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EFFECTS OF WHEAT GLUTEN ON NURSERY PIG PERFORMANCE

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Summary

One hundred eighty weanling pigs, averaging 23 d of age and 12.6 lb initial weight, were used to evaluate spray-dried wheat gluten (WG) in phase 1 (d 0 to 14) and(or) phase 2 (d 14 to 37) nursery diets. Phase 1 treatments were 1) dried skim milk-soybean meal-dried whey-based control (DSM-SBM), 2) Diet 1 with WG and lactose used to replace the DSM (WG-SBM), and 3) Diet 1 with WG used to replace the SBM (DSM-WG). Phase 2 treatments were 1) corn-SBM-dried whey-based control and 2) WG and lactose used to replace the dried whey. During phase 1, diets with WG supported average daily gain (ADG), average daily feed intake (ADFI), and feed/gain (F/G) similar to the DSM-SBM control. Pigs fed the diet with DSM-WG had improved F/G compared to pigs fed WG-SBM. Diets with WG had increased DM and N digestibilities but caused increased serum urea N compared to the DSM-SBM control. In the first week of phase 2 (d 14 to 21), pigs previously fed WG-SBM and DSM-WG had improved F/G and DM and N digestibilities compared to those previously fed the DSM-SBM control. Pigs previously fed the WG-SBM treatment had improved ADG, ADFI, and F/G compared to pigs previously fed DSM-WG. Overall (d 0 to 37), pigs fed WG in phase 1 had improved ADG and F/G compared to pigs fed the DSM-SBM control, and pigs fed WG-SBM during phase 1 had greater ADG and ADFI than pigs fed DSM-WG. As for the phase 2 diet treatments, dried whey supported improved ADG, ADFI, and F/G from d 14 to 21 compared to WG and lactose. However, for the entire phase 2 period (d 14 to 37) and overall (d 0 to 37), pigs fed WG in phase 2 had similar ADG and improved F/G compared to those fed dried whey. In conclusion, pigs fed WG in place of DSM during phase 1 had improvements of 13% in ADG, 9% in ADFI, and 4% in F/G for the entire nursery period.

(Key Words: Dried Skim Milk, Wheat Gluten, Nursery.)

Introduction

Wheat gluten (WG) is a product produced in Kansas that is used primarily by the baking industry to improve the protein concentration of poor quality flours. However, research published in the 1991 KSU Swine Day Report (Report of Progress No. 641, page 74) indicated increases of 10 to 20% in average daily gain (ADG) and average daily feed intake (ADFI) for the overall nursery phase when pigs were fed spray-dried WG vs dried skim milk from d 0 to 14 postweaning. Those data suggested an alternative for swine producers wishing to improve growth performance of their weanling pigs without use of rendered animal products. In an effort to further elucidate the growth enhancing effects of WG, an experiment was designed to determine the effects of feeding spray-dried WG in place of milk products during phase 1 (d 0 to 14), phase 2 (d 14 to 37), and for the entire nursery period.

Procedures

One hundred eighty weanling pigs, averaging 23 d of age and 12.6 lb initial weight, were used in a 37-d experiment to determine the effects of feeding spray-dried WG in phase 1 and(or) phase 2 on growth performance and nutrient digestibility. At weaning, the pigs were allotted to treatment based on initial weight, sex, and ancestry. The experiment was a randomized complete block with treatments arranged as a 3 × 2 factorial. Treatments for phase 1 were 1) dried skim milk-soybean meal-dried whey-based control (DSM-SBM), 2) Diet 1 with WG and lactose used to replace the DSM (WG-SBM), and 3) Diet 1 with WG used to replace the SBM (DSM-WG). On d 14, pigs were changed to phase 2 treatments that were 1) corn-SBM-dried whey-based control and 2) WG and lactose used to replace the dried whey. Phase 1 diets had 1.4% lysine and 25% lactose (Table 1). Phase 2 diets had 1.2% lysine and 15% lactose. All diets were pelleted. Each pen had three barrows and three gilts, with five pens per treatment. Pens were 4 ft × 5 ft with a self-feeder and nipple waterer to allow ad libitum consumption of feed and water.

Fecal samples were collected from four pigs per pen on d 14 and 21; dried; pooled within pen; and analyzed for DM, N, and Cr concentrations to determine apparent nutrient digestibilities. On d 13 and 20, feeders were removed for 3 h and blood was collected from four pigs per pen for determination of serum urea N concentrations.

Results and Discussion

Crude protein concentrations of the protein sources ranged from 13.3% for the dried whey to 74.3% for the spray-dried WG (Table 2). Of particular importance were the differences in lysine concentrations. When expressed as a percentage of CP, dried skim milk, dried whey, soybean meal, and WG had 7.6, 7.1, 6.3, and 1.7% lysine. Thus, it should be noted that use of WG to replace the protein from DSM or SBM in phase 1 starter diets will necessitate use of crystalline lysine (i.e., 10 to 12 lb/ton).

During phase 1, pigs fed WG-SBM and DSM-WG had similar performance ($P > .15$) to pigs fed the DSM-SBM control, although pigs fed the DSM-WG diet (without soybean meal) tended to have the greatest ADG and superior F/G (Table 3). Pigs fed WG-SBM had greater ADFI ($P < .01$) but poorer F/G ($P < .001$) compared to pigs fed DSM-WG. Pigs fed DSM-SBM had the lowest serum urea N concentrations, and pigs fed DSM-WG had the greatest. Normally, we would anticipate lower serum urea N concentrations to be associated with superior amino acid balance and, therefore, improved growth performance. In the present experiment, serum urea N was not an adequate predictor of nutritional status, because pigs with the greatest growth performance also had the greatest serum urea N. Diets with WG had greater DM and N digestibilities than the DSM-SBM control ($P < .001$), and the DSM-WG diet had greater DM and N digestibilities than the WG-SBM diet ($P < .001$). Comparison of the DSM-SBM control diet to the DSM-WG diet indicated 4 and 9% improvements in digestibilities of DM and N, respectively, when WG was used to replace SBM.

Growth performance, nutrient digestibilities, and serum urea N were determined for the first 7 d of phase 2 (d 14 to 21) to evaluate the response of pigs to a diet change. For d 14 to 21, there were carryover effects of phase 1 treatment, with pigs fed WG in phase 1 having improved F/G ($P < .01$), DM ($P < .01$), and N ($P < .001$) digestibilities compared to pigs fed the DSM-SBM control diet in phase 1 (Table 4). Pigs fed WG-SBM in phase 1 had improved ADG ($P < .001$), ADFI ($P < .001$), and F/G ($P < .05$) compared to those fed DSM-WG. Thus, the advantage of using WG to formulate diets without SBM in phase 1 was lost when the pigs were changed to a phase 2 diet with SBM.

For d 14 to 37 and overall (d 0 to 37), pigs fed WG in phase 1 had improved ADG ($P < .06$) and F/G ($P < .01$) compared to pigs fed DSM-SBM. Also, pigs fed WG-SBM in phase 1 had greater ADG ($P < .001$) and ADFI ($P < .001$) and improved F/G ($P < .01$) in phase 2 compared to those fed DSM-WG, demonstrating again that using WG to replace the DSM in phase 1 diets is of more benefit than replacing the SBM. The diet with WG-SBM supported 18, 11, and 6% improvements in ADG, ADFI, and F/G in phase 2, and 13, 9 and 4% improvements in ADG, ADFI, and F/G overall when compared to the DSM-SBM control. These values are similar to those reported in the 1991 KSU Swine Day Report, which indicated overall improvements of 10 to 20% in ADG and ADFI for pigs fed spray-dried WG vs those fed DSM during phase 1.

Regarding phase 2 treatments, pigs consuming dried whey had improved ADG ($P<.01$), ADFI ($P<.05$), and F/G ($P<.05$) compared to pigs fed WG and lactose for d 14 to 21 (the first 7 d of phase 2). However, WG and lactose supported better F/G ($P<.05$) for the entire phase 2 period. Serum urea N was greater ($P<.001$) for pigs fed diets with WG in phase 2.

In conclusion, using spray-dried WG and lactose to replace DSM in diets for early-weaned pigs resulted in greater growth performance during the nursery phase with lower diet costs. However, our data do not support use of spray-dried wheat gluten to formulate nonsoybean meal diets for phase 1 or to replace dried whey in phase 2 diets.

Table 1. Diet Composition, %

	Phase 1[ab]			Phase 2[c]	
Item	DSM-SBM	WG-SBM	DSM-WG	Whey	WG
Corn	33.96	32.78	33.92	45.10	45.49
Soybean meal (48%)	19.85	19.85	—	28.85	28.85
Dried whey (edible)	20.00	20.00	20.00	20.00	—
Dried skim milk	20.00	—	20.00	—	—
Spray-dried WG	—	9.20	13.00	—	3.50
Lactose	—	10.40	—	—	14.90
Lysine-HCl	—	.50	.58	—	.18
Cornstarch	—	—	6.00	—	—
Soybean oil	3.00	3.00	3.00	3.00	3.00
Monocalcium phosphate	1.20	2.20	1.70	1.30	2.05
Limestone	.34	.42	.15	.60	.63
Vitamins and minerals[d]	.65	.65	.65	.65	.65
Salt	—	—	—	—	.25
Antibiotic[e]	1.00	1.00	1.00	.50	.50
Total	100	100	100	100	100

[a]Phase 1 diets were formulated to 1.4% lysine, 22% CP, 25% lactose, .9% Ca, and .8% P.
[b]DSM = dried skim milk; SBM = soybean meal, and WG = spray-dried wheat gluten.
[c]Phase 2 diets were formulated to 1.2% lysine, 20% CP, 15% lactose, .8% Ca, and .7% P.
[d]KSU vitamin mix (.25%), KSU mineral mix (.15%), Se mix (.05%), copper sulfate (.10%), and chromic oxide (.10% as an indigestible marker).
[e]Phase 1 antibiotic supplied 200 g furazolidone, 100 g oxytetracycline, and 90 g arsanilic acid per ton of diet; phase 2 antibiotic supplied 100 g chlortetracycline, 100 g sulfathiazole, and 50 g penicillin per ton of diet.

Table 2. Chemical Composition of Protein Sources, %

Item	Dried skim milk[a]	Whey[a]	Soybean meal[b]	Spray-dried wheat gluten[b]
CP	33.3	13.3	45.84	74.34
Amino acids				
Arginine	1.16	.33	3.97	2.56
Histidine	.86	.17	1.15	1.38
Isoleucine	2.18	.78	1.96	2.15
Leucine	3.30	1.18	3.62	4.73
Lysine	2.54	.94	2.91	1.27
Methionine	.90	.19	.75	2.45
Phenylalanine	1.57	.35	1.83	3.43
Threonine	1.57	.89	1.84	2.37
Tryptophan	.43	.18	.59	.61
Valine	2.29	.67	1.84	2.19

[a]From NRC (1988) Nutrient Requirements for Swine.
[b]Analyzed values.

Table 3. Phase 1 Growth Performance of Weanling Pigs Fed Spray-Dried Wheat Gluten[a]

	Phase 1 treatments (d 0 to 14)			
Item	DSM-SBM[b]	WG-SBM	DSM-WG	CV
d 0 to 14				
ADG, lb	.65	.64	.66	7.4
ADFI, lb[e]	.64	.66	.60	6.2
F/G[f]	.98	1.03	.91	5.7
Apparent digestibility (d 14), %				
DM[c,f]	87.1	87.5	90.7	1.0
N[c,f]	82.6	83.9	89.7	1.5
Serum urea N (d 13), mg/dL[c,d]	7.4	11.4	12.6	12.2

[a]A total of 180 pigs (six pigs/pen and five pens/treatment) with an average initial wt of 12.6 lb.
[b]DSM = dried skim milk, WG = spray-dried wheat gluten, and SBM = soybean meal.
[c]DSM-SBM vs WG-SBM and DSM-WG (P<.001).
[def]WG-SBM vs DSM-WG (P<.05, P<.01, and P<.001, respectively).

Table 4. Phase 2 Growth Performance of Weanling Pigs Fed Spray-Dried Wheat Gluten[a]

	DSM-SBM[b]		WG-SBM		DSM-WG		
Item	Whey	WG	Whey	WG	Whey	WG	CV
d 14 to 21							
ADG, lb[h,j]	.80	.70	1.00	.84	.76	.68	11.7
ADFI, lb,[h,i]	1.22	1.14	1.32	1.20	1.09	1.05	7.5
F/G[d,f,i]	1.53	1.63	1.32	1.43	1.43	1.54	8.3
d 14 to 37							
ADG, lb[c,h]	1.04	1.00	1.21	1.20	.97	1.02	9.5
ADFI, lb[h]	1.64	1.54	1.80	1.72	1.52	1.55	7.9
F/G[d,g,j]	1.58	1.54	1.49	1.43	1.57	1.52	3.2
d 0 to 37							
ADG, lb[c,h]	.89	.86	1.00	.98	.85	.89	7.4
ADFI, lb[h]	1.26	1.20	1.37	1.32	1.17	1.19	6.6
F/G[d,i]	1.42	1.40	1.37	1.35	1.38	1.34	2.7
Apparent digestibility (d 21), %							
DM[d]	83.6	82.4	85.6	85.4	85.5	84.5	2.4
N[e]	79.2	79.0	81.6	82.6	80.4	81.4	2.6
Serum urea N (d 20), mg/dL[k,l]	11.4	12.7	11.3	14.0	9.8	13.7	10.2

[a]A total of 180 pigs (six pigs/pen and five pens/treatment) with an average initial wt of 12.6 lb.
[b]DSM = dried skim milk, WG = spray-dried wheat gluten, and SBM = soybean meal. Note that DSM-SBM, WG-SBM, and DSM-WG were phase 1 treatments fed from d 0 to 14 only.
[cde]DSM-SBM vs WG-SBM and DSM-WG ($P<.06$, $P<.01$, and $P<.001$, respectively).
[fgh]WG-SBM vs DSM-WG ($P<.05$, $P<.01$, and $P<.001$, respectively).
[ijk]Whey vs WG ($P<.05$, $P<.01$, and $P<.001$, respectively).
[l]DSM-SBM vs WG-SBM and DSM-WG × whey vs WG ($P<.04$).