THE EFFECT OF SOY PRODUCTS WITH OR WITHOUT MOIST EXTRUSION ON STARTER PIG PERFORMANCE

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Summary

One hundred and seventy pigs, averaging 11.88 lb and 21 d of age, were utilized in a 35 d experiment evaluating the effect of moist extrusion of soy products on growth performance and nutrient digestibility. Pigs were fed one of seven experimental diets for the first 14 d of the trial. A diet containing all milk protein served as a control. Comparisons were made between pigs fed the milk control diet and diets containing either defatted soy flakes, soy protein concentrate, or experimental soy protein concentrate. Treatments consisted of: 1) 20% dried skim milk, 20% dried whey; 2 and 3) defatted soy flakes with or without moist extrusion; 4 and 5) soy protein concentrate with or without moist extrusion; 6 and 7) experimental soy protein concentrate with or without moist extrusion. A common diet formulated to 1.25% lysine was fed from d 14 to 35. Weekly pig weights and feed consumption were recorded to determine average daily gain (ADG), average daily feed intake (ADFI), and feed efficiency (F/G). Blood serum samples were collected on d 13 and analyzed for urea nitrogen concentration. Fecal samples were collected on d 14 to determine apparent dry matter (DM) and nitrogen (N) digestibilities. A significant interaction between extrusion and protein source was detected in ADG and F/G during the first 2 wk post-weaning. Pigs fed soy proteins processed by moist extrusion had improved ADG and F/G, with the largest improvement being detected in defatted soy flakes. Dry matter and N digestibilities were increased by processing soy proteins with moist extrusion. Nitrogen utilization was also improved by utilizing moist extrusion as evidenced by decreased concentrations of blood urea nitrogen. Based on these results, soy protein utilization in starter pig diets can be improved with moist extrusion. Though a large response to extrusion was not detected in highly processed soy products (soy protein concentrate and experimental soy protein concentrate), dramatic improvements in growth performance resulted when soy flakes were processed by moist extrusion.

(Key Words: Soybean, Starter, Performance, Milk.)

Introduction

Emphasis on increasing the number of pigs weaned per sow per year, has led to a decreased weaning age over the past several years. Pigs are commonly weaned at 21 d of age, increasing the potential for a post-weaning lag or depression in growth performance. This lag period results when pigs are removed from a highly digestible, liquid diet (sow's milk) and placed on a dry diet based upon plant proteins sources (soybean meal). Research at Kansas State University has identified an intestinal allergic reaction to antigenic properties present in soy proteins. This reaction causes intestinal damage leading to malabsorption of nutrients from the small intestine. Decreased growth rate and poor feed efficiency result from nutrient malabsorption. The small intestine is also vulnerable to secondary bacterial infections (*E. coli*), because of damage to the intestinal tis-

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sues. This problem is compounded by the increasing demand of milk products for human consumption, which increases product costs. Thus, research is being conducted to find alternative products that support high growth rates for the early-weaned pig. One such area of emphasis is further processing of soy products by moist extrusion. The goal of utilizing moist extrusion is to reduce antigenic concentrations in soy products, thus reducing the severity of the allergic reaction in the small intestine and promoting improved growth performance of early-weaned pigs.

Procedures

A total of 170 crossbred pigs, weaned at 21 d of age, averaging 11.88 lb, was utilized in a 35 d growth trial. Pigs were allotted to seven dietary treatments based upon weight, sex, and ancestry. There were five pigs per pen with five replicate pens per dietary treatment. Pigs were housed in an environmentally controlled nursery in 4 X 5 ft pens with woven wire flooring. Feed and water were offered to the pigs on an ad libitum basis.

Experimental diets were formulated to contain 1.4% lysine, 24.4% lactose, .9% calcium, and .8% phosphorus (Table 1) and fed from d 0 to 14 post-weaning. Dietary treatments were arranged in a 2 X 3 factorial including a milk diet as a control treatment. Three soy proteins were utilized; defatted soy flakes, soy protein concentrate, and experimental soy protein concentrate. The factorial arrangement was completed by further processing the three protein sources by moist extrusion. Thus, the seven Phase I dietary treatments were: 1) milk protein (MP); 2 and 3) defatted soy flour with or without moist extrusion (SF and ESF, respectively); 4 and 5) soy protein concentrate with or without moist extrusion (SPC and ESPC, respectively); and 6 and 7) experimental soy protein concentration with or without moist extrusion (ExSPC and EExSPC, respectively). A common diet was fed for the Phase II period (d 14 to 35), containing 1.25% lysine and 10% dried whey. Pig weights and feed consumption were recorded weekly to determine ADG, ADFI, and F/G.

Soy proteins were processed in a Wenger X-20 single screw extruder. The extruder was maintained at a constant temperature and pressure conditions to produce a quality textured product. Extruder conditions were maintained at similar standards for all three soy proteins. The extruded products were then ground through a hammermill equipped with a 1/16 in screen for inclusion in the experimental diets.

Blood samples were collected on d 13 of the trial to determine urea nitrogen concentrations. Fecal samples were collected on d 14 to calculate DM and N digestibilities using chromic oxide (.10%) as an indigestible marker.

Results and Discussion

An improvement in ADG and F/G ($P < .06$) for the phase I period was detected when soy proteins were further processed by moist extrusion (Table 2). The largest improvement in gain and efficiency was detected when defatted soy flour was moist extruded. The moist extrusion was the first heat processing for the soy flour. Proper heat treatment has been proven to decrease antinutritional factor concentrations, improving growth performance. Extrusion of soy protein concentrate and experimental soy protein concentrate did not improve starter pig performance. These two products had already been processed to reduce concentrations of complex carbohydrates and antinutritional factors that possibly caused depressed performance in pigs fed the SF diet. Thus, an extrusion processing by protein source interaction resulted because extrusion improved the quality of soy flakes more than the quality of the two highly processed soy protein concentrates. Pigs fed the milk-based diet had higher ADG ($P < .05$) when compared to the mean of the soy protein treatments. Average daily feed intake was not affected by moist extrusion, though numerical increases of 10 to 15% were detected. An interaction ($P < .06$) occurred between moist extrusion and soy protein source for ADG and F/G. Feed efficiency was improved dramatically when defatted soy flour was processed by moist extrusion ($P < .05$). The F/G ($P < .01$) of pigs fed milk protein was better than the mean F/G of pigs fed soy proteins.

During Phase II, all pigs were fed a common diet. Performance during Phase II was not affected by Phase I treatment. Slight numerical improvements were evident for ESF compared to SF. Extrusion of either SPC or ExSPC in Phase I did not show any advantage in growth performance during Phase II.

The overall ADG indicated an interaction ($P < .06$) between moist extrusion and soy protein source. This interaction was due to the 20% increase in daily gain for pigs fed defatted soy flour processed by moist extrusion. Average daily feed intake was not affected by moist extrusion, although numerical increases were detected. An interaction ($P < .06$) between moist extrusion and soy protein source was detected for F/G. The largest improvement in efficiency was detected between SF and ESF. The efficiency of pigs fed milk protein tended to be greater ($P < .01$) than the mean efficiency of the pigs fed soy protein.

Nutrient digestibility was improved by moist extrusion of soy products. An interaction ($P < .06$) was detected between moist extrusion and protein source for both DM and N digestibility. Nitrogen digestibility was increased in SF because heat treatment reduced the antinutritional factor. Further increases in N digestibility may be related to structural changes within the protein matrix of soy products. Nitrogen utilization was also improved ($P < .06$) by moist extrusion, as evidenced by decreased blood urea nitrogen in pigs fed extruded soy protein diets.

These data suggest that moist extrusion can be utilized to improve the nutritional value of various soy products. Though a large response to extrusion was not detected in highly processed soy product (SPC and ExSPC), large improvements were seen when the raw soy product (SF) was moist extruded.

Table 1. **Diet Composition**

Ingredient, %	Milk	SF[a] ESF	SPC ESPC	ExSPC EExSPC	Phase II Common Diet
Corn	43.56	19.98	33.66	34.41	55.83
Soy protein		45.00	31.33	30.56	
Soybean meal, 48%					22.71
Fishmeal					4.00
Dried whey	20.00				10.00
Dried skim milk	20.00				
Casein	7.41				
Lactose		24.40	24.40	24.40	
Lysine-HCl	0.15				
DL-Methionine, 98%				0.03	
Soybean oil	6.00	6.00	6.00	6.00	4.00
Monocal phos, 21% P	1.24	2.09	2.15	2.17	1.46
Limestone	0.49	1.08	1.01	1.01	.55
Vitamin premix	0.25	0.25	0.25	0.25	0.25
Trace Mineral premix	0.15	0.15	0.15	0.15	0.15
Copper sulfate	0.10	0.10	0.10	0.10	0.10
Selenium premix	0.05	0.05	0.05	0.05	0.05
Salt		0.30	0.30	0.30	0.25
Antibiotic[b]	0.50	0.50	0.50	0.50	0.50
Chromic oxide	0.10	0.10	0.10	0.10	
Total	100.00	100.00	100.00	100.00	100.00
Calculated Analysis, %					
Lysine	1.40	1.40	1.40	1.40	1.25
Lactose	24.40	24.40	24.40	24.40	7.20
Ca	0.90	0.90	0.90	0.90	0.90
P	0.80	0.80	0.80	0.80	0.80

[a]SF=soy flakes, ESF=extruded soy flakes, SPC=soy protein concentrate, ESPC=extruded soy protein concentrate, ExSPC=experimental soy protein concentrate, EExSPC=extruded experimental soy protein concentrate.
[b]CSP 250.

Table 2. Effect of Moist Extrusion on Starter Pig Performance, Nutrient Digestibility, and Urea Nitrogen Concentrations

Item	Milk	SF	ESF	SPC	ESPC	ExSPC	EExSPC	CV
d 0 to 14								
ADG, lb[bc]	.54	.16	.49	.47	.51	.43	.47	17.4
ADFI, lb	.65	.57	.63	.61	.72	.63	.72	14.4
F/G[cd]	1.21	4.17	1.30	1.31	1.43	1.40	1.53	33.9
d 14 to 35								
ADG, lb	1.19	1.17	1.27	1.26	1.25	1.27	1.26	7.6
ADFI, lb	2.03	1.93	2.11	2.05	2.13	2.19	2.16	7.7
F/G	1.71	1.65	1.66	1.63	1.70	1.72	1.72	3.8
d 0 to 35								
ADG, lb[c]	.93	.76	.96	.95	.95	.94	.94	8.2
ADFI, lb	1.48	1.38	1.82	1.47	1.56	1.56	1.58	7.8
F/G[cd]	1.59	1.81	1.58	1.56	1.64	1.66	1.68	3.6
Dry Matter, %[bc]	90.40	81.60	88.29	87.37	88.38	85.63	88.81	1.4
Nitrogen, %[bc]	86.43	67.43	85.02	86.80	87.51	85.60	87.16	2.5
Serum urea N, mg/dl[bc]	4.74	22.56	17.81	16.87	16.74	17.64	17.13	8.2

[a]SF=soy flakes, ESF=extruded soy flakes, SPC=soy protein concentrate, ESPC=extruded soy protein concentrate, ExSPC=experimental soy protein concentrate, EExSPC=extruded experimental soy protein concentrate.
[b]Milk vs soy protein ($P<.01$).
[c]Moist extrusion X protein source interaction ($P<.06$).
[d]Milk vs soy protein ($P<.10$).