EFFECT OF SUBSTITUTING SPRAY-DRIED PLASMA PROTEIN FOR MILK PRODUCTS IN STARTER PIG DIETS

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Summary

Two growth trials utilizing 444 weaned pigs were conducted to determine the efficacy of substituting spray-dried porcine plasma protein (PP) for dried skim milk (DSM) and/or dried whey (DW) in starter pig diets. Trial 1 was a field study in which 240 pigs were fed either a control diet containing 20% DSM and 20% DW during phase I (0 to 14 d postweaning) and 15% DW and 5% select menhaden fishmeal in phase II (14 to 28 d postweaning) of the 28 d trial. Plasma protein was substituted on a lysine basis for DSM in the phase I diet and for DW in the phase II diet. Diets were isolactose in both phases. Pigs fed the diets containing PP grew faster and consumed more feed from d 0 to 7 than pigs fed the control. However, pigs fed the control diet compensated during wk 2 to achieve equal performance during phase I. No treatment differences were detected during phase II or in overall performance. In Trial 2, 204 pigs were allotted to one of the following treatments: 1) control diet containing 20% DSM and 20% DW, 2) as 1 with casein replacing soybean meal (lysine basis; all milk protein), 3) as 1 with PP and lactose replacing 20% DSM (lysine and lactose basis), 4) as 3 with starch replacing lactose (wt/wt), 5) as 1 with PP and lactose replacing DSM and DW (lysine and lactose basis), 6) as 5 with starch replacing lactose, 7) corn-soybean meal plus 20% DW. Pigs fed diets containing PP grew faster and consumed more feed than pigs fed the control, casein, or 20% DW diets from 0 to 14 d postweaning. Similarly, overall gains were significantly greater for pigs fed PP than pigs fed the control, casein, and DW diets. Also, pigs fed PP consumed greater quantities of feed over the entire trial than those pigs fed the control or casein diets. Serum was collected on d 13 and analyzed for blood urea nitrogen. Blood urea N was higher for pigs fed PP, indicating that the amino acids in PP are more available to the pig, but not all are utilized for protein synthesis. Skinfold thickness was measured on d 7 following intradermal injections of protein extracts of PP soybean meal and DSM; these data indicate that PP and DSM cause extremely small changes in skinfold thickness compared to soybean proteins. Based on the results of these experiments, PP has an equal, if not better, feeding value than milk protein.

(Key Words: Starter Performance, DSM, Whey, Plasma Protein.)

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Introduction

Previous research has indicated that soybean proteins have several antinutritional factors that cause morphological and immunological changes to the small intestine of newly weaned pigs. This results in reduced nutrient uptake and significant reductions in growth rate and feed intakes of the weanling pigs. Milk protein is considered to be one of nature's most perfect proteins for new-born animals. For this reason, it is often included in starter pig diets to offset some of the detrimental effects of the soybean proteins typically added to those diets. Many researchers have demonstrated tremendous advantages to using milk products in swine diets, especially dried whey (DW) and dried skim milk (DSM). From 0 to 14 d postweaning Kansas State University recommends using 20% DSM and 20% DW in starter diets for pigs weaned at 3 weeks of age. The present trials were conducted to determine if spray-dried PP is a viable alternative to milk products in starter pig diets.

Procedures

Trial 1 was a field study utilizing 240 weaned pigs (16.5 lb initial wt; 25 d of age; 28 d trial) to determine the efficacy of substituting PP and lactose for DSM during phase I and for dried whey during phase II, on a lysine and lactose basis. Diets (Table 1) were formulated to contain 1.5% and 1.25% lysine in phase I and phase II, respectively, plus .9% calcium and .8% phosphorus. Pigs were blocked by weight and assigned by sex and ancestry to experimental treatments. Pigs were housed 15 per pen (8 pens per treatment) in an environmentally controlled nursery with woven wire flooring and allowed ad libitum access to feed and water. Individual pig weights and feed intakes per pen were obtained and recorded at weekly intervals. Feed conversions were calculated based on gains per pen and feed intakes. The pen was considered an experimental unit.

Skinfold thickness was determined at 7 d postweaning. Pigs were intradermally injected with .5 ml of sterile saline (physiological), soybean protein, milk protein, and PP extracts. Skinfold thickness was measured using a micrometer 24 hr postinjection. All test solutions contained equimolar quantities of the respective protein extracts to determine the immunological response to injection, as well as to determine dietary treatment by injection treatment interaction.

In Trial 2, 204 pigs were weaned at about 21 ± 2 d age (initial wt 12.9 lb; 35 d trial), blocked by weight and sex, then randomly assigned to experimental treatments within blocks according to ancestry. There were five replicate pens (6 pigs/pen) for all treatments, except the diet containing casein, which had only four replicate pens. Pigs were housed in 4 ft x 5 ft pens (woven wire floors) in an environmentally controlled nursery and allowed feed and water ad libitum. Pigs were weighed weekly and feed disappearance per pen was obtained for feed conversion analysis. Serum samples were obtained on d 13 of the trial and subsequently analyzed for blood urea nitrogen (BUN). Skinfold thickness was determined as in trial 1.

Experimental treatments (Table 2) were: 1) control (HNDD), corn-soybean meal + 20% DSM + 20% DW; 2) casein (CAS), as 1 with casein replacing soybean meal, 3) plasma-lactose-whey (PLW), as 1 with plasma and lactose replacing DSM; 4) plasma-starch-whey

(PSW), as 3 with corn starch replacing lactose; 5) plasma-lactose (PL), as 1 with plasma and lactose replacing DSM and DW; 6) plasma-starch (PS), as 5 with corn starch replacing lactose; 7) dried whey (DW), corn-soybean meal + 20% DW. All diets were formulated to contain similar amounts of lysine (1.4%), calcium (1.0%), phosphorus (.9%), sodium (.91%), and at least .39% methionine. All other amino acids were calculated to exceed National Research Council (NRC, 1988) and Kansas State Universities nutrient estimates for 12 lb pigs. The diets were pelleted through a 10/64 in x 1.5 in die with a conditioning temperature of 140 to 144° F, with the exception that the PS diet was pelleted with a conditioning temperature of 158 to 167° F, indicating a higher absorptive capacity for water by the starch.

Table 1. Trial 1 Diet Composition

	Phase I		Phase II	
Ingredient	Control	Plasma protein	Control	Plasma protein
Corn	25.06	24.05		
Sorghum			53.4	54.15
Soybean meal, (48.5% CP)	22.15	22.15	19.3	19.3
Dried whey	20	20	15	
Dried skim milk	20			
Fishmeal, select menhaden			5	5
Lactose		10		10.8
Plasma protein		10		2.9
Soybean oil	10	10	4	4
Monocalcium phosphate (21% P, 18% Ca)	1.1	2.05	1.3	1.8
Limestone	.5	.7	.5	.6
Lysine•HCl, 98%	.14		.2	.15
Salt			.3	.3
Premix[a]	.95	.95	.95	.95
Vitamin E[d]	.1	.1	.1	.1
Total	100	100	100	100
Calculated Analysis, %				
Crude protein	22.2	22.3	19.1	19.1
Lysine	1.55	1.55	1.25	1.25
Methionine	.42	.3	.34	.33
Sodium	.38	.89	.36	.34

[a] Premixes provided 5 g chlortetracycline; 5 g sulfathiazole; 2.5 g penicillin; vitamin A, 2,500 IU; vitamin D_3, 250 IU; vitamin E, 10 IU; menadione, 1 mg; riboflavin 2.5 mg; pantothenic acid, 6.25 mg; niacin, 13.75 mg; choline, 250 mg; and vitamin B_{12}, .5 μg; 4.5 mg Mn; 4.5 mg Fe; 4.5 mg Zn; 1.81 mg Ca; 115.7 mg Cu; .18 mg K; .14 mg I; .09 mg Na and .05 mg Co per lb of finished diet.

[b] Each lb of premix contained 20,000 IU vitamin E.

Table 2. Trial 2 Diet Composition

Ingredient	Phase I[a] HNDD	CAS	PLW	PSW	PL	PS	DW	Phase II
Corn	33.4	42.2	33.1	33.1	34.7	34.7	36.4	55.3
Soybean meal, 48.5%	16.1		16	16	16	16	32	23.3
Dried whey	20	20	20	20			20	10
Dried skim milk	20	20						
Plasma protein			10.3	10.3	13.4	13.4		
Fishmeal, select menhaden								4
Lactose			10		24.4			
Corn starch				10		24.4		
Soybean oil	6	6	6	6	6	6	6	4
Monosodium phosphate (18.8% P, 26% Na)	1.6	1.63			.26	.26	2.03	
Monocalcium phosphate (21% P, 18% Ca)		.05	2.58	2.58	2.99	2.99		1.46
Limestone	1.24	1.31	.68	.68	.92	.92	1.7	.54
Salt	.3						.3	.25
Lysine•HCl, 98%	.14						.15	.15
Dl-methionine, 99%			.13	.13	.15	.15	.06	
Premix[b]	.95	.95	.95	.95	.95	.95	.95	.95
Selenium premix[c]	.05	.05	.05	.05	.05	.05	.05	.05
Cr_2O_3	.1	.1	.1	.1	.1	.1	.1	
Total	100	100	100	100	100	100	100	100
Calculated Analysis, %								
Crude protein	19.9	19.5	20.1	20.1	19.7	19.7	21.2	19.4
Lysine	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.25
Methionine	.39	.49	.39	.39	.39	.39	.39	.35
Lactose	24.4	24.4	24.4	14.4	24.4	0	14.4	7.2

[a] HNDD=control; CAS=casein; PLW=plasma-lactose-whey; PSW=plasma-starch-whey; PL=plasma-lactose; PS=plasma starch; DW=dried whey.
[b] Same as Table 1.
[c] Selenium premix provided 136.2 μg per lb complete diet.

Results and Discussion

Skinfold Thickness. Skinfold thickness data (Table 3) for both trials showed no injection by dietary treatment interactions, indicating that feeding casein, DSM or PP offers no potential for immunological changes past the intestinal level. All measurements were relative to saline, thus, negative values could be obtained, as indicated by DSM. Plasma protein caused slightly higher changes in skinfold thickness, which could be due to the different proteins and immunoglobulins that would be foreign to the pig. Because the composition of milk protein compared to PP would include large quantities of casein rather than functional circulating proteins, the possible antigenicity could be due to the proteins in plasma. There was a significant change in skinfold thickness from the soybean proteins, indicating that the anti-nutritional factors present in soybean meal cause significant immunological changes in the pig. These data are in agreement with previous data from this station.

Table 3. Skinfold Thickness Change Due to Protein Source for Trials 1 and 2

		Protein source			
Item		Plasma protein	Skim milk	Soybean meal	CV
Trial 1	Skinfold thickness vs. saline[a], µm	.69	.58	1.28	72.5
Trial 2	Skinfold thickness vs. saline[a], µm	.33	-.1	1.37	116.2

[a] Soybean meal vs others (P<.01).

Trial 1. Week one performance data (Table 4) indicate that the replacement of milk protein with PP and lactose increased daily feed intake (ADFI; .48 vs .39 lb/d; P<.10) and average daily gain (ADG; .49 vs .40 lb/d; P<.05). The response to added PP was not maintained, however, because pigs fed the control diet compensated during wk 2. Therefore, no net differences were detected for phase I (0 to 2 wk). A similar pattern was noticed in phase II and overall performance, in which no treatment differences were found. In general, these data suggest that PP plus lactose has an equal feeding value to DSM during the first 2 weeks postweaning. The PP may be more beneficial during the first 7 to 10 d postweaning when maximal stress is possible, whereas the DSM appears to be most beneficial when the pigs have overcome the postweaning stress.

Trial 2. In trial 2, wk 1 and 0 to 14 d gains (P<.05) and feed intakes (P<.05) of pigs fed PP (Table 5) were superior to those fed the control diet. The substitution of plasma and lactose for DSM (PLW diet) appeared to maximize the response in growth and intake. This could be the combined effect of adding lactose compared to starch (P<.10) and the low compared to high level of PP (P<.05) on both ADG and ADFI. Similarly, ADG for pigs fed the PSW diet was second only to the PLW diet, indicating the need for lactose and DW during the initial 7 d postweaning. The PL diet performed similarly to the PSW diet, indicating again that lactose has a profound positive effect on initial postweaning performance. It is important to note, however, that the PL diet had higher quantities of lactose than the PSW diet (24.4 vs 14.4%), indicating that the higher inclusion rate of PP is not essential to maximize growth response. In general, pigs fed diets containing PP grew faster because of an increased feed intake (P<.05) than pigs fed the HNDD, CAS, or DW diets.

Pigs fed the DW diet had poorer ADG (P<.05) than those fed the HNDD diet during week 1, but this effect was not observed throughout the 0 to 14 d period. These results indicate that the inclusion of only 20% DW would be adequate during the first 14 d postweaning, which is inconsistent with previous research evaluating these of diets. Pigs fed the DW diet tended to sort out unwanted particles in the trough, as indicated by average daily feed refusal (Table 5). Because all feeders were managed to allow the opportunity for pigs to consume fresh feed, the potential for poor performance on the DW diet could have been minimized, because the pigs could eat the most desirable components and leave the rest. From an economical standpoint, the DW diet was least desirable because pigs refused large quantities of feed.

Pigs fed the CAS diet performed as well as the pigs fed the HNDD or DW diets during the first week and 0 to 14 d postweaning. There was a clear trend for pigs fed the CAS diet to have reduced feed intakes during these periods as well. However, the reduction in feed intake was offset by a more efficient utilization of feed for gain. It appears that casein would be best utilized in diets for pigs weighing less than 15 lb.

Table 4. Effect of Substituting Plasma Protein and Lactose for Milk Products in Starter Pig Diets (Trial 1)[a]

Item	Control	Plasma protein	CV
0-7 d			
ADG, lb[b]	.40	.49	11.7
ADFI, lb[c]	.39	.48	8.6
F/G	.97	.98	6.4
0-2 wk			
ADG, lb	.58	.59	5.2
ADFI, lb	.67	.67	6.8
F/G	1.16	1.14	5.9
2-4 wk			
ADG, lb	1.16	1.12	3.3
ADFI, lb	1.9	1.86	2.8
F/G	1.63	1.65	3.1
0-4 wk			
ADG, lb	.87	.84	2.6
ADFI, lb	1.28	1.26	2.4
F/G	1.48	1.49	3.2

[a] Values are means of eight pens containing 15 pigs per pen (initial wt 16.5 lb; 28 d trial; 25 d of age).
[b] Means differ ($P<.05$).
[c] Means differ ($P<.10$).

Blood urea nitrogen data (Table 5) indicate that pigs fed the lower levels of plasma protein had significant excesses of amino acids that could be metabolized to urea. Similarly, pigs fed the higher level of PP had BUN levels higher than those of the HNDD pigs. These results suggest that the amino acids in PP are more available for use by the pig; therefore, some may be in excess. Blood urea nitrogen data parallel F/G data. Pigs fed the diets containing PP had slightly poorer F/G; therefore, higher BUN values would be anticipated. These factors are expected to be influenced at this age mainly by feed intake, because the pigs consuming more feed in this trial had somewhat poorer feed efficiencies.

During phase II, all pigs had similar weight gains and feed intakes, with the exception of pigs fed the CAS diet, which had poorer gains and feed intakes. In general, pigs fed the diets containing PP tended to have reduced performance during wk 3, possibly caused by such a significant change in diet, but compensated during wk 4 and 5 to have slightly better gains and much higher feed-intakes (P<.05) for the 2 to 5 wk period. However, pigs fed the HNDD or DW diet showed very little difference in performance when the switch was made to a common phase II diet.

During the 0 to 5 wk period, pigs fed the diets containing PP had significantly faster rates of gain (P<.05) and greater feed intakes (P<.05) than pigs fed the HNDD diet. The PLW diet produced the highest ADG (11% greater than HNDD) and ADFI (14% greater than HNDD) of all experimental treatments.

Based on these results, spray-dried porcine plasma protein can be an effective alternative to DSM in starter pig diets. These data indicate that substituting PP on a lysine basis for DSM, with subsequent additions of 10% lactose during the first 7 to 14 d postweaning, can produce better growth rates and feed intakes than a diet containing 20% DSM plus 20% DW.

Table 5. Effect of Substituting Plasma Protein and Lactose or Starch for Milk Products in Starter Pig Diets (Trial 2)[ab]

Item	HNDD	CAS	PLW	PSW	PL	PS	DW	CV
0-7 d								
ADG, lb[cdef]	.67	.73	.89	.83	.82	.69	.57	9.8
ADFI, lb[cde]	.66	.65	.88	.76	.79	.67	.62	8.1
F/G[f]	.98	.89	.99	.93	.97	.97	1.08	7.5
Blood urea N, mg/dl[de]	4.24	3.42	6.09	6.56	4.99	4.65	5.42	41.4
0-2 wk								
ADG, lb[cde]	.69	.73	.98	.93	.91	.83	.72	8.9
ADFI, lb[cde]	.86	.82	1.18	1.07	1.06	.96	.92	8.2
F/G[e]	1.24	1.12	1.21	1.16	1.17	1.15	1.27	4.7
Feed refusal, $lb/pen{\cdot}d^{-1}$	.18		.09		.27	.19	.98	
2-5 wk								
ADG, lb	1.30	1.19	1.34	1.30	1.34	1.33	1.33	6.4
ADFI, lb[e]	2.30	2.22	2.48	2.43	2.53	2.54	2.49	6.3
F/G[e]	1.77	1.86	1.86	1.88	1.90	1.90	1.88	5.6
0-5 wk								
ADG, lb[e]	1.05	1.01	1.19	1.15	1.17	1.13	1.09	6.1
ADFI, lb[e]	1.72	1.66	1.96	1.89	1.95	1.91	1.86	6.3
F/G	1.63	1.64	1.65	1.64	1.67	1.68	1.72	4.3

[a] Values are means of four (CAS) or five (others) pens with 6 pigs/pen (initial wt 12.9 lb; 35 d trial; 21 ± 2 d of age).

[b] HNDD=control; CAS=casein; PLW=plasma-lactose-whey; PSW=plasma-starch-whey; PL=plasma-lactose; PS=plasma starch; DW=dried whey.

[c] Main effect of lactose (P<.10).

[d] Main effect of plasma protein level (P<.05).

[e] Plasma protein vs control (P<.05).

[f] Control vs dried whey diet (P<.05).