Effects of Sorghum Particle Size on Milling Characteristics, Growth Performance, and Carcass Characteristics in Finishing Pigs

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Summary

A total of 200 finishing pigs (PIC TR4 × 1050; average initial BW of 103.2 lb) were used in a 69-d growth assay to determine the effects of sorghum particle size on growth performance. Pigs were sorted by sex and ancestry and balanced by BW, with 5 pigs per pen and 10 pens per treatment. Treatments were a corn-soybean meal-based control with the corn milled to a target mean particle size of 600 µm, and sorghum diets milled to a target mean particle size of 800, 600, or 400 µm. Actual mean particle sizes were 555 µm for corn, and 724, 573, and 319 µm for sorghum, respectively. Feed and water were offered on an ad libitum basis until the pigs were slaughtered (average final BW of 271 lb) at a commercial abattoir. Reducing sorghum particle size improved (linear, $P < 0.01$) F/G, and we observed a tendency for decreased ($P < 0.06$) ADFI. Reducing sorghum particle size from 724 to 319 µm had no effects on HCW, backfat thickness, loin depth, or percentage fat-free lean index (FFLI), but tended to increase ($P < 0.06$) carcass yield. Pigs fed the sorghum-based diets had no difference in growth performance or carcass characteristics compared with those fed the control diet, except carcass yield, which was numerically greater ($P < 0.07$) for pigs fed the sorghum-based diets. When using a regression equation, we determined that sorghum must be ground to 513 µm to achieve a F/G equal to that of a corn-based diet, with corn ground to 550 µm. In conclusion, linear improvements in F/G and carcass yield were demonstrated with the reduction of sorghum particle size to 319 µm. In this experiment, sorghum should be ground 42 µm finer than corn to achieve a similar feeding value.

Key words: corn, particle size, sorghum, finishing pig

Introduction

With the continuous increase in corn prices, swine producers are utilizing alternative feedstuffs to reduce diet cost. Sorghum is a cereal grain that can be an economical replacement for corn; its attributes, such as resistance to heat stress and drought, make it favorable to produce in certain regions worldwide.

Through the years, the nutritional value of sorghum has been enhanced through genetic selection of sorghum grains and by applying feed processing strategies. The most common feed manufacturing practice used to enhance swine performance is the grinding of cereal grains; however, the particle size necessary to make the feeding value of sorghum equal to that of corn is not well defined. Thus, we designed an experiment to determine the effects of reducing sorghum particle size on milling inputs and growth

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performance, and to develop a sorghum particle size necessary to achieve the same performance as corn when fed to growing and finishing pigs.

Procedures

The Kansas State University Institutional Animal Care and Use Committee approved the protocol used in this experiment. The experiment was completed at the K-State Swine Teaching and Research Center in Manhattan, KS.

A total of 200 pigs (PIC line TR4 × 1050; average initial BW of 103.2 lb) were sorted by sex and ancestry, balanced by BW, and assigned to treatments, with 5 barrows per pen or 5 gilts per pen and 10 pens per treatment. Pigs were housed in an environmentally controlled finisher with pens (10 ft × 5 ft) that had concrete slatted floors. Each pen contained a self-feeder and 2 nipple waterers to allow ad libitum consumption of feed and water.

The control diet was corn-based with the corn milled to a target geometric mean particle size of 600 μm. Treatments were sorghum-based with sorghum milled to a targeted mean particle size of 800, 600, or 400 μm. For the control, corn was milled using a hammer mill (Jacobson P240D) with a screen size of ¼ in. ("teardrop" full circle screen). For the 400 μm treatment, sorghum was milled using the same hammer mill (Jacobson P240D) with a screen size of 1/16 in. ("teardrop" full circle screen). For the 800- and 600-μm treatments, sorghum was milled using a three-high roller mill (1:1, 1.5:1, 1.5:1 differential drives; 3.2, 4.7, and 6.3 corrugations per cm; and 0, 8.3, and 8.3 cm of spiral/meter of roller, Model K, Roskamp Manufacturing, Cedar Falls, IA). All diets were pelleted in a 30 horsepower pellet mill (30 HD Master Model, California Pellet Mill, San Francisco, CA) with a 1 ¼-in.-thick die that had 5/32-in. openings. Pellets were analyzed for pellet durability index (PDI) and modified PDI. PDI was determined using the standard tumbling-box technique and modified PDI by altering the procedure by adding 5 hexagonal nuts prior to tumbling. An amp-volt meter (Model DM-II, Amprobe Instrument, Lynbrook, NY) was used to calculate energy used during grinding and pelleting.

The experimental treatments (Table 1) were fed in 3 phases, with Phase 1 fed from d 0 to 28, Phase 2 from d 28 to 48, and Phase 3 from d 48 to 69. All diets were formulated to meet or exceed NRC (1998[2]) recommendations. Pigs and feeders were weighed on d 0, 20, 41, and 69 to calculate ADG, ADFI, and F/G. On d 69, pigs were harvested (average final BW of 271 lb) at a commercial abattoir (Farmland Foods, Inc.; Crete, NE) and HCW, carcass yield, backfat thickness, loin depth, and percentage FFLI were recorded.

The MIXED procedure (SAS Inst. Inc., Cary, NC) was used to perform the statistical analysis. All growth data were analyzed as a completely randomized design with pen as the experimental unit. For analyses of backfat thickness, loin depth, and FFLI, HCW was used as a covariate. The corn treatment was compared with the average of the 3 sorghum particle sizes, and the shape of the response to decreasing particle size of sorghum was characterized using polynomial regression. Results were considered significant at $P \leq 0.05$ and considered a trend at $P \leq 0.15$.

[2] NRC. 1998. Nutrient Requirements of Swine. 10th ed. Natl. Acad. Press, Washington, DC.

Results and Discussion

The particle size for each treatment was lower than that of the targeted value. Actual mean particle sizes were 555 µm for corn and 724, 573, and 319 µm for sorghum (Table 2). Energy required for pelleting the sorghum treatments increased slightly as particle size decreased; however, pelleting the corn-based diet required 5% more energy than the average of the sorghum treatments. Pelleting the 319-µm sorghum treatment resulted in the highest production rate or largest amount of pellets produced in an hour, which were 7% higher than that of the 724 and 573 µm treatments and 4% higher than that of the corn control. As particle size was decreased from 724 to 573 µm, minor improvements were observed in PDI, and all were higher than that of corn.

No difference was found in growth performance for pigs fed the corn compared with the mean of the 3 sorghum-based diets (Table 3), but F/G improved (linear, $P < 0.01$) as particle size decreased in sorghum-based diets. This resulted from a numerical decrease (linear, $P < 0.06$) in ADFI as particle size of sorghum was reduced. A linear regression was plotted to demonstrate the improvements in F/G when reducing the particle size of sorghum from 724 to 319 µm. When applying the F/G achieved by pigs fed the corn control (corn ground to 555 µm), it was demonstrated that sorghum needed to be ground to 513 µm to achieve similar efficiencies of gain to that of the corn control (Figure 1).

Among pigs fed sorghum-based diets, no difference in HCW, backfat thickness, loin depth, and FFLI were observed compared with those fed the corn-based control; however, pigs fed sorghum-based diets had numerically greater ($P < 0.07$) carcass yield compared to those fed the corn-based control. As sorghum particle size was reduced from 724 to 319 µm, there was a tendency for a linear increase ($P < 0.06$) in carcass yield.

In conclusion, reducing the particle size of sorghum from 724 to 319 µm improved efficiency of gain by 3.6% and tended to increase carcass yield. Feeding sorghum-based diets to growing-finishing pigs resulted in no significant differences in growth performance or carcass characteristics compared to those fed a corn-based diet, but the average of the 3 sorghum-based treatments resulted in a trend toward an increase in carcass yield compared to those fed the corn-based treatment. We found that F/G improved by 0.9% for every 100-µm reduction in particle size, and sorghum should be ground 42 µm finer than corn to achieve the same efficiency of gain as corn.

Table 1. Composition of experimental diets (as-fed basis)[1]

	Phase 1		Phase 2		Phase 3	
Item	Corn	Sorghum	Corn	Sorghum	Corn	Sorghum
Ingredient, %						
Corn	76.22	—	78.60	—	80.67	—
Sorghum	—	76.21	—	78.60	—	80.64
Soybean meal (46.5% CP)	21.5	21.5	19.5	19.5	17.5	17.5
L-Lysine HCl	0.21	0.23	0.14	0.16	0.074	0.096
DL-Methionine	0.03	0.04	—	0.002	—	—
L-Threonine	0.06	0.04	0.018	0.002	—	—
Monocalcium P (21% P)	0.70	0.70	0.50	0.50	0.51	0.51
Limestone	0.88	0.88	0.85	0.85	0.86	0.86
Salt	0.25	0.25	0.25	0.25	0.25	0.25
Vitamin premix	0.04	0.04	0.04	0.04	0.04	0.04
Mineral premix	0.06	0.06	0.06	0.06	0.06	0.06
Antibiotic[2]	0.05	0.05	0.05	0.05	0.05	0.05
Total	100.00	100.00	100.00	100.00	100.00	100.00
Calculated analyses,%						
CP	16.6	17.3	15.7	16.5	15.0	15.6
SID lysine[3]	0.88	0.88	0.78	0.78	0.68	0.68
Ca	0.55	0.55	0.50	0.50	0.50	0.50
Available P	0.21	0.22	0.17	0.18	0.17	0.18

[1] Experimental treatments were fed in pelleted form.
[2] Provided (per kilogram of diet) 9.1 mg/kg of tylosin.
[3] Standardized ileal digestible.

Table 2. Processing characteristics of corn and sorghum

	Corn, µm	Sorghum, µm		
Item	555[1]	724[2]	573[2]	319[3]
dgw, µm[4]				
Milled grain	555	724	573	319
sgw, µm[5]				
Milled grain	3.14	2.46	2.31	2.52
Grinding				
Energy, kWh/ton	6.0	2.62	6.1	11.4
Production rate, ton/h	2.7	1.9	2.7	2.1
Pelleting				
Energy, kWh/ton	10.31	9.67	9.84	9.96
Production rate, ton/h	1.43	1.39	1.39	1.49
Durability, %	88.4	89.0	89.7	90.4
Modified durability, %[6]	85.0	85.2	86.8	86.9

[1] Corn was milled using a hammer mill (Jacobson P240D) with a screen size of ¼ in. ("teardrop" full circle screen).
[2] Sorghum was milled using a three-high roller mill (Model K, Roskamp Manufacturing, Cedar Falls, IA).
[3] Sorghum was milled using the same hammer mill (Jacobson P240D) with a screen size of 1/16 in. ("teardrop" full circle screen).
[4] Geometric mean particle size.
[5] Log normal standard deviation.
[6] Modified by adding 5 ½-in. hexagonal nuts prior to tumbling.

Table 3. Effects of sorghum particle size in finishing pig diets[1]

	Corn, µm	Sorghum, µm				*P*-value		
Item	555	724	573	319	SE	Corn vs. sorghum	Linear	Quadratic
ADG, lb	2.38	2.49	2.43	2.43	0.05	0.22	0.39	0.68
ADFI, lb	6.40	6.82	6.60	6.41	0.15	0.24	0.06	0.91
F/G	2.69	2.74	2.71	2.64	0.03	0.81	0.01	0.52
Final BW, lb	267.0	274.9	271.0	270.7	5.3	0.40	0.57	0.78
HCW, lb	194.2	199.8	197.8	198.3	4.0	0.33	0.78	0.80
Yield, %	72.5	72.7	73.0	73.2	0.2	0.07	0.06	0.99
Backfat, in.[2]	0.89	0.87	0.87	0.88	0.04	0.68	0.85	0.91
Loin depth, in.[2]	2.35	2.40	2.36	2.34	0.04	0.76	0.24	0.83
FFLI, %[2,3]	49.2	49.7	49.5	49.3	0.6	0.69	0.67	0.97

[1] A total 200 pigs (PIC line TR4 × 1050, average initial BW of 103.2 lb) were used in the 69-d growth assay.
[2] HCW used as a covariate.
[3] Fat-free lean index.

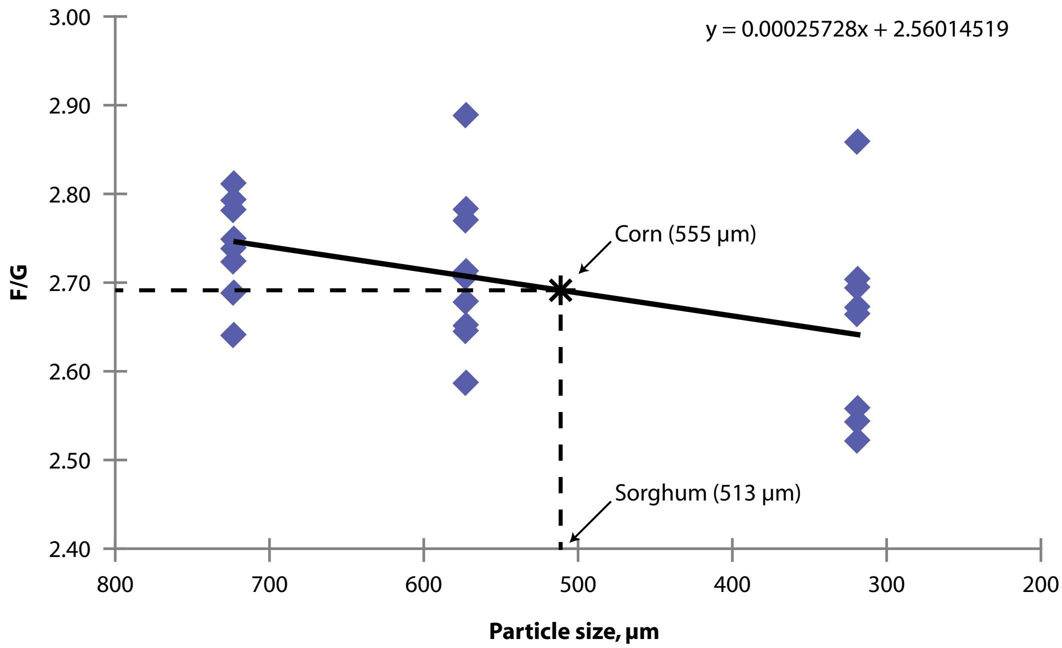

Figure 1. Particle size of sorghum required to obtain an efficiency of gain equal to that of corn.