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Effects of corn particle size, complete diet grinding, and diet form on 24- to 50-lb nursery pig growth performance

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Abstract

A total of 996 pigs (PIC TR4; initially 24.5 lb BW and 40 d of age) were used in a 21-d study to determine the effects of corn particle size, complete diet grinding, and diet form on nursery pig growth performance and caloric efficiency. Pens of pigs were balanced by initial BW and randomly allotted to 1 of 6 dietary treatments with 6 replications per treatment and 28 pigs per pen. The same corn-soybean mealâ€“based diet containing 30% corn dried distillers grains with solubles (DDGS) and 10% wheat middlings (midds) was used for all treatments. The 6 treatments were: (1) roller millâ€“ ground corn (737 Âµ) fed in meal form; (2) treatment 1 fed in pellet form; (3) hammer millâ€“ground corn (324 Âµ) fed in meal form; (4) treatment 3 fed in pellet form; (5) complete mixed diet reground through a hammer mill (541 Âµ) fed in meal form; and (6) treatment 5 in pellet form. Overall (d 0 to 21), ADG and ADFI decreased when corn was finely ground and fed in meal form but increased when fed in pelleted form, resulting in a tendency (P < 0.09) for a diet form Ã— corn particle size interaction. Fine-grinding the complete mixed diet had no effects. Pelleting diets improved (P < 0.04) ADG, F/G, ME and NE energetic efficiencies, and final BW. In conclusion, pelleting diets significantly improved performance, and reducing the particle size of corn from 737 to 324 Âµ improved nursery pig performance when fed in pelleted form.; Swine Day, Manhattan, KS, November 21, 2013

Keywords

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Effects of Corn Particle Size, Complete Diet Grinding, and Diet Form on 24- to 50-lb Nursery Pig Growth Performance[1,2]

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Summary

A total of 996 pigs (PIC TR4; initially 24.5 lb BW and 40 d of age) were used in a 21-d study to determine the effects of corn particle size, complete diet grinding, and diet form on nursery pig growth performance and caloric efficiency. Pens of pigs were balanced by initial BW and randomly allotted to 1 of 6 dietary treatments with 6 replications per treatment and 28 pigs per pen. The same corn-soybean meal–based diet containing 30% corn dried distillers grains with solubles (DDGS) and 10% wheat middlings (midds) was used for all treatments. The 6 treatments were: (1) roller mill–ground corn (737 µ) fed in meal form; (2) treatment 1 fed in pellet form; (3) hammer mill–ground corn (324 µ) fed in meal form; (4) treatment 3 fed in pellet form; (5) complete mixed diet reground through a hammer mill (541 µ) fed in meal form; and (6) treatment 5 in pellet form.

Overall (d 0 to 21), ADG and ADFI decreased when corn was finely ground and fed in meal form but increased when fed in pelleted form, resulting in a tendency ($P < 0.09$) for a diet form × corn particle size interaction. Fine-grinding the complete mixed diet had no effects. Pelleting diets improved ($P < 0.04$) ADG, F/G, ME and NE energetic efficiencies, and final BW.

In conclusion, pelleting diets significantly improved performance, and reducing the particle size of corn from 737 to 324 µ improved nursery pig performance when fed in pelleted form.

Key words: nursery pig, fine-grinding, pelleting

Introduction

Cereal grains are ground to improve nutrient digestibility and pig growth performance. A wide range of ingredient particle sizes can be obtained by grinding through 1-, 2-, 3-, or even 4-high roller mills or hammer mills equipped with various screen sizes, hammer configurations, and operating conditions. Although numerous research studies have been conducted to investigate the impact of grinding cereal grains, little research has reported the effects of grinding complete diets after initial mixing.

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Pelleting is another feed processing technology used throughout the swine industry to improve nutrient utilization and pig performance, but few data are available on the interactions of pelleting diets in the presence of different particle sizes for individual ingredients or the entire diet. Therefore, the objective of this experiment was to determine the interactive effects of fine-grinding corn or complete diet grinding and diet form (pellet vs. meal) on nursery pig growth performance and caloric efficiency.

Procedures

The protocol for this experiment was approved by the Kansas State University Institutional Animal Care and Use Committee. The study was conducted at New Fashion Pork's nursery research facility in Buffalo Center, IA. Pens (6 × 13 ft) contained a 5-hole dry self-feeder and nipple waterer to allow for ad libitum access to feed and water. All pigs were fed common pelleted starter diets for the 19 d between weaning and the start of the experiment.

A total of 996 pigs (PIC TR4; initially 24.5 lb BW and 40 d of age) were used in a 21-d study to determine the effects of corn particle size, complete diet grinding, and diet form on nursery pig growth performance and caloric efficiency. Pens of pigs (28 pigs per pen) were balanced by initial BW and randomly allotted to 1 of 6 dietary treatments with 6 replications per treatment. The same corn-soybean meal–based diet containing 30% corn DDGS and 10% wheat midds was used for all treatments. The 6 treatments were: (1) roller mill–ground corn (737 µ) fed in meal form; (2) treatment 1 fed in pellet form; (3) hammer mill–ground corn (324 µ) fed in meal form; (4) treatment 3 fed in pellet form; (5) treatment 3 reground through a hammer mill (541 µ) fed in meal form; and (6) treatment 5 fed in pellet form.

All ingredients were ground and mixed at New Fashion Pork's feed mill in Estherville, IA. All 737-µ corn (treatments 1 and 2) was ground by a 2-high roller mill (RMS Roller Grinder, Tea, SD). Corn used in treatments 3 and 4 was finely ground using a full-circle hammer mill (Jacobsen Machine Works, Minneapolis, MN) equipped with a 1/16-in. screen. The complete diets used for treatments 5 and 6 were ground using a hammer mill (Easy Automation, Welcome, MN) equipped with a 1/16-in. screen. All pelleted diets were processed using a CPM pellet mill (California Pellet Mill, San Francisco, CA) equipped with a 1/6-in. die.

Pig weight and feed disappearance were measured on d 0, 7, 14, and 21 of the experiments to calculate ADG, ADFI, and F/G. Caloric efficiency of pigs was determined on both an ME and NE basis. Caloric efficiencies were determined using calculated dietary ingredient values for ME from NRC (2012) and for NE from INRA (2004). Values provided by the commercial producer were used for the ME and NE of DDGS. Caloric efficiency was calculated on a pen basis by multiplying total pen feed intake by the dietary energy level (kcal/lb) and dividing by total pen gain.

Multiple samples of each diet were collected from feeders, blended and subsampled, then submitted to Ward Laboratories, Inc. (Kearney, NE) for analysis of DM, CP, crude fat, crude fiber, ash, Ca, P, ADF, NDF, and NFE.

Bulk density was determined for all ingredients pre- and post-grind as well as for the complete diets. Particle size of the corn, soybean meal, DDGS, midds, and complete meal diets were determined using Tyler sieves, with numbers 6, 8, 10, 14, 20, 28, 35, 48, 65, 100, 150, 200, and 270 and a pan. A Ro-Tap shaker (W.S. Tyler, Mentor, OH) was used to sift the 100-g samples for 10 min. A geometric mean particle size (dgw) and the log-normal SD (sgw) were calculated by measuring the amount of grain remaining on each screen. Pellets were analyzed for standard pellet durability index (PDI), and a modified PDI was determined by adding five 13-mm hexagonal nuts prior to tumbling. Percentage fines and angle of repose were also determined for all pellet and meal diets, respectively.

Data were analyzed as a completely randomized design using PROC MIXED in SAS (SAS Institute, Inc., Cary, NC) with pen as the experimental unit. Contrasts were used to compare the effects of diet form, corn particle size, diet particle size, and the interactions of diet form × corn particle size and diet form × diet particle size. Results were considered significant at $P \leq 0.05$ and a trend at $P \leq 0.10$.

Results and Discussion

Chemical analysis of corn, soybean meal, midds, and DDGS confirmed that nutrients were similar to those used for diet formulation (Tables 1 and 2). The minor differences were not expected to influence the results of the experiment. Nutrient analysis of treatment diets (Table 3) showed that the concentrations were similar to formulated values. As expected, as the particle size of the diets decreased, the angle of repose increased, which illustrates reduced flowability with the finer particle sizes (Table 4). Bulk densities of meal diets were relatively similar. Diets that were pelleted were higher in bulk density compared with the meal diets. Across all treatments, PDI, modified PDI, and percentage fines were similar.

Overall (d 0 to 21), ADG and ADFI decreased when corn was finely ground and fed in meal form but increased when fed in pelleted form, resulting in a tendency ($P < 0.09$) for a diet form × corn particle size interaction. Fine-grinding the complete diet did not influence pig performance or the response to pelleting. Pelleting diets improved ($P < 0.04$) ADG, F/G, ME and NE energetic efficiencies, and final BW (Tables 5 and 6).

The interaction of diet form × corn particle size and numerical decreases in intake of pigs fed the fine-ground complete diet suggests that finely ground feed fed in meal form may reduce palatability of the diet; however, improved performance from fine-grinding may be realized if the diet is fed in pelleted form. In conclusion, pelleting diets significantly improved performance, and fine-grinding corn numerically improved performance when fed in pelleted form. No additional improvements were found when the complete diet with fibrous ingredients was finely ground compared with grinding only the corn.

Table 1. Diet composition (as-fed basis)[1]

Ingredient, %	
Corn	33.33
Soybean meal (46.5% CP)	22.82
Wheat middlings	10.00
DDGS[2]	30.00
Beef tallow	1.00
Monocalcium phosphate	0.30
Limestone	1.50
Salt	0.35
L-lysine HCl	0.45
Methionine hydroxy analog	0.08
L-threonine	0.08
Vitamin and mineral premix	0.10
Total	100.00
Calculated analysis	
Standardized ileal digestible (SID) amino acids, %	
Lysine	1.23
Isoleucine:lysine	64
Leucine:lysine	150
Methionine:lysine	33
Met & Cys:lysine	58
Threonine:lysine	62
Tryptophan:lysine	17.4
Valine:lysine	74
Total lysine, %	1.44
ME, kcal/lb[3]	1,522
NE, kcal/lb[4]	1,094
SID lysine:ME, g/Mcal	3.88
CP, %	3.66
Crude fiber, %	4.06
NDF, %	19.49
ADF, %	8.04
Ca, %	0.71
P, %	0.59
Available P, %	0.42

[1] Experimental diets were fed for 21 d beginning when pigs weighed 24.5 lb.
[2] Dried distillers grains with solubles.
[3] NRC. 2012. Nutrient Requirements of Swine. 11th ed. Natl. Acad. Press, Washington DC.
[4] INRA (Institut National de la Recherche Agronomique). 2004. Tables of composition and nutritional value of feed materials, Sauvant, D., J-M. Perez and G. Tran, Eds. Wageningen Academic Publishers, The Netherlands and INRA, Paris, France.

Table 2. Chemical analysis of ingredients (as-fed basis)[1,2]

Item	DDGS	Soybean meal	Corn	Wheat middlings
DM, %	89.56	90.06	87.67	89.34
CP, %	29.4 (27.2)	47.7 (46.5)	7.7 (8.50)	16.1 (15.90)
ADF, %	10.4	4.2	2.5	12.1
NDF, %	25.9	6.1	6.0	34.2
Crude fiber, %	8.0 (7.3)	3.1 (3.9)	1.6 (2.2)	8.9 (7.00)
NFE, %	37.5	31.4	73.6	53.6
Ca, %	0.05 (0.03)	0.56 (0.03)	0.06 (0.03)	0.25 (0.12)
P, %	0.91 (0.71)	0.70 (0.69)	0.25 (0.28)	1.15 (0.93)
Fat, %	9.9	0.9	3.2	4.2
Ash, %	4.39	6.62	1.20	5.75
Starch	3.1	1.7	61.9	16.3
Particle size, μ[3]	483	786	737; 324[3]	590
Particle size, SD[4]	2.07	2.01	1.89; 2.00	2.15
Bulk density, lb/bu	50.0	64.4	49.8; 48.2[4]	22.8

[1] Values in parentheses for dried distillers grains with solubles (DDGS) are taken from Stein (2007).
[2] Values in parentheses from NRC (1998).
[3] Values listed first are initial particle sizes, values listed second are particle sizes post–hammer mill grinding.
[4] Values listed first are roller mill–ground SD; values listed second are hammer mill–ground SD.

Table 3. Chemical analysis of diet[1]

Item	
DM, %	88.97
CP, %	19.7
ADF, %	4.9
NDF, %	11.2
Crude fiber, %	3.6
NFE, %	55.8
Ca, %	0.88
P, %	0.47
Fat, %	5.1
Ash, %	4.48
Starch, %	39.0

[1] Diet 1 was used for analysis.

Table 4. Physical characteristic of diets

Item	Treatment:	1	2	3	4	5	6
	Ingredient processed:	---	---	Corn[1]	Corn	Diet[2]	Diet
	Diet form:	Meal	Pellet	Meal	Pellet	Meal	Pellet
Particle size, µ		656	---	425	---	540	---
Bulk density, lb/bu		51.8	62.6	52.8	59.0	52.0	59.4
Angle of repose, °		46.9	---	54.4	---	51.8	---
Standard pellet durability index		---	91.6	---	93.5	---	92.1
Modified pellet durability index		---	89.4	---	91.5	---	90.1
Fines, %		---	1.3	---	1.3	---	1.2

[1] Corn was fine-ground to approximately 324 µ.
[2] Diet was fine-ground to approximately 540 µ.

Table 5. Effects of corn particle size, complete diet grinding, and diet form on 24- to 50-lb nursery pig growth performance[1]

Item	Treatment:	1	2	3	4	5	6	
	Ingredient finely ground:	---	---	Corn[2]	Corn	Diet[3]	Diet	
	Diet form:	Meal	Pellet	Meal	Pellet	Meal	Pellet	SEM
d 0 to 21								
ADG, lb		0.93	0.95	0.89	1.00	0.92	0.99	0.03
ADFI, lb		1.22	1.19	1.18	1.24	1.20	1.23	0.03
F/G		1.54	1.46	1.57	1.45	1.54	1.43	0.21
Caloric efficiency[4]								
ME		5.18	4.90	5.28	4.87	5.17	4.79	32.71
NE		3.72	3.53	3.80	3.50	3.72	3.44	23.51
Wt, lb								
d 21		44.2	44.6	43.1	45.5	44.0	45.4	0.8

[1] A total of 996 pigs (initially 24.5 lb BW and 40 d of age) were used in a 21-d study with 28 pigs/pen and 6 pens/treatment.
[2] Corn was fine-ground to approximately 324 µ.
[3] Diet was fine-ground to approximately 540 µ.
[4] Caloric efficiency is expressed as kcal/lb gain.

Table 6. Effects of corn particle size, complete diet grinding, and diet form on 24- to 50-lb nursery pig growth performance

	Probability, *P* <				
Item Contrast:	Pelleting × Corn µ[1]	Pelleting × portion ground[2]	Diet form[3]	Corn µ[4]	324-µ corn vs. 540-µ diet[5]
d 0 to 21					
ADG, lb	0.07	0.45	0.002	0.84	0.61
ADFI, lb	0.09	0.42	0.84	0.65	0.88
F/G	0.33	0.82	0.001	0.61	0.20
Caloric efficiency[6]					
ME	0.34	0.82	0.001	0.61	0.20
NE	0.34	0.82	0.001	0.61	0.20
Wt, lb					
d 21	0.23	0.55	0.04	0.90	0.62

[1] Interactive effects of diet form and corn µ.
[2] Interactive effects of diet form and corn or complete diet grinding.
[3] Treatments 1, 3, and 5 vs. 2, 4, and 6.
[4] Treatments 1 and 2 vs. 3 and 4.
[5] Treatments 3 and 4 vs. 5 and 6.
[6] Caloric efficiency is expressed as kcal/lb gain.