# EFFECTS OF WHEAT GLUTEN AND PLASMA PROTEIN ON GROWTH PERFORMANCE AND DIGESTIBILITY OF NUTRIENTS IN NURSERY PIGS

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## Summary

An experiment was conducted to determine the nutritional value of wheat gluten and spray-dried porcine plasma in diets for weanling pigs. For the experiment, 120 pigs (14 lb avg initial body wt) were used in a 35-d growth assay. Treatments fed from d 0 to 14 postweaning were: 1) a dried skim milk-dried whey-soybean meal-based control; and 2, 3, and 4) spray-dried wheat gluten, spray-dried porcine plasma, and a blend of the wheat gluten and porcine plasma used to replace dried skim milk on a protein basis. All pigs were fed the same corn-soybean meal-dried whey-based diet from d 14 to 35. For d 0 to 14, pigs fed porcine plasma protein had greater average daily gain and average daily feed intake than pigs fed wheat gluten. However, for d 14 to 21 (i.e., during the transition period to the phase II diet), pigs fed diets with wheat gluten had the greatest feed intake and rate of gain compared with pigs fed other protein sources during phase I. Overall, pigs fed diets with wheat gluten and(or) plasma protein had greater rates and efficiencies of gain than pigs fed dried skim milk. The results indicate that spray-dried porcine plasma protein improves growth rate for the initial postweaning phase; however, feeding spray-dried wheat gluten during phase I results in improved growth performance during the transition to a phase II diet.

(Key Words: Wheat Gluten, Plasma Protein, Growth, Digestibility, Nursery.)

## Introduction

Nutritional programs for weanling pigs have evolved greatly in the last decade, largely in response to the use of high quality sources of ingredients such as human-grade milk products. Use of milk products has improved rates and efficiencies of gain in weanling pigs, but the demand for milk products as human food often makes their use in diets for pigs cost prohibitive. Therefore, identifying less expensive protein sources that can be used in diets for weanling pigs is a major focus of research here at Kansas State University.

Spray-dried wheat gluten (WG) is wheat protein (70 to 80% total CP), with some carbohydrates, lipids, and fiber remaining when the starch is removed from wheat kernels. Previously reported experiments here at KSU indicated improved growth performance in nursery pigs when WG was used to replace the dried skim milk (DSM) in phase I diets (i.e., for 7 to 14 d postweaning). However, this response resulted from a carryover effect into phase II rather than an immediate response during phase I. In contrast, spray-dried porcine plasma protein (SDPP) improves growth performance of nursery pigs when added to phase I diets, but much of the benefit is lost unless SDPP or a high quality spray-dried blood meal is fed during phase II. Thus, questions remain as to the possible complementary effects from improved growth performance in phase I by adding SDPP and improved growth performance in phase II from the carry-over effect of WG fed during phase I. The experiment reported herein was conducted to determine the benefits of feeding WG and(or) SDPP in phase I on growth performance and nutrient digestibility of pigs for the entire nursery period.

## Procedures

One hundred and twenty weanling pigs, averaging 21 d of age and 14 lb body weight, were used in a 35-d growth assay to evaluate WG and SDPP as replacements for DSM in phase I nursery diets. The pigs were randomly allotted to five treatments based on body weight, sex, and ancestry. Treatments were: 1) a DSM-dried whey-soybean meal-based control; 2) WG and lactose to replace the DSM; 3) SDPP and lactose to replace the DSM; and 4) a WG-SDPP blend and lactose to replace the DSM. The WG, SDPP, and WG-SDPP blend were added to supply the same amount of CP supplied by the DSM in the control diet, with lactose added so all diets had 25% lactose. The WG-SDPP blend had 50% of the CP from WG and 50% from SDPP. The diets (Table 1) were fed from d 0 to 14 postweaning (phase I) in pelleted form. All pigs were fed the same pelleted corn-soybean meal-dried whey-based diet from d 14 to 35 (phase II).

The pigs were housed in 4 ft × 5 ft pens with wire-mesh flooring. Room temperatures were 90, 87, 84, 80, and 75°F for wk 1 to 5, respectively. Each pen had a self-feeder and nipple water to allow ad libitum consumption of feed and water. There were six pigs per pen and five pens per treatment. Pigs and feeders were weighed weekly to allow calculation of average daily gain (ADG), average daily feed intake (ADFI), and feed/gain (F/G). Chromic oxide (.2%) was included in the diets as an indigestible marker. On d 10 and 20 (i.e., before and after the change to the phase II diet) fecal samples were collected from four pigs per pen by rectal massage. The fecal samples were dried, pooled, and ground for determination of dry matter (DM), nitrogen (N), and chromium concentrations. Apparent digestibilities of DM and N were calculated using the indirect ratio procedure with chromic oxide as the marker.

The experiment was a randomized complete block with initial body weight as the blocking criterion. Pen was the experimental unit. Response criteria were ADG, ADFI, F/G, and apparent digestibilities of DM and N. Treatment means were separated using the orthogonal contrasts: 1) DSM vs the other protein sources; 2) WG and SDPP vs the WG-SDPP blend; and 3) WG vs SDPP.

## Results and Discussion

Crude protein concentrations of the protein sources were 33%, 74%, and 72% for DSM, WG, and SDPP, respectively (Table 2). However, in formulations of cereal grain-based diets for nonruminants, the lysine concentration is of greater importance than CP. When expressed as a percent of CP, DSM and SDPP had 7.5 and 9.0% lysine, but WG had only 1.8% lysine. Thus, when using WG in diets for nursery pigs, careful attention must be given to ensure that diets are adequate for the essential amino acids rather than crude protein per se.

During phase I, pigs fed SDPP had greater ADG ($P<.03$) and ADFI ($P<.04$) compared to pigs fed WG, but pigs fed the various protein sources had similar F/G (Table 3). Comparison of pigs fed the diet with SDPP to those fed the diet with WG also indicated 6% and 8% improvements in digestibilities of DM ($P<.001$) and N ($P<.02$), respectively, on d 10 of the experiment.

For the first 7 d of phase II (d 14 to 21), there were carryover effects of phase I treatments, with pigs fed WG in phase I having greater ADG ($P<.09$) and ADFI ($P<.02$) compared to pigs fed diets with SDPP. Pigs fed diets with WG and SDPP during phase I had greater ADFI ($P<.04$)

compared to pigs fed the WG-SDPP blend. Nutrient digestibilities were not statistically different at d 20 for the treatment groups.

For d 14 to 35, pigs fed DSM in phase I had the poorest ADG (P<.08) and F/G (P<.05) compared to those fed the other diets. Pigs fed WG in phase I had greater ADFI (P<.07) than pigs fed SDPP. Overall (d 0 to 35), pigs fed the diet with DSM during d 0 to 14 had lower ADG (P<.05) and worse F/G (P<.01) than pigs fed the other protein sources. Pigs fed the WG-SDPP blend during phase I had numerically the greatest ADG of any treatment (7% greater than any other treatment); however, the effect was not statistically significant (P<.15).

In conclusion, using WG, SDPP, or a WG-SDPP blend in phase I diets with a common whey-soybean meal-corn-based phase II diet for nursery pigs improved overall ADG and F/G when compared to a phase I diet with DSM. These results seem to result from a greatly improved feed intake for weaned pigs fed SDPP during phase I and from a carryover effect of WG into the transition to a phase II diet. Further studies are needed to quantify additional benefits that might be achieved by feeding WG-SDPP blends and to determine the effects of feeding WG, SDPP, and a WG-SDPP blend for the entire nursery phase.

**Table 1. Diet Composition**

| | Phase I Protein Sources[ab] | | | | Phase II |
|---|---|---|---|---|---|
| Item, % | DSM | WG | SDPP | WG-SDPP | Diet[c] |
| Corn | 34.22 | 33.59 | 33.86 | 33.83 | 45.11 |
| Dried whey | 20.00 | 20.00 | 20.00 | 20.00 | 20.00 |
| DSM | 20.00 | — | — | — | — |
| WG | — | 8.88 | — | 4.48 | — |
| SDPP | — | — | 9.25 | 4.63 | — |
| Lactose | — | 10.00 | 10.00 | 10.00 | — |
| Soybean meal (48% CP) | 19.64 | 19.64 | 19.64 | 19.64 | 28.81 |
| Soybean oil | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 |
| Monocalcium phosphate | 1.19 | 2.12 | 2.21 | 2.16 | 1.27 |
| Limestone | .28 | .40 | .34 | .37 | .51 |
| Vitamin premix[d] | .25 | .25 | .25 | .25 | .25 |
| Trace mineral premix[d] | .15 | .15 | .15 | .15 | .15 |
| Salt | — | .20 | — | — | .20 |
| Copper sulfate | .10 | .10 | .10 | .10 | .10 |
| Chromic oxide | .10 | .10 | .10 | .10 | .10 |
| Lysine-HCl | .07 | .57 | — | .29 | — |
| DL-methionine | — | — | .10 | — | — |
| Antibiotic[e] | 1.00 | 1.00 | 1.00 | 1.00 | .50 |
| Total | 100 | 100 | 100 | 100 | 100 |

[a]The phase I diets (d 0 to 14) were formulated to 22% CP, 1.4% lysine, 25% lactose, .9% Ca, and .8% P.
[b]DSM = dried skim milk, WG = spray-dried wheat gluten, and SDPP = spray-dried porcine plasma.
[c]The phase II diet (d 14 to 35) was formulated to 20% CP, 1.2% lysine, 15% lactose, .8% Ca, and .7% P.
[d]KSU vitamin and trace mineral premixes.
[e]Antibiotic supplied 100, 100, and 50 g/ton of chlortetracycline, sulfathiazole, and penicillin, respectively.

**Table 2. Chemical Composition of Protein Sources[a]**

| Item | DSM[b] | WG[c] | SDPP[d] |
|---|---|---|---|
| Crude protein, % | 33.3 | 74.3 | 72.0 |
| Amino acids, % of sample | | | |
| Arginine | 1.2 | 2.6 | 4.3 |
| Histidine | .9 | 1.4 | 2.4 |
| Isoleucine | 2.2 | 2.2 | 2.8 |
| Leucine | 3.3 | 4.7 | 7.3 |
| Lysine | 2.5 | 1.3 | 6.5 |
| Methionine | .9 | 2.5 | .7 |
| Phenylalanine | 1.6 | 3.4 | 4.1 |
| Threonine | 1.6 | 2.4 | 5.2 |
| Tryptophan | .4 | .6 | 1.5 |
| Valine | 2.3 | 2.2 | 4.7 |
| Amino acids, % of CP | | | |
| Arginine | 3.6 | 3.5 | 6.0 |
| Histidine | 2.7 | 1.9 | 3.3 |
| Isoleucine | 6.6 | 3.0 | 3.9 |
| Leucine | 9.9 | 6.3 | 10.1 |
| Lysine | 7.5 | 1.8 | 9.0 |
| Methionine | 2.7 | 3.4 | 1.0 |
| Phenylalanine | 4.8 | 4.6 | 5.7 |
| Threonine | 4.8 | 3.2 | 7.2 |
| Tryptophan | 1.2 | .8 | 2.1 |
| Valine | 6.9 | 3.0 | 6.5 |

[a]DSM = dried skim milk, WG = spray-dried wheat gluten, and SDPP = spray-dried porcine plasma.
[b]Amino acid profile from NRC (1988).
[c]Amino acids analyzed using AOAC (1990) procedures.
[d]Amino acid profile courtesy of Merrick's, Inc.

**Table 3. Performance of Pigs Fed Spray-Dried Wheat Gluten and Spray-Dried Plasma Protein during Phase I[a]**

| | Protein Sources[b] | | | | Contrasts[cd] | | | |
|---|---|---|---|---|---|---|---|---|
| Item | DSM | WG | SDPP | WG-SDPP | 1 | 2 | 3 | SE |
| d 0 to 14 | | | | | | | | |
| ADG, lb | .79 | .77 | .87 | .82 | — | — | .03 | .03 |
| ADFI, lb | .82 | .75 | .86 | .79 | — | — | .04 | .03 |
| F/G | 1.04 | .97 | .99 | .96 | — | — | — | .06 |
| d 14 to 21 | | | | | | | | |
| ADG, lb | .64 | .94 | .68 | .72 | — | — | .09 | .10 |
| ADFI, lb | 1.10 | 1.30 | 1.08 | 1.03 | — | .04 | .02 | .06 |
| F/G | 1.72 | 1.38 | 1.59 | 1.43 | — | — | — | .74 |
| d 14 to 35 | | | | | | | | |
| ADG, lb | .89 | 1.02 | .94 | 1.09 | .08 | .15 | — | .06 |
| ADFI, lb | 1.59 | 1.63 | 1.52 | 1.63 | — | — | .07 | .04 |
| F/G, lb | 1.79 | 1.60 | 1.62 | 1.50 | .05 | — | — | .10 |
| d 0 to 35 | | | | | | | | |
| ADG, lb | .85 | .92 | .91 | .98 | .05 | .15 | — | .03 |
| ADFI, lb | 1.28 | 1.28 | 1.25 | 1.29 | — | — | — | .03 |
| F/G, lb | 1.51 | 1.39 | 1.37 | 1.32 | .01 | — | — | .05 |
| Apparent digestibilities, % | | | | | | | | |
| DM (d 10) | 83.1 | 81.9 | 87.2 | 83.4 | — | — | .001 | .7 |
| N (d 10) | 81.0 | 77.7 | 84.3 | 79.8 | — | — | .02 | 1.4 |
| DM (d 20) | 79.8 | 83.1 | 77.3 | 80.9 | — | — | — | 3.1 |
| N (d 20) | 74.6 | 76.6 | 73.4 | 74.1 | — | — | — | 4.8 |

[a]A total of 120 pigs (six pigs per pen and five pens per treatment) with an average initial body wt of 14 lb.
[b]DSM = dried skim milk, WG = spray-dried wheat gluten, and SDPP = spray-dried porcine plasma. Note that all pigs were fed a common diet (corn-SBM-dried whey-based) for phase II (d 14 to 35).
[c]Contrasts were: 1) DSM vs the other protein sources; 2) WG and SDPP vs the WG-SDPP blend; and 3) WG vs SDPP.
[d]Dash indicates $P>.15$.