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Abstract

Two hundred and ten weanling pigs were fed diets containing nonextruded corn (14.5% gelatinization; control) or corn that was extruded to provide 38.7%, 52.7%, 64.4%, or 89.3% starch gelatinization in the complete diet. With increasing gelatinization, ADG and ADFI decreased and then increased. but apparent digestibility of DM, CP, and energy increased then decreased. These results suggest that the degree of starch gelatinization has an inconsistent effect on weanling pig performance.; Swine Day, Manhattan, KS, November 20, 1997

Keywords

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EFFECTS OF STARCH GELATINIZATION ON WEANLING PIG PERFORMANCE

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Summary

Two hundred and ten weanling pigs were fed diets containing nonextruded corn (14.5% gelatinization; control) or corn that was extruded to provide 38.7%, 52.7%, 64.4%, or 89.3% starch gelatinization in the complete diet. With increasing gelatinization, ADG and ADFI decreased and then increased, but apparent digestibility of DM, CP, and energy increased then decreased. These results suggest that the degree of starch gelatinization has an inconsistent effect on weanling pig performance.

(Key Words: Weanling Pigs, Extrusion, Gelatinization.)

Introduction

Over the last several years, numerous experiments have been conducted to evaluate the effects of moist extrusion processing of cereal grains or the complete diet on weanling pig performance. Results of these studies have been variable, with some showing no beneficial response to extrusion processing but other showing improved pig performance. When carbohydrates are exposed to heat and moisture in extrusion processing, the starch may become gelatinized. We hypothesized that the variable responses to extrusion processing in previous experiments might have been the results of different degrees of starch gelatinization. Therefore, the objective of this experiment was to investigate the influence of degree of starch gelatinization on growth performance and nutrient digestibility of early-weaned pigs.

Procedures

Two hundred and ten weanling pigs (PIC L326 × C15) averaging 21 d of age and initially 15 ± 3 lb were used in an 18-d growth assay. Pigs were blocked by weight and allotted randomly to one of five treatments. The dietary treatments included nonextruded corn (control; 14.5% gelatinization) or extruded corn with 38.7%, 52.7% , 64.4%, or 89.3% gelatinization. In this study, only the corn was extruded through a Wenger X-20 single screw extruder (Wenger Inc., Sabetha, KS), The diets were mixed and then pelleted through a 5/32-inch die following conditioning at 140°F. Experimental diets were fed from d 0 to 18 after weaning. All diets were formulated to 1.4% total lysine, .39% methionine, .9% Ca, and .8% P and contained 10% dried whey and 2.5% spray-dried blood meal (Table 1). The extruder conditions were varied to create the various degrees of starch gelatinization (Table 2). The degree of starch gelatinization in the diet after pelleting was analyzed by a modified glucoamylase method.

Pigs were housed in 4 ft × 5 ft pens and allowed ad libitum access to feed and water. Each treatment included seven pigs per pen and six replications (pens). The pigs and feeders were weighed on d 7, 14, and 18 to calculate ADG, ADFI, and F/G. Chromic oxide (.20%) was included in the diets as an indigestible marker. On d 14, fecal samples were collected from at least three pigs per pen by rectal massage. Apparent nutrient digestibilities were determined for DM, CP, and DE. Linear and quadratic polynomials

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were evaluated using coefficients for unequally spaced treatments.

Table 1. Diet Composition[a]

Ingredient	%
Corn	50.70
Dried whey	10.00
Soybean meal	28.59
Spray-dried blood meal	2.50
Soybean oil	3.00
Monocalcium phosphate	1.85
Limestone	1.01
Zinc oxide	.25
Vitamin premix	.25
L-Lysine·HCl[g]	.15
DL-Methionine	.10
Trace minerals	.15
Salt	.25
Antibiotic[b]	1.00
Chromic oxide	.20
Total	100.00

[a]Diets were formulated to contain 1.4% lysine, .39% methionine. Dietary treatments varied based on ground corn with 14.5%, 38.7%, 52.7%, 64.4%, 89.3% gelatinized starch.
[b]Provided 50 g/ton of carbadox.

Results and Discussion

From d 0 to 18, ADG and ADFI decreased and then increased with increasing starch gelatinization (quadratic, P=.05 and .01, respectively). Average daily gain and ADFI were maximized in pigs fed diets containing either 14.5 or 89.3% gelatinized corn. Feed efficiency was not affected by degree of starch gelatinization (P>.10).

Increasing the degree of starch gelatinization in corn increased apparent digestibility of all three variables (quadratic, P<.01). Although pigs fed the diet containing 64.4% gelatinized starch had the greatest apparent nutrient digestibilities, the greatest increase in nutrient digestibility occurred between pigs fed the control diet (14.5% gelatinized starch) and those fed 38.7% gelatinized starch.

Previous studies have reported both negative and positive effects of extrusion processing on growth performance of pigs fed corn- or grain sorghum-based diets. We hypothesized that a correlation exists between extruder conditions that result in different degrees of starch gelatinization and variations in growth performance. Under the ingredient processing conditions used in this experiment, increasing starch gelatinization in corn decreased and then increased ADG and ADFI. Apparent digestibility of DM, CP, and energy seemed to be correlated negatively with feed intake, increasing and then decreasing with increasing gelatinization. These results may be explained by changes in cereal chemistry. During extrusion processing, too much water and (or) too low a temperature can prevent full gelatinization of starch. After processing, because of ample moisture and rapidly decreasing temperature, the starch paste is cooled. This results in the starch chains becoming more stable and forming a firmer gel. As the gel ages, the starch chains interact and force water out of the system. Longer periods of storage give rise to more interaction between the starch chains and eventually can lead to formation of crystals. This process, called retrogradation, is the crystallization of starch chains in the gel. The retrogradation of starch (formation of beta-amylose and crystallized amylopectin) can decrease the ability of enzymes (amylases) to break down the linkages in starch and convert it into more soluble carbohydrates. Therefore, although gelatinization of starch can increase the digestibility of carbohydrates, retrogradation will decrease digestibility of starch in the small intestine. Under our processing conditions, we added high levels of water to produce corn with a low degree of gelatinized starch. Immediately drying the extruded corn may have allowed less opportunity for retrogradation and, therefore, increased the apparent nutrient digestibility. The diets with the highest degree of starch gelatinization may have contained damaged or burnt starch (Maillard reaction) as well as having a great-

er potential loss of available amino acids and(or) vitamins. Although an intermediate degree of gelatinization (38 to 64%) might be beneficial for digestibility, it did not affect pig growth performance. Additional research will be needed to determine the optimal extrusion processing conditions necessary to improve pig growth performance.

Table 2. Extrusion Processing Conditions[a]

	Starch Gelatinization			
Extruder Conditions	38.7%	52.7%	68.7%	89.3%
Barrel jacket temperature at the 8th head, °F	217	230	246	279
Barrel pressure, lb/in^2	200	300	600	500
Production rate, lb/min	4.40	5.00	6.25	5.50
Exit temperature, °F	190	202	212	221
Water flow, lb/min	1.22	1.00	.60	.40

[a]Corn was extruded through a Wenger X-20 extruder (Wenger Inc., Sabetha, KS) and dried at 250°F to 12 to 13% moisture, ingredients then were mixed, the complete feed was pelleted, and samples collected for starch gelatinization analysis.

Table 3. Effects of Increasing Starch Gelatinization on Growth Performance of Early-Weaned Pigs[a]

	Starch Gelatinization, %[b]						Probability (P<)	
Item	14.5%	38.7%	52.7%	64.4%	89.3%	CV	Linear	Quadratic
Day 0 to 18								
ADG, lb	.78	.71	.70	.67	.75	11.86	.37	.05
ADFI, lb	1.05	.97	.98	.90	1.02	5.75	.10	.01
F/G	1.35	1.37	1.41	1.35	1.37	9.55	.89	.75
Apparent Digestibility (d 14), %								
DM	77.83	84.11	81.54	84.62	81.76	2.24	.01	.01
N	69.43	79.74	76.98	81.13	75.89	5.75	.01	.01
GE	76.63	84.39	81.75	85.35	82.12	2.57	.01	.01

[a]A total of 210 weanling pigs (initially 15 ± 3 lb and 21 d of age) was used with seven pigs/pen and six replicate pens/treatment.
[b]Ground corn was extruded to provide the different starch gelatinization treatments, then mixed and pelleted.