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Conditions during expander processing of soybean meal and raw soybeans affect nutrient digestibility in finishing pigs (1998)

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CONDITIONS DURING EXPANDER PROCESSING OF SOYBEAN MEAL AND RAW SOYBEANS AFFECT NUTRIENT DIGESTIBILITY IN FINISHING PIGS[1]

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Summary

Expander processing improved nutrient digestibility in diets with soybean meal and raw soybeans. Furthermore, with 600 psi cone pressure (20 kWh/ton of specific energy input), the diets with raw soybeans had equal or greater digestibility of nutrients compared to the soybean meal-based control diet.

(Key Words: Expander, Soybean, Digestibility, Finishing Pigs.)

Introduction

Research from our laboratory indicates that extrusion of cereal grains and soybeans improves their feeding value for nursery and(or) finishing pigs. Expander technology is similar to extrusion, with primary benefits of improved pellet quality and feed hygiene. However, this technology probably could be used to inactivate the antinutritional factors found in raw soybean seeds. Thus, we designed an experiment to determine the effects of expander processing on nutrient digestibility in finishing pigs fed a diet with corn-soybean meal and whole soybeans.

Procedures

A total of 64 pigs was used in the 15-d (three replicates of a 5-d treatment period) digestibility assay. The pigs were blocked by weight and sorted by sex and ancestry. There were eight pigs (average initial BW of 190 lb) in each 6-ft × 16-ft pen. Diets were formulated to .9% lysine, .65% Ca, and .55% P (Table 1). Treatments were corn-soybean meal- and corn-raw soybean-base diets that were processed without pressure and at 200, 400, and 600 psi cone pressure. Feed and water were consumed on an ad libitum basis. Grab samples of feces were collected by rectal massage from at least six of the pigs in a pen at 6:00 p.m. on d 4 and 6:00 a.m. on d 5 of each treatment period. The samples were dried; pooled within pen; and analyzed for DM, N, GE, and Cr concentrations to allow calculation of apparent nutrient digestibilities.

Table 1. Diet Compositions[a]

Ingredient, %	Soybean Meal	Raw Soybeans
Corn	75.01	72.89
Soybean meal (46.5% CP)	18.54	--
Raw soybean	--	23.94
Soybean oil	3.24	--
Monocalcium phosphate	1.05	.95
Limestone	1.02	1.04
Salt	.30	.30
KSU Vit/Min/AA/Ab[b]	.64	.68
Chromic oxide[c]	.20	.20

[a]Formulated to .9% lysine, .65% Ca, .55% P, and 1.62 Mcal of DE/lb.
[b]Provided 100g/ton of lysine.
[c]Used as an indigestible marker.

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The diets for all experiments were steam conditioned at 160°F; processed through a 100 horsepower expander (Amandus-Kahl, Model OE15.2); and pelleted with a 30 horsepower California Pellet Mill. The pellet mill loaded a 11/2 in.-thick die with 3/16 in. diameter openings. Production rate was held constant at .9 ton/h for all treatments. The pellet mill and expander motors were equipped with a volt-amp meter to allow calculation of electrical energy consumption. Specific energy consumption was calculated as the difference between total energy during processing and idle energy consumption. Pellet samples were collected immediately after exiting the pellet die and cooled with ambient air. The cooled pellet samples were analyzed for pellet durability index (PDI) using standard procedures and also using the standard procedures with five (1/2) hexagonal nuts added to the pellet sample before tumbling.

The data were analyzed as a randomized complete design with a 2 × 4 factorial arrangement of treatments. Main effects were soy source (soybean meal and raw soybeans) and cone pressure (0, 200, 400, and 600 psi).

Results and Discussion

Moisture concentrations in the conditioned mash and cooled pellets and moisture loss with expanding, pelleting, and cooling were similar for the soybean meal- versus whole soybean-based diets (Table 2). Starch damage was less in the soybean diets, especially at the greater cone pressures. The whole soybeans apparently had a lubricating effect during expander processing that decreased the gelatinization and(or) shear of starch.

The soybean meal-based diets were devoid of urease activity as cone pressure was increased from none to 600 psi. Urease activity in the whole soybean diets was decreased from 1.66 to .21. The recommended urease activity for soy products is .02 to .2, so even at 600 psi, urease activity was still fairly high.

Energy required to expand and expand/pellet was more for soybean meal-based diets ($P<.001$) (Table 3). This was especially true at the greater cone pressures (diet × cone pressure quadratic interaction, $P<.001$). Pellet durability index (standard and modified) increased markedly with increasing cone pressure in the soybean meal-based diets, but the PDIs of the soybean-based diets were less responsive to cone pressure (diet × cone pressure, quadratic interaction, $P>.008$).

As for nutritional difference among the treatments, digestibilities of DM, N, and GE were greater ($P<.007$) for the soybean meal treatments. Also, nutritent digestibilities increased with increased cone pressures (linear effects varying from $P<.06$ to $P<.001$). However, the effects of soy source and cone pressure were not independent. Digestibilities of DM, N, and GE were increased only slightly in the soybean meal diets, with maximal digestibilities achieved at 200 to 400 psi (i.e., specific energy inputs of 7 to 18 kWh/ton). In contrast, digestibility of nutrients in the diets with raw whole soybeans increased markedly as cone pressure was increased from none to 600 psi (diet × cone pressure linear effects ranging from $P<.10$ to $P<.001$). Note that even with 600 psi (specific energy input of 20 kWh/ton), nutritional value of the whole soybean diets was still improving. This suggests that even move cone pressure and energy input would be beneficial for diets with raw soybeans.

In conclusion, expander processing improved the nutritional value of corn-soy-diets. This response was most pronounced in diets with raw soybeans. Optimal cone pressure/specific energy inputs were 200 to 400 psi(7 to 18 kWh/ton) for diets with soybean meal and 600 psi (20 kWh/ton) for diets with whole soybeans.

Table 2. Effects of Cone Pressure on Diet Characteristic and Nutrient Digestibility in Soybean Meal and Raw Soybean Diets[a]

	Soybean Meal				Raw Soybeans				
Item	0	200	400	600	0	200	400	600	SE
Conditioned mash moisture, %	15.6	15.7	15.7	15.8	15.6	15.4	15.5	15.5	-
Pellet moisture, %	15.3	15.1	14.6	12.8	15.4	14.9	13.9	11.7	-
Moisture loss, %	.3	.6	1.1	3.0	.2	.5	1.6	3.8	-
Starch damage, %	26.0	33.7	46.3	66.0	20.7	41.3	37.4	39.5	-
Urease activity, pH rise	.00	.01	.00	.00	1.66	.42	.16	.21	-
Energy consumption, kWh/ton									
Expander									
Specific	.4	6.6	18.1	54.8	.9	8.7	14.4	19.8	
Total	26.0	32.2	43.8	80.5	26.7	34.2	39.9	45.6	
Pellet mill total	12.8	10.8	9.9	11.5	12.1	9.7	9.9	10.1	
Overall total	38.8	43.0	54.7	92.0	38.8	43.9	49.8	55.7	
Pellet durability index, %									
Standard	47.4	81.9	93.1	91.5	79.3	86.1	84.3	84.3	3.3
Modified	24.5	71.1	91.2	89.7	69.9	71.5	76.7	78.7	4.4
Nutrient digestibility, %									
DM	81.2	83.1	82.6	81.7	78.3	78.7	80.4	82.0	1.0
N	75.8	77.4	77.1	77.8	58.1	68.8	71.1	73.8	3.0
GE	81.1	84.0	84.0	83.3	75.1	77.7	80.4	82.8	1.2
DE of diet, kcal/lb	1,496	1,546	1,556	1,545	1,353	1,423	1,510	1,576	21

[a]A total of 64 pigs (eight pigs/pen with an average initial BW of 190 lb) and three replicates/treatment.
[b]The ADFI ranged from 6.2 to 7.5 lb/d for the 15-d experiment.

Table 3. Probability, P <

Item	Diet[a]	Lin	Quad	Cubic	Diet × Lin	Diet × Quad	Diet × Cubic
Energy consumption, kWh/ton							
Expander							
Specific	.001	.001	.001	.06	.001	.001	.13
Gross	.001	.001	.001	.07	.001	.001	.12
Pellet mill	.003	.001	.001	-	-	-	.09
Overall	.001	.001	.001	.10	.001	.001	.08
Pellet durability index, %							
Standard	.05	.001	.001	-	.001	.008	-
Modified	.13	.001	.002	-	.001	.002	-
Nutrient digestibility, %							
DM	.007	.06	-	-	.10	-	-
N	.001	.02	-	-	.04	-	-
GE	.001	.001	-	-	.02	-	-
De of diet , kcal/lb	.001	.001	-	-	.001	-	-

[a]Diets were either soybean meal- or whole soybean-based.
[b]Dash indicates P>.15.