent digestible methionine), .90% Ca, and .80% P.
[b]A second experimental potato protein replaced the first on an equal weight basis to provide the sixth dietary treatment.
[c]Provided 150 g/ton apramyacin.

Table 4. Amino Acid Analysis of Protein Sources[a]

Item	Spray-Dried Animal Plasma	Select Menhaden Fish Meal	Spray-Dried Blood Meal	Potato Protein	Experimental Potato Protein
Essential and semi-essential amino acids, %					
Arginine	4.59	3.43	3.77	4.09	4.09
Cysteine	2.54	.58	.74	1.45	1.55
Histidine	2.62	1.55	7.03	1.80	1.87
Isoleucine	2.84	2.35	.47	4.44	4.46
Leucine	7.64	4.40	12.98	8.18	8.47
Lysine	6.95	4.52	8.52	5.94	6.27
Methionine	.72	1.65	.84	1.75	1.80
Phenylalanine	4.50	2.42	6.64	5.11	5.35
Threonine	4.38	2.52	3.20	4.33	4.53
Tryptophan	1.30	.64	1.66	1.08	1.12
Tyrosine	4.07	1.87	2.14	4.37	4.50
Valine	5.23	2.95	8.81	5.60	5.63
Nonessential amino acids, %					
Alanine	4.20	3.96	7.89	3.81	3.91
Glutamic acid	10.33	7.36	7.30	8.27	8.25
Glycine	2.81	4.12	4.50	4.05	4.24
Ornithine	.04	.04	.03	.03	.02
Proline	4.57	2.61	3.28	3.87	4.18
Serine	3.85	2.16	3.90	3.82	4.03

[a]Values expressed on an as-fed basis. Total glycoacaloid concentrations (mg/100 g) were: potato protein, 303 and experimental potato protein, 15.6. The second experimental potato protein contained 18.3 mg/100 g glycoalkaloid (amino acid analysis not provided).

Table 5. Effect of Experimental Potato Protein on Starter Pig Performance (Exp. 1)[a]

Item	Animal Plasma, %:Experimental Potato Protein, %					CV
	7.0:0	5.25:2.0	3.50:4.0	1.75:6.0	0:8.0	
Day 0 to 7						
ADG, lb[b]	.54	.68	.65	.68	.58	12.7
ADFI, lb[b]	.58	.68	.61	.66	.56	8.4
F/G[cd]	1.10	1.00	.94	.98	.99	8.7
Day 0 to 14						
ADG, lb[ef]	.64	.77	.71	.74	.73	9.9
ADFI, lb[d]	.77	.85	.77	.83	.75	7.5
F/G[c]	1.20	1.12	1.09	1.12	1.03	6.1
Day 14 to 35						
ADG, lb	1.33	1.30	1.32	1.35	1.35	7.2
ADFI, lb	1.79	1.75	1.75	1.83	1.84	11.4
F/G	1.33	1.35	1.32	1.33	1.35	7.7
Day 0 to 35						
ADG, lb	1.06	1.08	1.08	1.11	1.10	7.1
ADFI, lb	1.38	1.39	1.36	1.43	1.41	9.9
F/G	1.30	1.28	1.27	1.28	1.27	6.3

[a]A total of 180 weanling pigs (initially 12.98 lb and 20 ± 2 days of age). Each treatment had six pigs per pen and six replications (pens). Pigs were fed experimental diets from d 0 to 14 postweaning. From d 14 to 25, all pigs were fed a corn-soybean meal-based diet containing 10% dried whey and 2.5% spray-dried blood meal (1.35% lysine).
[b]Quadratic effect of experimental potato protein ($P < .01$).
[c,d]Linear and quadratic effect of experimental potato protein ($P < .05$), respectively.
[e,f]Linear and quadratic effect of experimental potato protein ($P < .11$), respectively.

Table 6. Effect of Protein Sources on Starter Pig Growth Performance (Exp. 2)[a]

Item	Spray-Dried Blood Meal	Select Menhaden Fish Meal	Potato Protein	Exp. Potato Protein	Exp. Potato Protein (8.34%)	CV
Day 7 to 14[b]						
ADG, lb	.44	.45	.41	.47	.43	18.2
ADFI, lb	.79	.75	.76	.68	.78	13.0
F/G	1.82	1.64	1.85	1.51	1.82	16.4
Day 7 to 21[b]						
ADG, lb	.64	.65	.61	.65	.66	9.2
ADFI, lb	1.02	.95	.95	.94	1.00	9.0
F/G	1.56	1.45	1.59	1.95	1.51	7.4
Day 7 to 28[b]						
ADG, lb	.79	.78	.75	.79	.79	6.7
ADFI, lb	1.26	1.18	1.17	1.18	1.23	6.1
F/G	1.56	1.49	1.56	1.49	1.56	4.8

[a]A total of 255 pigs (initially 11.72 lb and 17 ± 2 d of age) were used with eight to 10 pigs per pen and six replications (pens) per treatment. Day 0 to 7 ADG, ADFI, and F/G were: .39, .48 lb, and 1.20, respectively.
[b]No treatment differences were observed ($P > .10$).

Table 7. **Effect of Added Animal Plasma or Potato Protein in Starter Pig Diets (Exp. 3)[a]**

Item	Dried Skim Milk	Animal Plasma 3.5%	Animal Plasma 7.0%	Exp. Potato Protein 4.0%	Exp. Potato Protein 8.0%	Exp. Potato Protein 2 8.0%	CV
Day 0 to 7							
ADG, lb[bcd]	.63	.67	.73	.65	.53	.58	10.13
ADFI, lb[be]	.53	.61	.67	.60	.53	.54	10.90
F/G[c]	.85	.92	.91	.93	1.00	.94	9.40
Day 0 to 14							
ADG, lb[df]	.83	.81	.83	.86	.77	.76	7.87
ADFI, lb	.85	.83	.87	.89	.82	.82	7.34
F/G	1.02	1.03	1.05	1.03	1.06	1.09	4.78
Day 14 to 28							
ADG, lb	1.11	1.06	1.07	1.08	1.12	1.17	7.25
ADFI, lb	1.93	1.76	1.98	1.86	1.82	1.96	9.10
F/G[g]	1.72	1.67	1.85	1.72	1.63	1.69	6.90
Day 0 to 28							
ADG, lb	.97	.93	.95	.97	.94	.96	5.94
ADFI, lb[h]	1.39	1.29	1.43	1.37	1.32	1.39	6.69
G:F[g]	1.42	1.39	1.49	1.41	1.41	1.44	4.59

[a]Two hundred ten weanling pigs were used (initially 12.21 lb and 20 lb of age ±3 d of age) with seven pigs per pen. Day 0 to 14 diets were formulated to contain 1.5% lysine, .42% methionine, .9% Ca, and .8% P.
[b]Linear effect of animal plasma ($P < .05$).
[c,f]Linear effect of potato protein ($P < .05$); ($P < .10$), respectively.
[d,e]Quadratic effect of potato protein ($P < .10$); ($P < .05$), respectively.
[g,h]Quadratic effect of animal plasma ($P < .10$); ($P < .05$), respectively.