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Extrusion processing of low-inhibitor soybeans improves growth performance of nursery pigs fed protein-adequate diets (1991)

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EXTRUSION PROCESSING OF LOW-INHIBITOR SOYBEANS IMPROVES GROWTH PERFORMANCE OF NURSERY PIGS FED PROTEIN-ADEQUATE DIETS

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Summary

One hundred fifty weanling pigs (15.4 lb avg initial wt) were used in a 35-d growth assay to determine the effects of processing method (roasting in a Roast-A-Tron® roaster vs extrusion in an Insta-Pro® extruder) on nutritional value of soybeans with (+K) and without (-K) gene expression for the Kunitz trypsin inhibitor. Treatments were: 1) soybean meal with added soybean oil; 2) +K roasted; 3) +K extruded; 4) -K roasted; and 5) -K extruded. All diets were corn-based and formulated to 1.25% lysine for d 0 to 14 and 1.10% lysine for d 14 to 35 of the experiment. For d 0 to 14, 14 to 35, and 0 to 35, pigs fed extruded soybeans had improved ADG and F/G compared to pigs fed roasted soybeans. Digestibilities of DM, N, and gross energy were greater for diets with extruded soybeans than diets with roasted soybeans, and diets with soybean meal and soybean oil were intermediate. The response to extrusion processing was greater with -K than +K soybeans, with pigs fed extruded -K soybean having the greatest growth performance and nutrient digestibilities and lowest skinfold thickness of any treatment. Extrusion processing of +K and -K soybeans improved growth performance and nutrient digestibility in weanling pigs fed protein-adequate diets.

(Key Words: Soybeans, Process, Starter, Performance, Trypsin Inhibitor, Immunology.)

Introduction

In last year's KSU Swine Day Report (page 52), we reported that compared to nursery pigs fed conventional soybeans, pigs fed low-inhibitor soybeans had a 6% improvement in F/G and 5 and 3% improvements in digestibility of DM and N, respectively. Also, compared to roasting, extrusion processing improved ADG by 21%, F/G by 7%, DM digestibility by 6%, and N digestibility by 5%. These improvements resulted with diets that were formulated to provide only 80% of the NRC requirement for lysine to ensure that differences in protein quality would be accentuated. If the greater nutritional value of extruded low-inhibitor soybeans reported last year was due only to differences in protein quality, there should be no differences in performance for pigs given those soybean preparations in protein-adequate diets. However, if performance is still different in protein-adequate diets, some other factor(s) is also contributing to improved nutritional value. An experiment was designed to determine the effects of roasting and extrusion on nutritional value of conventional and low-inhibitor soybeans in protein-adequate diets for nursery-age pigs.

Procedures

Williams 82 soybeans with (+K) and without (-K) gene expression for the Kunitz trypsin inhibitor were either roasted or extrud-

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ed and incorporated into corn-based diets with 20% dried whey (Table 1). Treatments were: 1) soybean meal with added soybean oil; 2) +K roasted; 3) +K extruded; 4) -K roasted; and 5) -K extruded. The roasting and extrusion temperatures were those deemed usual for soybean processing, i.e., a throughput of approximately 1,000 lb/h and an average exit temperature of 245°F in a Roast-A-Tron® roaster versus a throughput of approximately 1,500 lb/h and an average barrel temperature of 290°F in an Insta-Pro® dry-extruder. All diets were formulated to provide 1.25% lysine and 1.60 Mcal DE/lb of diet for d 0 to 14 of the experiment and 1.10% lysine and 1.61 Mcal DE/lb of diet for d 14 to 35 of the experiment. The diets were formulated to be in excess of NRC (1988) requirements for lysine and protein to ensure that differences in growth performance would not be due to difference in digestibility or availability of a limiting amino acid.

One hundred fifty weanling pigs (15.4 lb avg initial wt) were fed the treatment diets in a 35-d growth assay. The pigs were housed (five pigs per pen and six pens per treatment) in an environmentally controlled nursery equipped with a woven-wire floor. Each pen had a self-feeder and nipple waterer, so feed and water could be consumed ad libitum. On d 6 of the experiment, the pigs were given intradermal injections of protein extracts from the soybean products. Results were expressed as the increase in skinfold thickness on d 7 compared to that from an injection of saline. On d 14 of the experiment, fecal samples were collected by rectal massage, pooled within pen, dried, and analyzed for DM, N, gross energy, and Cr concentrations. Apparent digestibilities of DM, N, and energy were calculated using the indirect ratio method. Response criteria were ADG; ADFI; F/G; digestibilities of DM, N, and energy; and skinfold thickness.

Results and Discussion

Chemical composition of the soybean preparations is given in Table 2. Dry matter concentrations were similar among all soybean preparations, and protein concentrations were similar to expected values for soybean meal and full-fat soybean products. Trypsin inhibitor activities were acceptably low, ranging from 1.0 to 2.8 mg/g. However, antigenic potential (i.e., glycinin and β-conglycinin activity) of extruded soybeans was less than half that of roasted soybeans and soybean meal.

Pigs fed roasted and extruded soybeans had greater ADG from d 14 to 35 and greater ADFI for d 14 to 35 and overall (d 0 to 35) compared to pigs fed SBM and soybean oil (Table 3). The diet with SBM and soybean oil had greater digestibilities of DM, N, and gross energy than diets with roasted and extruded soybeans, but these differences were due to the low digestibilities for diets with roasted soybeans.

For d 0 to 14, pigs fed the extruded soybeans gained 21% faster (.58 vs .48 lb) and were 25% more efficient (1.53 vs 2.05 F/G) than pigs fed roasted soybeans. Similar responses were observed for d 14 to 35, so that overall, pigs fed extruded soybeans had 13% greater ADG (.93 vs .82 lb) and were 18% more efficient (1.63 vs 1.99 F/G). Digestibilities of DM, N, and gross energy were increased by 8, 13, and 12% when soybeans were extruded versus roasted. An objective of this experiment was to determine if factors other than protein quality might have contributed to the greater nutritional value of extruded soybeans noted in last year's KSU Swine Day Report. In the present experiment, extrusion processing improved growth performance and nutrient digestibility in pigs fed +K and -K soybeans. Additionally, antigenic potential

(ELISA determination, $\log_2$) was reduced from 11 for roasted soybeans to 3.5 for extruded soybeans. Skinfold thickness was affected in a similar manner, with a mean of 1.07 mm for roasted soybeans and .73 mm for extruded soybeans. These differences in growth performance and nutrient digestibility in protein-adequate diets and the differences in skinfold thickness infer that residual anti-nutritional factors (e.g., antigenicity) are contributing to reduced nutritional value of roasted soybeans and soybean meal.

Improved nutritional value of -K versus +K soybeans was apparent primarily when they were extruded and not when roasted. Indeed, pigs fed extruded -K soybeans had numerically the greatest growth performance and nutrient digestibilities of any treatment. These responses were not anticipated for pigs fed protein-adequate diets and did not result from differences in palatability, because pigs fed +K roasted soybeans had the greatest ADFI throughout the experiment. Skinfold thickness was less for pigs fed roasted and extruded -K soybeans compared to roasted and extruded +K soybeans. Trypsin inhibitors have been reported to induce allergic responses in humans but have not been implicated as major antigenic factors in livestock. Whether the reduced skinfold thickness for pigs fed -K soybeans resulted from absence of the Kunitz trypsin inhibitor or some interaction between the glycinin and β-conglycinin of these soybeans with heat processing is not apparent.

In conclusion, dry-extrusion improved the nutritional value of +K and -K soybeans. Furthermore, when pigs were fed protein-adequate diets, extruded -K soybeans were of the greatest nutritional value, roasted soybeans were of the lowest nutritional value, and SBM was intermediate.

Table 1. Diet Composition for Phase I (d 0 to 14)[a]

Ingredient, %	Soybean meal	+K roasted	-K roasted
Soybean meal	31.05	—	—
Soybean oil	2.92	—	—
Whole soybeans[b]	—	38.74	37.25
Cornstarch	4.84	—	1.44
Corn	37.36	37.36	37.36
Dried whey	20.00	20.00	20.00
Vitamins and minerals	2.98	3.05	3.10
Copper sulfate	.10	.10	.10
Antibiotic[c]	.50	.50	.50
Chromic oxide	.25	.25	.25
Total	100.00	100.00	100.00

[a]Soybean treatments, cornstarch, monocalcium phosphate, and limestone were adjusted so that all diets supplied 1.25% lysine, 1.60 Mcal DE/lb, .9% Ca, and .8% P for Phase I and 1.10% lysine, 1.61 Mcal DE/lb, .9% Ca, and .8% P for Phase II.
[b]Extruded soybeans and cornstarch were added to replace roasted soybeans on a protein basis (analyzed values).
[c]Supplied per ton of diet: 100 g chlortetracycline, 100 g sulfathiazole, and 50 g penicillin.

Table 2. Effect of Roasting and Extrusion on Chemical Composition of Conventional (+K) and Low-Inhibitor (-K) Soybeans

Item	Soybean meal	+K roasted	+K extruded	-K roasted	-K extruded
Dry matter, %	92.6	94.7	94.4	94.0	95.2
Protein, %	48.9	38.1	44.1	38.9	45.8
Trypsin inhibitor, mg/g	1.0	2.1	2.1	2.8	1.1
Glycinin activity, $\log_2$	11	10	4	11	3
β-conglycinin activity, $\log_2$	11	11	4	11	3

Table 3. Performance of Nursery Pigs Fed Conventional (+K) and Low-Inhibitor (-K) Soybeans either Roasted or Extruded[a]

Item	Soybean meal	+K roasted	+K extruded	-K roasted	-K extruded	CV
d 0 to 14						
ADG, lb[e]	.58	.53	.55	.42	.61	24.7
ADFI, lb[j]	.92	1.03	.84	.82	.89	13.9
F/G[h]	1.62	2.02	1.58	2.07	1.47	19.0
d 14 to 35						
ADG, lb[cf]	.93	1.06	1.09	1.03	1.22	11.0
ADFI, lb[cej]	1.70	2.16	1.84	2.00	2.03	10.3
F/G[h]	1.85	2.05	1.68	1.95	1.67	6.6
d 0 to 35						
ADG, lb[fi]	.79	.85	.88	.78	.97	12.5
ADFI, lb[bej]	1.39	1.71	1.44	1.53	1.57	10.2
F/G[h]	1.76	2.03	1.65	1.95	1.61	6.0
Apparent digestibility (d 14)						
DM, %[bh]	82.2	75.0	81.7	77.1	83.3	3.3
N, %[bh]	78.6	71.3	79.5	69.9	80.6	4.2
Gross energy, %[bh]	81.0	72.2	81.2	73.8	82.9	4.0
Skinfold thickness, mm[de]	.78	1.28	.82	.85	.63	71.5

[a]A total of 150 weanling pigs (five pigs/pen and six pens/treatment) were fed in a 35-d growth assay (avg initial wt of 15.4 lb).
[bc]SBM vs extruded and roasted ($P<.05$, $P<.01$, respectively).
[d]-K vs +K ($P<.10$).
[efgh]Extruded vs roasted ($P<.10$, $P<.05$, $P<.01$, $P<.001$, respectively).
[ij]-K vs +K × extruded vs roasted ($P<.10$, $P<.05$, respectively).