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EFFECT OF REPLACING MILK PROTEINS WITH WHEAT GLUTEN AND SOYBEAN PRODUCTS ON DIGESTIBILITY OF NUTRIENTS AND GROWTH PERFORMANCE IN NURSERY PIGS

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Summary

Two experiments were conducted to evaluate the nutritional value of processed wheat gluten for early-weaned pigs. The first experiment involved 72 weanling pigs with an avg age of 20 d and avg wt of 9.2 lb. Six diets were fed to the pigs in individual metabolism cages. Protein sources were casein, flash-dried wheat gluten, spray-dried wheat gluten, two solubilized wheat glutens, and soybean meal. Response criteria were N digestibility, biological value, and N retention. Casein had greater N digestibility, biological value, and N retention than the other protein sources. The wheat gluten products had greater N digestibility than soybean meal. Modification of the wheat gluten, to increase its solubility, resulted in marked decreases in biological value and N retention. Experiment 2 was a nursery growth assay. A total of 180 pigs were used, with an avg age of 25 d and avg wt of 12.3 lb. The five pelleted diets fed from d 0 to 14 were: 1) a high nutrient density diet (HNDD) with 20% dried whey and 20% dried skim milk (DSM); 2) HNDD with the DSM replaced by flash-dried wheat gluten and lactose; 3) HNDD with the DSM replaced by spray-dried wheat gluten and lactose; 4) HNDD with the DSM replaced by solubilized-modified wheat gluten and lactose; 5) HNDD with DSM replaced by soy protein isolate and lactose. All pigs were fed a common diet from wk 3 to 5 of the experiment. No differences in ADG or ADFI were noted for d 0 to 14. Feed to gain was best for pigs fed diets with spray-dried wheat gluten and worst for those fed diets with soy-isolate. For d 0 to 35, pigs fed diets with flash-dried wheat gluten had lower ADG and ADFI than pigs fed diets with spray-dried and solubilized-modified wheat gluten. Furthermore, pigs fed spray-dried wheat gluten during Phase I had the greatest overall growth performance, with a 19% improvement in ADG compared to pigs fed DSM.

(Key Words: Starter, Dried Skim Milk, Wheat, Gluten, Process, Digestion, Performance.)

Introduction

The demand for milk products as human food can make their use in animal feeds impractical. Wheat gluten is commonly used in the bread making industry to improve low quality wheat flours, has 75% crude protein, and is priced much cheaper per unit of protein than dried skim milk. Four wheat gluten products, differing greatly in solubility and manufacturing process (i.e., flash-dried, spray-dried, solubilized, and solubilized plus further modifications) were evaluated as potential replacements for milk protein sources (especially dried skim milk) in diets for weanling pigs.

Procedures

In Experiment 1, 72 crossbred barrows were weaned at 20 d of age (avg wt of 9.2 lb) and started immediately on experimental diets. Pigs were individually housed in stainless steel metabolism cages to allow collection of feces and urine. The pigs were allowed to consume water ad libitum, and their daily feed allowance was calculated as .05 × body weight$^{.9}$. Treatments were: 1) casein; 2) flash-dried wheat

gluten[1]; 3) spray-dried wheat gluten[1]; 4) solubilized wheat gluten[1]; 5) solubilized and further modified wheat gluten[1]; and 6) soybean meal (Table 1).

The diets were fed for a 5-d adjustment period, followed by 4 d of total collection of feces and urine. The diets were fed four times per d at 6 h intervals. Room temperature was maintained at 82°F.

In Experiment 2, 180 crossbred pigs were weaned at 25 d of age (avg initial wt of 12.3 lb) and used in a 5-wk growth assay to determine the nutritional value of wheat gluten products and lactose as replacements for dried skim milk. Pigs were housed (three barrows and three gilts per pen) in 4 ft × 5 ft pens with woven wire flooring. Each pen had a self-feeder and nipple water to allow ad libitum intake.

The pigs were fed Phase 1 diets (Table 2) from weaning to d 14. Phase 1 treatments were pelleted and included: 1) a high nutrient density diet (HNDD) with 20% dried whey and 20% dried skim milk (DSM); 2) HNDD with the DSM replaced by flash-dried wheat gluten and lactose; 3) HNDD with the DSM replaced by spray-dried wheat gluten and lactose; 4) HNDD with the DSM replaced by solubilized-modified wheat gluten and lactose; 5) HNDD with DSM replaced by soy protein isolate and lactose. All Phase 1 diets contained .20% chromic oxide as an indigestible marker for determination of apparent digestibilities of DM and N. In phase 2 (d 14 to 35), all pigs were fed a common pelleted diet (corn-soybean meal- dried whey).

Pigs and feeders were weighed weekly to determine ADG, ADFI, and F/G. On d 14 of the experiment, fecal samples were collected from four pigs per pen. The fecal samples were dried and pooled within pen. The pooled samples were analyzed for DM, N, and Cr content to determine apparent digestibilities of DM and N.

[1]Wheat protein products were supplied by Midwest Grain Products, Inc., Atchison, KS.

Results and Discussion

In Experiment 1, diets with casein had greater N digestibility, biological value, and N retention than diets with the other protein sources (Table 3). The wheat glutens had N digestibilites that were slightly lower than casein but greater than soybean meal. The solubilized and solubilized-modified wheat gluten had lower biological value and N retention than the other wheat glutens.

In Experiment 2, no differences were noted in ADG, ADFI, or F/G for d 0 to 7, although pigs fed the HNDD diet with DSM had small numerical advantages in ADG and F/G compared to the other treatments (Table 4). For d 0 to 14, no differences were observed in ADG or ADFI, but pigs fed the wheat gluten products had better F/G than those fed the soy protein isolate. Pigs fed spray-dried wheat gluten had improved F/G compared to those fed solubilized-modified wheat gluten. The HNDD diet with DSM had greater apparent DM digestibility than the other diets.

Overall (d 0 to 35), pigs fed spray-dried wheat gluten and solubilized-modified wheat gluten had greater ADG and ADFI than pigs fed flash-dried wheat gluten. The spray-dried wheat gluten diet supported notably greater in ADG and ADFI when compared to all other diets.

In conclusion, wheat gluten products and lactose can effectively replace DSM in a Phase 1 diet. To d 14, relative feeding values (based on feed efficiency) of the diets with flash-dried, spray-dried, and solubilized-modified wheat gluten and soy protein isolate were 100, 109, 97 and 95%, respectively, compared

to the HNDD diet with DSM. Furthermore, pigs fed spray-dried wheat gluten during Phase I had the greatest overall growth performance, with 19% greater ADG (.99 vs .83 lb/d) than pigs fed DSM during Phase I.

Table 1. Diet Composition (Experiment 1)

Ingredient, %	Casein-based control
Corn	32.76
Casein[a]	17.80
Corn starch	17.19
Lactose	20.00
Fish meal	5.00
Soy oil	3.00
Monocalcium phosphate	2.00
Limestone	.37
Amino acids	.33
Vit/Min/Antibiotic[b]	1.00
Salt	.30
Chromic oxide	.25
Total	100

[a]Flash-dried, spray-dried, solubilized, and solubilized-modified wheat gluten, soybean meal, monocalcium phosphate, limestone, and amino acids were substituted for casein and cornstarch to bring all diets to 22% CP, 1.54% lysine, .9% Ca, and .8% P.

[b]Antibiotic supplied per ton of diet: 100g chlortetracycline, 100g sulfathiazole, and 50g penicillin.

Table 2. Diet Composition (Experiment 2)

Ingredient, %	HNDD[a] d 0-14
Corn	33.51
SBM (48% CP)	20.20
Whey	20.00
DSM[a]	20.00
Soy oil	3.00
Monocalcium phosphate	1.20
Limestone	.34
Vit/Min/Antibiotic[c]	1.55
Chromic oxide	.20
Total	100

[a]Diets were fed from d 0 to 14. All pigs were fed a common corn-SBM-whey diet from d 14 to 35.

[b]Flash-dried, spray-dried, and solubilized-modified wheat gluten, soy isolate, lactose, monocalcium phosphate, limestone, lysine and .2% salt were substituted for the dried skim milk so that all diets had 22% CP, 1.4% lysine, .9% Ca, and .8% P.

[b]Antibiotic supplied per ton of diet: 200g furazolidone, 100g oxytetracycline, and 90g arsanilic acid.

Table 3. Nitrogen Digestibility and Utilization of Wheat Gluten Products (Experiment 1)[a]

Item	Casein	Flash-dried gluten	Spray-dried gluten	Solubilized gluten	Sol-mod gluten	Soybean meal	CV
N digestibility, %[b]	95.1	90.7	91.5	91.2	92.1	87.2	4.2
Biological value, %[c]	82.1	74.0	75.6	70.1	70.9	74.3	6.2
N retention, %[d]	78.3	68.2	68.3	63.4	65.8	65.5	8.3

[a]Twelve pigs/treatment for N digestibility and eight pigs/treatment for biological value and N retention.
[b]Casein vs others ($P < .01$); wheat glutens vs soybean meal ($P < .01$).
[c]Casein vs others ($P < .01$); solubilized and solubilized-modified vs flash- and spray-dried wheat glutens ($P < .02$).
[d]Casein vs others ($P < .01$).

Table 4. Effect of Wheat Gluten on Growth Performance and Nutrient Digestibility in Nursery Pigs (Experiment 2)[a]

Item	HNDD	Flash-dried wheat gluten	Spray-dried wheat gluten	Sol-mod wheat gluten	Soy isolate	CV
d 0 to 7						
ADG, lb[b]	.74	.69	.67	.71	.67	14.3
ADFI, lb[b]	.65	.61	.61	.65	.60	10.1
F/G[b]	.88	.90	.92	.92	.90	7.2
d 0 to 14						
ADG, lb[b]	.74	.70	.75	.71	.68	11.4
ADFI, lb[b]	.77	.74	.72	.77	.75	7.6
F/G[c]	1.05	1.05	.96	1.08	1.11	5.5
d 0 to 35						
ADG, lb[d]	.83	.85	.99	.89	.86	10.9
ADFI, lb[e]	1.27	1.26	1.49	1.37	1.32	10.3
F/G[b]	1.52	1.48	1.52	1.53	1.54	4.4
Apparent digestibility, %						
DM[f]	89.1	87.8	87.5	88.3	88.6	1.4
N[b]	85.9	86.4	86.3	85.7	86.5	2.1

[a]Six pigs/pen and six pens/treatment.
[b]No treatment effect ($P > .10$).
[c]Wheat glutens vs soy isolate ($P < .01$); spray-dried wheat gluten vs solubilized-modified wheat gluten ($P < .01$).
[d]Flash-dried wheat gluten vs spray-dried and solubilized-modified wheat gluten ($P < .08$).
[e]Flash-dried wheat gluten vs spray-dried and solubilized-modified wheat gluten ($P < .02$).
[f]HNDD with dried skim milk vs others ($P < .07$).