EFFECTS OF MILL TYPE (HAMMER VS ROLLER) AND PARTICLE SIZE UNIFORMITY ON GROWTH PERFORMANCE, NUTRIENT DIGESTIBILITY, AND STOMACH MORPHOLOGY IN FINISHING PIGS

K. J. Wondra, J. D. Hancock, K. C. Behnke[1], C. H. Fahrenholz[1], C. R. Stark[1], and R. H. Hines

Summary

Two experiments were conducted to determine the effects of mill type and particle size uniformity on finishing pigs. In Exp. 1, 120 pigs, with an average initial weight of 105 lb, were fed corn-soybean meal-based diets for 57 d. The corn was milled so that all diets had an average mean particle size of 800 μm (± 20), yet differed in particle size uniformity (Sgw). To obtain the most uniform treatment (1.9 Sgw), corn was milled through a roller mill. The intermediate treatment (2.3 Sgw) was obtained by milling corn through a hammermill. The least uniform treatment (2.7 Sgw) was obtained by blending coarsely and finely ground corn. Growth performance of pigs was not affected by Sgw of the diet. However, digestibilities of DM, N, and GE increased as Sgw was reduced. In Exp. 2, 128 pigs, with an average initial weight of 150 lb, were fed diets with corn milled to 450 μm (± 7) in a hammermill or a roller mill. The hammermilled corn had an Sgw of 1.8 and the roller-milled corn had an Sgw of 2.0. The diets were fed in meal or pelleted form. There were no interactions among mill type and diet form. Digestibilities of DM and N were greater for the hammermilled treatments, but no growth performance differences were due to mill type. Pelleting increased ADG 9% and improved efficiency of gain by 5%. Pelleting also increased the severity of stomach lesions. In conclusion, at 800 and 450 μm, mill type did not affect growth performance. However, nutrient digestibilities were improved by decreasing variability in particle size, a response that merits further investigation.

(Key Words: Particle Size, Pelleting, Roller Mill, Performance, Stomach Ulcers, G-F.)

Introduction

Much attention has been given to the positive effects of reducing mean particle size of diets for broiler chicks and nursery pigs (1991 KSU Swine Day Report, page 56) and finishing pigs and lactating sows (Wondra et al., p. 6 and 122). From these and other reports, few would argue that reducing mean particle size of cereal grains from ≥ 900 μm to ≤ 600 μm results in marked improvements in nutrient digestibility and efficiency of growth. However, these experiments resulted from investigation of the effects of mean particle size and say nothing about the effects of variation of particle size within that mean. Must all of the particles in a diet be the same size to give maximum nutrient digestibility and growth performance? Does a diet with many particles at ≥ 1,000 and ≤ 600 μm give an average effect similar to a diet with all of its particles near 800 μm? These questions are particularly important when deciding whether to buy a hammermill or roller mill, because roller mills usually give greater particle size uniformity. The experiments reported herein were designed to determine the effects of particle size uniformity and milling with a hammermill vs roller mill on growth performance, nutrient digest-

[1]Department of Grain Science and Industry.

ibility, and stomach morphology in finishing pigs.

Procedures

In Exp. 1, 120 finishing pigs, with an average initial wt of 105 lb, were blocked by weight and allotted to treatment based on sex and ancestry. There were eight pigs per pen and five pens per treatment. The pigs were housed in a modified open-front building, with 50% solid concrete and 50% concrete slat flooring. Each pen (6 ft × 16 ft) had a three-hole self-feeder and nipple waterer to allow ad libitum consumption of feed and water.

For the grain treatments, a single lot of corn was purchased from the 1990 harvest. Corn was ground through a well maintained hammermill, equipped with a 1/4 in. screen, to yield an intermediate degree of particle size uniformity (denoted as Sgw). Average particle size was 862 μm with an Sgw of 2.3. For the minimum Sgw, a well maintained roller mill was used to grind the corn, with an actual average particle size of 840 μm and Sgw of 2.0. For the high Sgw treatment, finely ground (ground through a 1/16 in. screen, avg particle size of 400 μm and Sgw of 1.8) and coarsely rolled (avg particle size of 2,200 μm and Sgw of 2.0) corn were blended, yielding a mixture with analyzed avg particle size of 868 μm and Sgw of 2.7.

The grain treatments were incorporated into a corn-soybean meal-based diet (Table 1). The pigs were fed for 57 d and scanned ultrasonically for fat thickness at the last rib; then all barrows were slaughtered. Samples of digesta were collected from the rectum for determination of DM and N digestibility (using the indirect ratio method with .20% chromic oxide as an indigestible marker), and the stomachs were harvested. The esophageal regions of the stomachs were scored on a scale of normal (0) to severe (3) for keratinization and erosions. The scores were transformed (square root transformation) before statistical analyses. Response criteria were ADG; ADFI; F/G; last rib fat depth; stomach keratinization; stomach lesions; and apparent digestibilities of DM, N, and GE.

In Experiment 2, 128 finishing pigs, with an average initial wt of 150 lb, were blocked by weight and allotted to four dietary treatments based on sex and ancestry. There were eight pigs per pen and four pens per treatment. Housing and management were the same as in Exp. 1.

Table 1. Composition of Basal Diet[a]

Ingredient	%
Corn	82.73
Soybean meal (48% CP)	14.37
Monocalcium phosphate	1.08
Limestone	1.02
Salt	.30
Vitamins and minerals[b]	.40
Antibiotic[c]	.10
Total	100.00

[a]The basal diet was formulated to .65% lysine, .65% Ca, .55% P, and 1.56 Mcal DE/lb.
[b]KSU vitamin mix (.25%), KSU mineral mix (.10%), and KSU selenium mix (.05%).
[c]Antibiotic supplied 100 g/ton chlortetracycline.

To prepare the corn treatments, a single lot of corn was purchased from the 1991 harvest and milled through either a hammermill or roller mill to approximately 450 μm. The milled corn was incorporated into the same corn-soybean meal-based diet used in Exp. 1. The diet was fed as a meal and pelleted to determine if mill type would affect pelleting characteristics and(or) growth performance. Furthermore, pelleting can increase the incidence and severity of stomach lesions, and we wanted to know if mill type would prevent or aggravate that condition. This resulted in a 2 × 2 factorial arrangement of treatments.

Five weeks after initiation of the experiment, chromic oxide was added to the diets (.20%) as an indigestible marker. After a 5-d adjustment period, fecal samples were collected from each pig and pooled within pen. The fecal and diet samples were dried; ground; and analyzed for Cr, DM, energy, and N concentrations so that apparent digestibilities of DM, energy, and N could be calculated. The diets were fed until pigs in one pen of a wt block averaged 260 lb. The block was then slaughtered, and stomachs were scored using the same scale as in Exp. 1. Response criteria were ADG, ADFI, F/G, stomach keratinization, stomach lesions, and apparent digestibilities of DM, N, and GE.

Results and Discussion

The effects of particle size uniformity in diets for finishing pigs are given in Table 2. Targeted and actual particle sizes and Sgws were very similar. The actual particle size of the three corn treatments differed by only 28 μm, averaging 857 μm. Particle size of the complete diets averaged 804 μm. Growth performance of pigs was not affected by Sgw of the diets ($P > .10$). However, apparent digestibilities of DM, N, and GE were greater for diets with lower Sgws (linear, $P < .01$). These results indicated that digestibility values were more sensitive to the effects of particle size uniformity than growth performance.

One pig fed the most uniform diet (1.9 Sgw) died from a stomach ulcer during the experiment. No ulcers were present in the stomachs of the other barrows at slaughter, indicating that the fine particles in diets with high Sgws did not induce formation of stomach lesions.

Results from Exp. 2 are given in Table 3. Particle sizes of hammermilled corn and roller-milled corn were similar, differing by only 14 μm. The Sgws differed slightly, with the hammermilled corn having the most uniform particle size. This is contrary to the general rule (at larger particle sizes) that grains milled through a roller mill have lower Sgws than grains milled through a hammermill. Pellet durabilities were similar for diets with corn processed in either the hammermill or roller mill (i.e., 91 vs 94%).

Growth performance was not affected by mill type. However, apparent digestibilities of DM ($P < .01$) and N ($P < .05$) were greatest for the hammermill treatment. Although grain milled through a roller mill had greater nutrient digestibilities in Exp. 1, in both experiments, the grain with the lowest Sgw (roller milled in Exp. 1 and hammermilled in Exp. 2) had the greatest nutrient digestibilities. Pigs fed pelleted diets had 9% greater ADG ($P < .01$) and were 5% more efficient ($P < .05$) than pigs fed diets in meal form. Pigs fed pelleted diets had greater lesion scores than pigs fed meal diets ($P < .001$). There were no interactions among mill type and diet form.

In conclusion, these data indicate that particle size uniformity and(or) mill type have minimal effect on growth performance. However, the discrepancies in nutrient digestibilities (i.e., greater for roller milled grain in Exp. 1 and greater for hammermilled grain in Exp. 2) warrant further investigation. Finally, although growth and health status of pigs in Exp. 2 was not compromised with any grain treatment, the lower lesion scores for stomachs from pigs fed corn ground through a roller mill may be of biological significance.

Table 2. Effects of Particle Size Uniformity on Performance and Nutrient Digestibility in Finishing Pigs[a]

	Uniformity of particle size, Sgw			
Item	2.7	2.3	1.9	CV
Grain characteristics				
Mean particle size, μm	868	862	840	—
Diet characteristics				
Mean particle size, μm	801	817	793	—
Variation in particle size (Sgw)	2.5	2.3	2.0	—
Pig performance				
ADG, lb	1.83	1.83	1.85	4.1
ADFI, lb	6.39	6.39	6.79	5.2
F/G	3.49	3.49	3.67	5.6
Fat thickness, in.	1.06	1.18	1.13	16.6
Apparent nutrient digestibility, %				
DM[b]	80.2	80.3	83.1	1.4
N[b]	72.4	76.5	78.5	2.5
GE[bc]	79.6	79.1	82.6	1.6
Stomach keratinization	.56	.88	.76	8.4

[a]120 pigs (8 pigs/pen and 5 pens/trt) with an avg initial wt of 105 lb, and an avg final wt of 209 lb.
[b]Linear effect of Sgw ($P < .01$).
[c]Quadratic effect of Sgw ($P < .05$).

Table 3. Influence of Diet Form and Mill Type on Finishing Pigs[a]

	Hammermill		Roller mill		
Item	Meal	Pellet	Meal	Pellet	CV
Grain characteristics					
Mean particle size, μm	457	457	443	443	-
Variation in particle size, Sgw	1.8	1.8	2.0	2.0	-
Diet characteristics					
Mean particle size, μm	460	-	491	-	-
Variation in particle size, Sgw	1.7	-	1.9	-	-
Pellet durability	-	91	-	94	-
Pig performance					
ADG, lb[e]	1.82	1.93	1.83	2.04	4.1
ADFI, lb	6.69	6.93	6.61	6.79	5.2
F/G[f]	3.68	3.59	3.61	3.33	4.2
Apparent nutrient digestibility, %					
DM[b]	87.2	88.2	85.2	85.5	1.5
N[c]	83.7	84.3	82.5	82.4	1.2
GE	87.8	88.2	86.2	86.4	2.0
Stomach keratinization	2.19	1.63	1.00	1.63	15.3
Stomach lesions[bd]	.44	1.31	.19	.63	11.4

[a]128 pigs (8 pigs/pen and 4 pens/trt) with an avg initial wt of 150 lb and an avg final wt of 263 lb.
[bc]Mill effect ($P < .01$ and $P < .05$, respectively).
[def]Form effect ($P < .001$, $P < .01$, and $P < .05$, respectively).