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Abstract

One hundred weanling pigs (16.5 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 the nutritional value of Williams 82 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 contain .92% lysine and 3.50 Mcal/kg DE for d 0 to 14 of the experiment and .76% lysine and 3.49 Mcal/kg DE for d 14 to 35 of the experiment. From d 0 to 14, pigs fed extruded soybeans (+K and -K) ate more feed (greater ADFI), grew faster (greater ADG), and were more efficient (better F/G) than pigs fed roasted soybeans. From d 14 to 35 and overall, the same effects were noted, i.e., pigs fed extruded soybeans had greater ADFI and ADG and better F G than pigs fed roasted soybeans. Also, pigs fed -K soybeans were more efficient than pigs fed +K soybeans. The average performance of all pigs fed diets containing the roasted and extruded soybeans was not different from that of pigs fed diets with soybean meal and added soybean oil, although diets with -K extruded soybeans consistently supported numerically greater rates and efficiencies of gain. Extrusion processing yielded soybean products of greater nutritional value than roasting, and -K soybeans were of greater nutritional value than +K soybeans when roasted or extruded.; Swine Day, Manhattan, KS, November 15, 1990

Keywords

Swine day, 1990; Kansas Agricultural Experiment Station contribution; no. 91-189-S; Report of progress (Kansas State University. Agricultural Experiment Station and Cooperative Extension Service); 610; Swine; Soybean; SBM; Processing; Starter; Performance; Trypsin

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PROCESSING METHOD AFFECTS THE NUTRITIONAL VALUE OF LOW-INHIBITOR SOYBEANS FOR NURSERY PIGS

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Summary

One hundred weanling pigs (16.5 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 the nutritional value of Williams 82 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 contain .92% lysine and 3.50 Mcal/kg DE for d 0 to 14 of the experiment and .76% lysine and 3.49 Mcal/kg DE for d 14 to 35 of the experiment. From d 0 to 14, pigs fed extruded soybeans (+K and -K) ate more feed (greater ADFI), grew faster (greater ADG), and were more efficient (better F/G) than pigs fed roasted soybeans. From d 14 to 35 and overall, the same effects were noted, i.e., pigs fed extruded soybeans had greater ADFI and ADG and better F/G than pigs fed roasted soybeans. Also, pigs fed -K soybeans were more efficient than pigs fed +K soybeans. The average performance of all pigs fed diets containing the roasted and extruded soybeans was not different from that of pigs fed diets with soybean meal and added soybean oil, although diets with -K extruded soybeans consistently supported numerically greater rates and efficiencies of gain. Extrusion processing yielded soybean products of greater nutritional value than roasting, and -K soybeans were of greater nutritional value than +K soybeans when roasted or extruded.

(Key Words: Soybean, SBM, Processing, Starter, Performance, Trypsin.)

Introduction

The major constituent that limits the nutritional value of raw soybeans is a group of small proteins collectively called trypsin inhibitors. In last year's KSU Swine Day Report, we reported data that indicated improved nutritional value of soybeans lacking gene expression for the Kunitz soybean trypsin inhibitor. As roasting temperature was increased to full-roast, utilization of both conventional and low-inhibitor soybeans was increased. Although full-roasting was necessary to optimize performance of pigs fed conventional and low-inhibitor soybeans, even with full-roasting, the low-inhibitor soybeans were still of greater nutritional value than conventional soybeans for growing and finishing pigs. Considering those results and with the current interest in on-farm soybean processing, an experiment was designed to determine the effects of roasting and extruding on the nutritional value of low-inhibitor soybeans for nursery pigs.

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Procedures

Williams 82 soybeans with (+K) and without (-K) gene expression for the Kunitz trypsin inhibitor were either roasted or extruded 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 treatments 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 contain .92% lysine and 3.50 Mcal/kg DE for d 0 to 14 of the experiment, and .76% lysine and 3.49 Mcal/kg DE for d 14 to 35 of the experiment. The diets were formulated to be slightly deficient in lysine to ensure that differences in protein quality would be detected.

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

Ingredient, %	Soybean meal	+K roasted[b]	-K roasted[b]
Soybean meal	20.06	—	—
Soybean oil	2.50	—	—
Whole soybeans	—	24.55	24.85
Cornstarch	2.21	.30	—
Corn	51.38	51.38	51.38
Dried whey	20.00	20.00	20.00
Vitamins and minerals	3.25	3.17	3.17
Copper sulfate	.10	.10	.10
CSP-250	.50	.50	.50
Total	100.00	100.00	100.00

[a]Soybean treatments, cornstarch, monocalcium phosphate, and limestone were adjusted so that all diets contained .92% lysine, 3.50 Mcal/kg DE, .9% Ca and .8% P for Phase 1, and .76% lysine, 3.49 Mcal/kg DE, .8% Ca, and .7% P for Phase 2 (d 14 to 35).
[b]Extruded soybeans were added to replace the roasted soybeans on a protein basis.

One hundred weanling pigs (16.5 lb avg initial wt) were fed the treatment diets. The pigs were housed (four pigs per pen and five 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 14 of the experiment, fecal samples were collected by rectal massage, pooled within pen, dried, and analyzed for DM, N, and chromium contents. Apparent digestibilities of DM and N were calculated using the indirect ratio method. Response criteria were ADG, ADFI, F/G, and digestibilities of DM and N.

Results and Discussion

Chemical composition of the soybean preparations is given in Table 2. Dry matter content was similar among all soybean preparations. The protein content of the soybean meal was higher than that of the roasted and extruded soybeans. Trypsin inhibitor activities were

lower for the -K soybeans than for the +K soybeans. Soybean antigenic activity (i.e., glycinin activity and β-conglycinin activity) was reduced by extrusion processing compared to roasting and soybean meal.

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, %	92.2	92.7	93.7	93.7	93.5
Protein, %	49.4	37.4	38.9	37.8	40.1
Trypsin inhibitor, mg/g	.5	2.2	1.8	1.1	1.4
Glycinin activity, log 2	>10[a]	>10	4	>10	3
β-Conglycinin activity, log 2	>10	>10	7	>10	>10

[a]Activity was too high to quantitate.

Performance of nursery pigs fed the soybean preparations is given in Table 3. For d 0 to 14, pigs fed the extruded soybeans (+K and -K) ate 15% more feed (.86 vs .75 lb/d), grew 29% faster (.66 vs .51 lb/d), and were 11% more efficient (1.30 vs 1.46 F/G) than pigs fed the roasted soybeans. Similar responses were observed from d 14 to 35, so that overall, pigs fed the extruded soybeans ate 13% more feed (1.78 vs 1.58 lb/d), gained 21% faster (1.04 vs .86 lb/d), and were 6% more efficient (1.73 vs 1.85 F/G) than pigs fed the roasted soybeans. The improved performance of pigs fed the extruded soybeans compared to roasted soybeans corresponds with the 6% improvement in DM digestibility and 5% improvement in N digestibility for diets with extruded soybeans. It is unlikely that the difference seen for extrusion processing can be attributed to trypsin inhibitor content, because all of the values were acceptably low (i.e., 2.2 or less). However, the improvements in nutrient digestibility and performance of pigs fed the extruded soybeans may have resulted from the disruption and structural changes in soybean proteins that are normally attributed to extrusion processing, thus increasing their susceptibility to enzymatic hydrolysis. Also, disruption of the soybean proteins reduced their antigenicity (i.e., reduced glycinin and β-conglycinin activities), which could have contributed to improved gut function and nutrient digestibility.

From d 14 to 35, pigs fed the -K soybeans grew 8% faster (1.23 vs 1.14 lb/d) and were 7% more efficient (1.86 vs 1.99 F/G) than pigs fed the +K soybeans. Overall, pigs fed the -K soybeans were 6% more efficient (1.73 vs 1.85 F/G) than pigs fed the +K soybeans. Apparent digestibilities of DM and N were also improved for -K soybeans compared to +K soybeans (i.e., 86.9 vs 82.9% and 84.7 vs 82.0% for DM and N, respectively). Also, the improved nutritional value of the -K soybeans was consistent when roasted or extruded, as indicated by a lack of interaction between soybean type and processing method for any of the response criteria (P>.11).

Performance of pigs fed the soybean meal plus soybean oil control was not different than the average performance of pigs fed all other treatments (P>.24). However, pigs fed diets with roasted +K and -K soybeans had consistently lower performance than pigs fed soybean meal plus soybean oil, and pigs fed -K extruded soybeans had consistently greater performance than pigs fed the other treatments, including those fed soybean meal plus soybean oil.

In conclusion, extrusion processing yielded soybean preparations of greater nutritional value than roasting, and -K soybeans were of greater nutritional value than +K soybeans when roasted or extruded.

Table 3. Performance of Nursery Pigs Fed Conventional (+K) or 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[b]	.60	.50	.66	.52	.66	13.8
ADFI, lb[c]	.82	.75	.87	.74	.84	16.6
F/G[d]	1.37	1.50	1.32	1.42	1.27	9.3
d 14 to 35						
ADG, lb[e]	1.18	1.07	1.21	1.10	1.36	9.0
ADFI, lb[f]	2.25	2.19	2.32	2.08	2.47	7.6
F/G[g]	1.91	2.05	1.92	1.89	1.82	5.2
d 0 to 35						
ADG, lb[h]	.95	.84	.99	.87	1.08	9.0
ADFI, lb[i]	1.68	1.62	1.74	1.54	1.82	8.2
F/G[j]	1.77	1.93	1.76	1.77	1.69	4.7
Apparent digestibility (d 14)						
DM, %[k]	85.6	80.5	85.3	84.5	89.3	4.1
N, %[l]	82.0	80.5	83.5	81.7	87.6	2.6

[a]Four pigs per pen, six pens per treatment, avg initial wt=16.5 lb.
[b]Extruded vs roasted (P<.001).
[c]Extruded vs roasted (P<.09).
[d]Extruded vs roasted (P<.02).
[e]-K vs +K (P<.08), extruded vs roasted (P<.001).
[f]Extruded vs roasted (P<.004).
[g]-K vs +K (P<.02), extruded vs roasted (P<.03).
[h]Extruded vs roasted (P<.001).
[i]Extruded vs roasted (P<.006).
[j]-K vs +K (P<.02), extruded vs roasted (P<.004).
[k]-K vs +K (P<.02), extruded vs roasted (P<.008).
[l]-K vs +K (P<.02), extruded vs roasted (P<.001).