EFFECT OF PARTICLE SIZE AND SURFACE AREA OF CORN ON PIG PERFORMANCE AND NUTRIENT DIGESTIBILITY

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Summary

Two feeding trials and two digestion trials were conducted to evaluate the effects of particle size and surface area of corn on the performance and nutrient digestibility of weaning and finishing pigs. The effects of particle size on production rate and grinding efficiency also were evaluated. Production rate and grinding efficiency decreased as particle size decreased. Average daily gain was not influenced by particle size. Feed intake tended to decrease as particle size decreased with the lowest feed intake on the fine partice size diet. Feed efficiency tended to improve as particle size decreased. The incidence of ulceration in the esophageal region of the stomach of finishing pigs increased as particle size of diet decreased. Digestibility of dry mattter, nitrogen and energy improved as particle size decreased or surface area increased with diets for both weaning and finishing pigs.

Introduction

Cereal grains are the predominant energy and amino acid sources in swine diets. Therefore, any processing treatment that effects the nutritional value of the cereal grain is of marked economic importance. It has been well established that whole dry cereal grains are inferior to hammer milled or rolled grain for swine. The influence of particle size of the cereal grain on swine performance may depend on the cereal grain and age of the animal. The objective of this study was to evaluate the effects of particle size and surface area on pig performance and nutrient digestibility. The effects of particle size on production rate and grinding efficiency also were evaluated.

Procedures

Two feeding trials and two digestion trials (one with weaning pigs and with finishing pigs) were conducted at the swine research unit. The diets were processed and the particle size analysis conducted at the pilot feed mill and production laboratory of the Department of Grain Science.

Corn was processed with a 30 horsepower full circle hammermill equipped with different screen sizes. Three hammermill screen sizes (1/16, 1/4, and 1/2 inch) were used to create the three experimental treatments. Electrical energy consumption used for grinding was measured using an amp/volt strip chart recorder. Samples of the ground grains were obtained for particle size analysis. Particle size determination was made by using the A.S.A.E. standard method of determining and expressing fineness of feed materials by sieving. The geometric mean particle size (d_{gw}) and the geometric standard deviation (S_{gw}) of the sample were calculated by using the amount of ground product collected on each screen. These values were used to calculate the total surface of one gram of each sample. Combining the surface area and the energy used in grinding into one number allows one to look at both particle size and efficiency using the same quantitative value.

Finishing Pigs

One hundred and fifty crossbred pigs averaging 105 lbs were assigned randomly to pens within replications based on weight and sex. Each pen housed 10 pigs with five pens per treatment. The corn-soybean diets were formulated to contain .6% lysine, .65% calcium and .55% phosphorus. The three treatments were corn ground with a hammermill with (1) a 1/16 in screen; (2) a 1/4 in screen or (3) a 1/2 in screen. The trial was conducted in a modified open-front finishing barn. Each pen was equipped with a nipple waterer and a self-feeder. The performance data was terminated when pigs weighed approximately 220 pounds. Eight barrows per treatment were slaughtered following a 24 hr fast and their stomachs were examined and classified as normal, cornified, eroded, or ulcerated according to the condition of epithelial area of the esophageal region.

Eighteen crossbred barrows averaging 134 lb were used in a digestion trial. Pigs were housed individually in metabolism cages in an environmentally controlled building. A 7-day pretest preceded the 5-day collection period. Pigs were fed 4.4 lb of the experimental diets daily in two equal feedings.

Weaning Pigs

Forty-five crossbred pigs averaging 14 lb were assigned to pens within replications by initial weight to determine the particle size on daily gain, feed intake and feed efficiency. All diets (corn-soybean meal) were formulated to contain 1.2% lysine, .9% calcium and .7% phosphorus. The three treatments were: (1) corn ground with a 1/16 in screen; (2) corn ground with a 1/4 in screen; and (3) corn ground with a 1/2 in screen. Each pen contained three pigs with five pens per treatment. Pigs were housed in an environmentally controlled nursery with woven wire floors. Each pen was equipped with a nipple waterer and a self-feeder. Weight gain and feed consumption was determined weekly for the 5-wk trial.

Twelve crossbred barrows averaging 18 lb were used in the digestion study. All pigs were housed in individual metabolism cages in an environmentally controlled building for two collection periods. Each period consisted of a 7-day adjust period and a 5-day collection period. Pigs were fed 150 g daily in the first collection period and 200 g daily in the second period.

Results and Discussion

A summary of the particle size analysis of the corn and corn diets used for the finishing pigs is shown in table 1. Average particle size diameter increased from 1.60 to 2.35 and 2.65, respectively, as particle size increased. Surface area decreased linearly ($P<.05$) from 113 to 84 and 67 cm^2/g, respectively, as particle size increased. Standardized production rate increased linearly ($P<.05$) form 89.1 to 218.9 and 276.1 lb/Hph, respectively, as particle size increased. Similarly, grinding efficiency and true efficiency increased ($P<.05$) as particle size increased.

The effect of particle size and surface area of corn diets on performance and apparent digestibilities of finishing pigs is shown in table 2. Average daily gain of finishing pigs was not affected by particle size or surface area. Daily feed intake increased slightly as particle size increased. The smaller particle size and increased surface area tended to improve feed efficiency.

The apparent digestion coefficient for dry matter decreased slightly from 88.36% to 88.29% and 86.61%, respectively, as particle size increased and surface area decreased, but this difference was not significant. The apparent diggestion coefficient for nitrogen decreased ($P<.05$) from 87.45% to 85.75% and 82.77%, respectively, as particle size increased and surface area decreased. The apparent digestion coefficient for energy also decreased ($P<.05$) from 88.81% to 87.71% and 85.78%, respectively, as particle size increased and surface area decreased. This study showed that nutrient digestibility improved in finishing pigs as particle size decreased and surface area increased.

The effect of particle size of corn diets on incidence of gastric lesions in finishing pigs is shown in table 3. Four stomach ulcers were observed in pigs eating the 1/16 inch screen diets and no stomach ulcer was found in pigs eating the other two diets. The data on stomach ulcer scores showed that the incidence of ulceration of the esophageal region of the stomach increased as particle size decreased.

A summary of particle size analysis of corn and corn diets for weaning pigs is shown in table 4. Average particle size diameter increased from 465 to 820 and 1363 microns, respectively as screen size increased. Geometric standard deviation also increased from 1.62 to 2.09 and 2.54, respectively as particle size increased. Surface area decreased from 110 to 72 and 52 cm^2/g, respectively as particle size increased. Standardized production rate increased from 99.0 to 185.9 and 265.98 lb/Hph, respectively as particle size increased. Similarly, grinding efficiency and true efficiency increased as particle size increased. These data show the same trends as in finishing pigs: as particle size decreases, surface area and energy input increase and particle size diameter and production capacity decrease.

Effect of particle size and surface area of corn diets on performance and apparent digestibilities of weaning pigs is shown in table 5. Average daily gain increased slightly from 0.77 to 0.84 and 0.79 lb, respectively, as particle size increased, but this difference was not significant. A smaller particle size tended to improve ($P<.06$) feed efficiency, as particle size decreased and surface area increased. This trial shows the same trend as in finishing pigs: the smaller particle size tended to improve feed efficiency but not daily gain.

The apparent digestion coefficient for dry matter decreased ($P<.05$) from 85.75% to 83.85% and 83.37%, respectively, as particle size increased and surface area decreased. The apparent digestion coefficient for nitrogen decreased ($P<.05$) from 85.22% to 82.95% and 82.58%, respectively, as particle size increased and surface area decreased. The apparent digestion coefficient for energy decreased ($P<.05$) from 86.07% to 83.21% and 82.50%, respectively, as particle size increased and surface area decreased. For all of these criteria, the differences were not significant between the 1/4 inch and 1/2 inch screen ground diets. This study showed that nutrient digestibility increases as particle size decreases and surface area increases.

Table 1. Particle Size Analysis of Corn and Corn Diets for Finishing Pigs

Item	Hammermill Screen Size (in) 1/16	1/4	1/2	SE
Corn				
Particle size diameter (microns)	460[a]	784[b]	1107[c]	21.23
Geometric standard deviation	1.60[a]	2.35[b]	2.65[c]	.06
Surface area (cm^2/g)	113[a]	84[b]	67[c]	4.83
Std. production rate (lb/Hph)	89.1[a]	218.9[b]	276.1[c]	6.34
Grinding efficiency (Kwh/Ton)	12.55[a]	4.81[b]	3.70[c]	.17
True efficiency (m^2/Kwh)	828[a]	1591[b]	1644[b]	45.40
Corn Diets				
Particle size diameter (microns)	509[a]	844[b]	1147[c]	40.86
Geometric standard deviation	1.73[a]	2.21[b]	2.43[c]	.03
Surface area (cm^2/g)	105[a]	72[b]	60[b]	4.81

[abc]Means of the same line with different superscripts differ (P<.05).

Table 2. Effect of Particle Size and Surface Area of Corn Diets on Performance and Apparent Digestibilities for Finishing Pigs.

Item	Particle Size			
Screen (in)	1/16	1/4	1/2	
Diameter (microns)	509	844	1147	SE
Surface area (cm^2/g)	105	72	60	
Average daily gain, lb	1.32	1.32	1.34	.02
Daily feed intake, lb	4.53	4.84	4.88	.11
Feed:gain	3.44[b]	3.65[c]	3.62[bc]	.06
Dry matter,[a] %	88.36	88.29	86.61	.58
Nitrogen,[a] %	87.45[b]	85.75[b]	82.77[c]	.80
Energy,[a] %	88.81[b]	87.71[b]	85.78[c]	.53

[a]Dry matter basis.
[bc]Means of the same line with different superscripts differ (P<.05).

Table 3. Effect of Particle Size on Corn Diets on Incidence of Gastric Lesions in Finishing Pigs.

Item	Hammermill Screen Size (in)		
	1/16	1/4	1/2
No. pigs	8	8	8
No. normal stomachs	0	4	5
No. cornifications	2	3	3
No. erosions	2	1	0
No. slight ulcers	3	0	0
No. serious ulcers	1	0	0

Table 4. Particle Size Analysis of Corn and Corn Diets for Weaning Pigs

Item	Hammermill Screen Size (in)		
	1/16	1/4	1/2
Corn			
Particle size diameter (microns)	465	820	1363
Geometric standard deviation	1.62	2.09	2.54
Surface area (cm^2/g)	110	72	52
Std. production rate (lb/Hph)	99.0	185.9	265.98
Grinding efficiency (Kwh/Ton)	13.00	5.39	3.78
True efficiency (m^2/Kwh)	766	1226	1240
Corn diets			
Particle size diameter (microns)	524	864	1117
Geometric standard deviation	2.04	2.11	2.32
Surface area (cm^2/g)	102	68	58

Table 5. Effect of Particle Size and Surface Area of Corn Diets on Performance and Apparent Digestibilities for Weaning Pigs.

Item	Particle Size			SE
	Screen (in)	1/16	1/4	1/2	
	Diameter (microns)	524	864	1117	
	Surface area (cm^2/g)	102	68	58	
Average daily gain, lb		.77	.84	.79	.04
Daily feed intake, lb		1.23	1.43	1.39	.07
Feed:gain		1.57[b]	1.68[bc]	1.75[c]	.05
Dry matter,[a] %		85.75[b]	83.85[c]	83.37[c]	.37
Nitrogen,[a] %		85.22[b]	82.95[c]	82.58[c]	.29
Energy,[a] %		86.07[b]	83.21[c]	82.50[c]	.36

[a]Dry matter basis.

[bc]Means of the same line with different superscripts differ ($P<.05$).