EFFECTS OF DRY-EXTRUDED WHOLE SOYBEANS ON GROWTH PERFORMANCE OF NURSERY PIGS AND GROWTH PERFORMANCE, CARCASS CHARACTERISTICS, AND STOMACH MORPHOLOGY OF FINISHING PIGS

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Summary

In a 31-d nursery experiment, replacing soybean meal (SBM) with dry-extruded whole soybeans (DEWS) tended to improve F/G (6% overall difference), but ADG was not affected. Ajusting the diet with DEWS to the nutrient:calorie ratio of the diet with SBM did not greatly improve growth performance compared to the diet that was simply formulated to the same concentration of lysine as the diet with SBM. In a second experiment (with finishing pigs), 50 and 100% of the SBM in a corn-based diet was replaced with DEWS. Replacement resulted in 2% greater ADG and 8% better F/G, without significantly increasing carcass fatness or the incidence of stomach ulcers. Our data suggest that DEWS are an acceptable (if not superior) alternative to SBM in diets for nursery and finishing pigs.

(Key Words: Soybeans, Extrusion, Ulcers, Backfat.)

Introduction

In the past several KSU Swine Day Reports, we shared data suggesting equal or greater growth performance in nursery pigs when soybean meal (SBM) and soybean oil were replaced with dry-extruded whole soybeans (DEWS). However, we still are asked frequently if the fat in extruded soybeans is adequately utilized by weanling piglets and if lysine and other nutrients should be increased to keep the same nutrient:calorie ratios in DEWS-based diets.

In contrast, it is generally agreed that fat in diets for growing/finishing pigs improves efficiency and sometimes rate of gain. However, the inclusion of only 5% added fat has been blamed for increased average backfat thickness (as much as .05 to .1 in). Therefore, the objectives of the experiments reported herein were to determine the effects of DEWS (with or without adjustment for nutrient:calorie ratios) on growth performance of nursery pigs. Also of interest was to determine the effects of increased percentage of DEWS in diets (in place of SBM) on growth performance, carcass characteristics, cost of gain, and stomach lesions in finishing pigs.

Procedures

In the first experiment, a total of 72 weanling pigs (initial wt of 10.6 lb) was used in a 31-d growth assay. The pigs (PIC Line 326 boars × C15 sows) were blocked by weight and assigned to treatment based on sex and ancestry. There were six pigs per pen and four pens per treatment. The experimental diets (Tables 1, 2, and 3) were fed in three phase (d 0 to 7, 7 to 17, and 17 to 31). Treatments were: 1) SBM-based control; 2) DEWS without nutrient:calorie ratios adjusted; and 3) DEWS with nutrient:calorie ratios adjusted. Diets with SBM and the DEWS treatment that was not adjusted for nutrient:calorie ratios were formulated to 1.6% lysine for d 0 to 7, 1.45% lysine for d 7 to17, and 1.3% lysine for d 17 to 31. The diets with adjustment for nutrient:calorie ratios were formulated to 1.67% lysine for d 0 to 7, 1.53% lysine for d 7 to 17, and 1.38% lysine for d 17 to 31. The soybeans were mill-run and processed in an Insta-Pro® extruder with a barrell temperature of 298°F and throughput of 1,500 lb/h.

The pigs were housed in an environmentally controlled nursery room with the tem-

perature at 90°F for wk 1 and reduced by 5°F per week thereafter. The pigs had ad libitum access to feed and water. Pigs and feeders were weighed on d 0, 7, 17, and 31 to allow calculation of ADG, ADFI, and F/G.

The data were analyzed as a radomized complete block design with orthogonal contrasts used to separate treatment means. Pen was the experiment unit.

In a second experiment, 150 crossbred (Duroc × Yorkshire × Hampshire × Chester White) finishing pigs (112 lb initial wt) were used. The pigs were housed in a modified open-front buildings (five barrows and five gilts per pen), with 50% solid concrete and 50% concrete slat flooring. Each pen (6 ft × 16 ft) had a two-hole self feeder and a nipple waterer to allow ad libitum consumption of feed and water. There were five pens per treatment. Treatments were: 1) SBM, 2) 50:50 blend (protein basis) of SBM and DEWS, and 3) 100% replacement of SBM with DEWS. The SBM (control) diet was corn-based and formulated to .7% lysine, .65% Ca, and .55% P (Table 4). All diets were formulated to the same lysine:DE ratio (i.e., 2.1 g lysine/Mcal of DE).

The pigs and feeders were weighed at initiation and conclusion of the experiment to allow calculation of ADG, ADFI, and F/G. When pigs in the heaviest pen of a weight block averaged 250 lb, the entire group was removed from the growth assay. The pigs were killed at a commercial slaughter facility, and hot carcass weight was recorded to allow calculation of dressing percentage. Last rib backfat thickness was measured with a ruler on both sides of the split carcass. Stomachs were collected and scored for severity of ulcers and keratinization. The scoring system for ulcers was: 0 = normal; 1 = erosions; 2 = ulcers; and 3 = severe ulcers. The scoring system for keratinization was: 0 = normal; 1 = mild keratosis; 2 = moderate keratosis; and 3 = severe keratosis.

All data were analyzed as a randomized complete block design with pen as the experimental unit. Polynomial regression was used to determine linear and quadratic effects of DEWS concentration.

Results and Discussion

For d 0 to 7 of the nursery experiment, pigs fed diets with DEWS tended to have better F/G ($P < .09$) than those fed diets with SBM (Table 5). For d 0 to 17, pigs fed DEWS had lower ADFI ($P < .04$) and a trend for better F/G ($P < .07$) than pigs fed SBM. Overall (d 0 to 31), no differences in ADG or F/G occurred among pigs fed SBM vs DEWS ($P > .22$), but pigs fed DEWS had a 6% numerical advantage in F/G. Although few statistically significant differences occurred in this experiment, the trends in the responses were consistent to other data generated at KSU during the past 7 yr. The general trend was for better ADG and F/G immediately after weaning, and an F/G effect in the late nursery phase. These responses suggest that the protein and fat in DEWS were utilized well by nursery pigs.

For the finishing experiment, ADG (linear effect, $P < .06$) and F/G (linear effect, $P < .001$) were improved as the concentration of DEWS in the diets was increased (Table 6).

No differences in slaughter weight ($P > .23$) occurred among pigs fed the soybean treatments. However, hot carcass weight and, thus, dressing percentage increased (linear effects, $P < .01$) as the concentration of DEWS was increased. Backfat thickness and fat free lean index were not affected as DEWS concentration was increased ($P > .26$).

The number of stomachs given each score for keratinization and ulceration and a mean score for each treatment are provided in Table 7. As concentration of DEWS was increased, stomach keratinization score increased (row mean scores differ test, $P < .005$). However, severity of ulceration was not affected (row mean scores differ test, $P > .52$) by DEWS concentration in the diet. Furthermore, of the 146 stomachs collected, none had a severe ulcer, and only one had

severe keratinization. Therefore, no symptoms of reduced animal health were noted in our experiment that could be related to dietary treatment.

In conclusion, our data suggest that DEWS provide an excellent protein source for weanling pigs and can be used to replace 100% of the SBM in nursery diets. Finally, finishing pigs fed diets with DEWS in place of SBM had improved rates and efficiencies of gain without negative effects on stomach morphology or carcass fatness.

Table 1. Diet Composition for d 0 to 7 of the Nursery Experiment, %

		DEWS[a]	
Ingredient	SBM[a]	Unadjusted	Adjusted[b]
Corn	31.81	25.04	24.75
Soybean product	21.43	30.17	30.17
Dried whey	20.00	20.00	20.00
Lactose	10.00	10.00	10.00
Plasma protein	4.00	4.00	4.00
Wheat gluten	4.00	4.00	4.00
Blood meal	2.00	2.00	2.00
Soybean oil	2.00	--	--
Dicalcium phosphate	1.90	1.77	1.93
Limestone	.67	.80	.83
Salt	.10	.10	.10
Vitamin premix	.25	.25	.25
Trace mineral premix	.15	.15	.15
L-lysine HCl	.25	.25	.33
DL-methionine	.07	.10	.11
Zinc oxide	.37	.37	.38
Antibiotic[c]	1.00	1.00	1.00
Total	100.00	100.00	100.00
Calculated analysis			
DE, kcal/kg	3,489	3,683	3,672
ME, kcal/kg	3,273	3,419	3,408
Lysine:ME, g/Mcal	4.9	4.7	4.9
CP, %	21.5	21.7	23.7
Lysine, %	1.60	1.60	1.67
Ca, %	.90	.90	.94
P, %	.80	.80	.83
Ether extract, %	3.7	7.4	7.4

[a]SBM=soybean meal and DEWS=dry-extruded whole soybeans.
[b]Adjusted to the same nutrient:calorie ratio as the SBM (control) diet.
[c]Provided 150 g/ton of apramycin.

Table 2. Diet Composition for d 7 to 17 of the Nursery Experiment, %

Ingredient	SBM[a]	DEWS[a] Unadjusted	DEWS[a] Adjusted[b]
Corn	43.78	34.36	33.92
Dried whey	20.00	20.00	20.00
Soybean product	27.67	39.02	39.02
Soybean oil	2.00	--	--
Blood meal	2.00	2.00	2.00
Dicalcium phosphate	1.62	1.47	1.69
Limestone	.73	.91	.94
Vitamin premix	.25	.25	.27
Trace mineral premix	.15	.15	.16
L-lysine·HCl	.15	.15	.26
DL-methionine	.09	.12	.14
Zinc oxide	.36	.37	.39
Salt	.20	.20	.21
Antibiotic[c]	1.00	1.00	1.00
Total	100.00	100.00	100.00
Calculated analysis			
DE, kcal/kg	3,490	3,764	3,748
ME, kcal/kg	3,294	3,506	3,491
Lysine:ME, g/Mcal	4.4	4.1	4.4
CP, %	21.67	21.93	21.91
Lysine, %	1.45	1.45	1.53
Ca, %	.90	.90	.95
P, %	.80	80	.85
Ether extract, %	4.2	9.5	9.5

[a]SBM=soybean meal and DEWS=dry-extruded whole soybeans.
[b]Adjusted to the same nutrient:calorie ratio as the SBM (control) diet.
[c]Provided 150 g/ton of apramycin.

Table 3. Diet Composition for d 17 to 31 of the Nursery Experiment, %

Ingredient	SBM[a]	DEWS[a] Unadjusted	DEWS[a] Adjusted[b]
Corn	59.15	48.43	47.99
Soybean product	33.48	47.14	47.14
Soybean oil	3.00	--	--
Monocalcium phosphate	1.51	1.32	1.53
Limestone	.90	1.12	1.15
Vitamin premix	.25	.25	.26
Tracer mineral premix	.15	.15	.16
L-lysine·HCl	.15	.15	.26
DL-methionine	.02	.05	.09
Copper sulfate	.09	.09	.10
Salt	.30	.30	.32
Antibiotic[c]	1.00	1.00	1.00
Total	100.00	100.00	100.00
Calculated analysis			
DE, kcal/kg	3,634	3,943	3,927
ME, kcal/kg	3,435	3,669	3,654
Lysine:ME, g/Mcal	3.8	3.5	3.8
CP, %	21.24	21.57	21.56
Lysine, %	1.30	1.30	1.38
Ca, %	.80	.80	.85
P, %	.70	.70	.74
Ether extract, %	5.6	11.5	11.4

[a]SBM=soybean meal and DEWS=dry-extruded whole soybeans.
[b]Adjusted to the same nutrient:calorie ratio as the SBM (control) diet.
[c]Provided 50 g/ton of mecadox.

Table 4. Diet Composition for the Finishing Experiment, %

Ingredient	SBM[a]	Replacement of SBM 50% DEWS[a]	100% DEWS
Sorghum	81.62	78.50	75.34
Soybean meal	15.71	7.86	--
Extruded soybeans	--	10.81	21.64
Moncalcium phosphate	1.04	1.11	1.18
Limestone	.93	.98	1.04
Salt	.30	.31	.32
Vitamin premix	.15	.15	.16
Tracer mineral premix	.10	.10	.11
Antibiotic[b]	.10	.10	.11
L-lysine·HCl	.05	.08	.10
Total	100.00	100.00	100.00
Calculated analysis			
DE, kcal/kg	3,365	3,405	3,446
ME, kcal/kg	3,208	3,293	3,378
Lysine:DE, g/Mcal	2.2	2.2	2.2
CP, %	14.57	14.61	14.65
Lysine, %	.70	.72	.74
Ether extract, %	2.5	4.5	6.6

[a]SBM=soybean meal and DEWS=dry-extruded whole soybeans.
[b]Provided 40g/ton of tylosin.

Table 5. Effects of Dry-Extruded Whole Soybeans with or without Adjustment for Nutrient:Calorie Ratios in Weaned Pigs[a]

Item	SBM[b]	DEWS[b] Unadjusted	Adjusted	CV	Contrasts[c] 1	2
d 0 to 7						
ADG, lb	.74	.83	.79	9.0	.15	--[d]
ADFI, lb	.73	.74	.68	5.9	--	.12
F/G	.99	.89	.86	9.9	.09	--
d 0 to 17						
ADG, lb	.91	.90	.90	8.2	--	--
ADFI, lb	1.04	.97	.94	5.6	.04	--
F/G	1.14	1.08	1.04	5.8	.07	--
d 0 to 31						
ADG, lb	.99	.96	.99	6.8	--	--
ADFI, lb	1.35	1.26	1.24	4.9	.04	--
F/G	1.36	1.31	1.25	7.5	--	--

[a]Seventy two weanling pigs were used (initial wt of 10.6 lb) with six pigs per pen and four pens per treatment.
[b]SBM=soybean meal and DEWS=dry-extruded whole soybeans.
[c]Contrasts were: 1) SBM vs DEWS; and 2) unadjusted vs adjusted.
[d]Dashes indicate P>.15.

Table 6. Effects of Dry-Extuded Whole Soybeans on Growth Performance in Finishing Pigs[a]

		Replacement of SBM			Contrast	
Item	SBM[b]	50% DEWS[b]	100% DEWS	CV	Linear	Quadratic
ADG, lb	1.82	1.81	1.91	3.9	.06	--[d]
ADFI, lb	6.01	5.74	5.53	4.5	.01	--
F/G	3.30	3.17	2.89	4.8	.001	--
Slaughter wt, lb	251	251	258	3.6	--	--
Hot carcass wt, lb	187	189	190	3.6	.01	--
Dressing percentage	73.7	74.5	74.8	.7	.01	--
Last rib backfat thickness, in	1.13	1.15	1.19	0.6	--	--
FFLI, %[c]	47.1	47.0	46.9	4.5	--	--

[a]A total of 150 finishing pigs were used (initial body wt of 112 lb) with 10 pigs per pen and five pens per treatment.
[b]SBM=soybean meal and DEWS=dry-extruded whole soybeans.
[c]Equation (NPPC, 1991) was: Fat Free Lean Index=51.537 + (.035 × hot carcass wt) - (12.26 × off-midline backfat thickness).
[d]Dashes indicate P>.15.

Table 7. Effects of Dry-Extruded Whole Soybeans on Stomach Morphology in Finishing Pigs[a]

		Replacement of SBM			Contrasts	
Item	SBM[b]	50% DEWS[b]	100% DEWS	CV	1[e]	2[f]
Stomach keratinization						
Total observation	47	50	49	--	--	--
Normal	32	26	18	--	--	--
Mild	11	20	25	--	--	--
Moderate	4	4	5	--	--	--
Severe	0	0	1	--	--	--
Mean score[c]	.58	.78	.93	79.0	.005	.02
Stomach ulceration						
Total observations	47	50	49	--	--	--
Normal	45	50	47	--	--	--
Erosions	1	0	0	--	--	--
Ulcers	1	0	2	--	--	--
Severe ulcer	0	0	0	--	--	--
Mean score[d]	.06	.00	.10	546.0	.52	.23

[a]A total of 146 stomachs were collected (47 to 50/treatment).
[b]SBM=soybean meal and DEWS=dry-extruded whole soybeans.
[c]Scoring system was: 0 = normal; 1 = mild keratinization; 2 = moderate keratinization; and 3 = severe keratinization.
[d]Scoring system was: 0 = normal; 1 = erosions; 2 = ulcers; and 3 = severe ulcers.
[e]Cochran-Mantel-Haenszel statistic, row mean scores differ test.
[f]Cochran-Mantel-Haenszel statistic, nonzero correlation test.