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Abstract

Eighty barrows (113.7 lb average initial weight) were used to determine the effects of extruding corn, sorghum, wheat, and barley on growth performance, carcass merit, nutrient digestibility, and changes in stomach morphology of finishing pigs. Treatments were grain source (com, sorghum, wheat, and barley) and processing procedure (grinding vs extrusion) arranged as a 4 x 2 factorial. Grinding was in a Jacobson hammermill and extrusion was in an Insta-Pro extruder. Pigs fed com had improved average daily gain (ADG), feed/gain (F/G), DM digestibility, and N digestibility compared to the other grain sources. Diets with barley supported the poorest growth performance and nutrient digestibilities, with sorghum and wheat intermediate. Extrusion of the cereal grains did not affect ADG but increased efficiency of gain by 4, 9, 6, and 3% for corn, sorghum, wheat, and barley, respectively. Digestibilities of DM and N were also increased on average by extrusion processing, with barley responding the most (9 and 12% increases for DM and N digestibilities) and wheat responding the least (no improvement). Overall, extrusion processing improved nutritional value of cereal grains for finishing pigs. However, swine producers must be careful to evaluate the overall economic benefits before adopting this or any other new technology.; Swine Day, Manhattan, KS, November 19, 1992

Keywords

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EXTRUDED CORN, SORGHUM, WHEAT, AND BARLEY FOR FINISHING PIGS

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Summary

Eighty barrows (113.7 lb average initial weight) were used to determine the effects of extruding corn, sorghum, wheat, and barley on growth performance, carcass merit, nutrient digestibility, and changes in stomach morphology of finishing pigs. Treatments were grain source (corn, sorghum, wheat, and barley) and processing procedure (grinding vs extrusion) arranged as a 4 × 2 factorial. Grinding was in a Jacobson hammermill and extrusion was in an Insta-Pro® extruder. Pigs fed corn had improved average daily gain (ADG), feed/gain (F/G), DM digestibility, and N digestibility compared to the other grain sources. Diets with barley supported the poorest growth performance and nutrient digestibilities, with sorghum and wheat intermediate. Extrusion of the cereal grains did not affect ADG but increased efficiency of gain by 4, 9, 6, and 3% for corn, sorghum, wheat, and barley, respectively. Digestibilities of DM and N were also increased on average by extrusion processing, with barley responding the most (9 and 12% increases for DM and N digestibilities) and wheat responding the least (no improvement). Overall, extrusion processing improved nutritional value of cereal grains for finishing pigs. However, swine producers must be careful to evaluate the overall economic benefits before adopting this or any other new technology.

(Key Words: Process, Extrusion, Sorghum, Wheat, Barley, Corn, Performance, G-F.)

Introduction

There is considerable interest in use of extrusion processing to prepare ingredients for swine diets. Previous articles in KSU Swine Day Reports indicated improved utilization of protein in weanling pigs fed conventional and low-inhibitor soybeans, soy flour, soy protein concentrates, and soybean flakes when extruded rather than toasted. However, much less is known about the effects of extruded cereal grains when used in swine diets. In the 1990 and 1991 KSU Swine Day Reports [Reports of Progress No. 610 (page 76) and 641 (page 92), respectively] we reported 5 to 20% improvements in growth performance and nutrient digestibility in finishing pigs fed diets with extruded sorghum and(or) soybeans compared to ground sorghum and soybean meal. These results suggest that extrusion processing might be used to increase the feeding value of cereal grains that have less digestible energy than corn. The data reported herein result from an experiment to determine the effects of extrusion processing on nutritional values of corn, sorghum, wheat, and barley for finishing pigs. In particular, the utility of extrusion compared to grinding to improve the nutritional values of sorghum, wheat, and barley relative to ground corn was of interest.

Procedures

Eighty barrows, with an average initial weight of 113.7 lb, were assigned to eight dietary treatments based on weight and ancestry. There were two pigs per pen and five pens per treatment. The pigs were housed in a totally enclosed, environmentally regulated building with slatted flooring. Each pen (5 ft × 5 ft) had a single-hole self-feeder and nipple waterer, so feed and water could be consumed on an ad libitum basis.

Treatments were grain source (corn, sorghum, wheat, and barley) and processing procedure (grinding vs extrusion), so that the overall treatment arrangement was a 4 × 2 factorial. The ground grain treatments were processed through a Jacobson Pulverator® hammermill with a targeted mean particle size of 750 μm. The hammermill had a screen with 3/16 in. openings and yielded particle sizes of 780, 720, 783, and 711 μm for corn, sorghum, wheat, and barley, respectively. All diets were supplemented with extruded soybeans as a protein source. For the extruded grain treatments, ground cereal grains were tempered to 18% moisture and blended with extruded soybeans, and the mixture was extruded. Extrusion was in an Insta-Pro® extruder with a targeted barrel temperature of 145°F. Actual barrel temperatures and throughputs for the corn, sorghum, wheat, and barley were 136°F (1,320 lb/hr), 137°F (1,320 lb/hr), 160°F (1,272 lb/hr), and 153°F (1,272 lb/hr), respectively. Previous experiments with sorghum indicated reduced feed intake in finishing pigs fed extruded grain, so a diet with .70% lysine (wheat-based) was formulated to ensure adequate intakes of amino acids. All other grain treatments were substituted for the ground wheat on an equal weight basis with crystalline lysine used to bring all diets to .70% (Table 1).

The pigs were fed to an average ending weight of 249 lb and slaughtered for collection of carcass measurements and stomach tissues. The esophageal regions of the stomachs were scored on a scale of 0 to 3 (0 = normal and 3 = severe) for keratinization and lesions. Additionally, 5 d before slaughter, .1% chromic oxide was added to the diets as an indigestible marker. The day before slaughter, fecal samples were collected. The fecal samples were dried; pooled within pen; and analyzed for Cr, DM, and N to allow calculation of DM and N digestibilities.

The data were analyzed for effects of grain source (corn vs others, sorghum and wheat vs barley, and sorghum vs wheat), processing procedure (grinding vs extrusion), and interactions of grain source with processing procedure. Dressing percentage and last rib fat thickness for each pig were adjusted to an average hot carcass weight (using regression analysis) before being pooled within pen. Also, stomach scores for keratinization and lesions were transformed (square root transformation) before statistical analyses.

Results and Discussion

The diets were formulated with equal weight substitutions of the cereal grains; thus, differences in nutrient concentrations of the grains were apparent in the diets (Table 1). Crude protein concentrations ranged from 13% for the corn-based diets to 16.2% for the wheat-based diets. The calculated metabolizable energy (ME) concentrations ranged from 1,519 kcal/lb for the corn-based diets to 1,385 kcal/lb for the barley-based diets. The sorghum and wheat diets were very similar in ME concentrations, with values of 1,468 and 1,481 kcal/lb, respectively. Fiber concentrations were similar for the diets with corn, sorghum, and wheat (average of 2.8%), but diets with barley had much more fiber (4.9%), that was largely responsible for the lower ME concentrations.

Diets with corn supported greater average daily gain (ADG) than the other cereal grains ($P<.01$), and diets with barley supported lower ADG than diets with sorghum and wheat ($P<.01$). As would be expected, the diets with greatest calculated ME concentrations (i.e., corn-based diets) gave the greatest efficiencies of gain ($P<.01$). Pigs fed barley were least efficient ($P<.01$), and pigs fed sorghum were more efficient than pigs fed wheat ($P<.05$). Extrusion did not affect ADG, but improved ($P<.01$) feed/gain (F/G) with increases of 4, 9, 6, and 3% for corn, sorghum, wheat, and barley, respectively. Because extrusion has been reported to improve starch, protein, and fiber digestibilities, we anticipated that feedstuffs typically lower in feeding value might benefit most from extrusion. This did result with sorghum and wheat, with larger improvements from extrusion than with corn. However, the smaller response (i.e., only 3% improvement) to extrusion in barley-based diets was disappointing.

Dressing percentage was not affected by grain source, but pigs fed extruded grains had 2% greater dressing percentages than pigs fed ground grains ($P<.01$). Last rib fat thickness was not affected by dietary treatment ($P>.23$).

Digestibilities of DM and N closely paralleled differences in F/G. Corn had greater DM and N digestibilities than the other grains, sorghum and wheat were more digestible than barley, and extruded grains were more digestible than ground grains ($P<.01$). There was an interaction between grain source and extrusion ($P<.05$), with DM digestibility of the barley-based diet responding more to extrusion than digestibilities of the sorghum- and wheat-based diets. However, even with the marked improvements from extrusion processing, the barley-based diet still had lower DM and N digestibilities than other treatments.

A final consideration in evaluation of extrusion processing of cereal grains is any adverse effects on stomach morphology. Reports in the 1960s suggested that extruded cereal grains caused marked increases in the incidence and severity of stomach ulcers. In the present experiment, extrusion increased stomach keratinization ($P<.01$). However, only two of the 80 pigs had stomach lesions, and both of those pigs were fed ground grain rather than extruded grain (i.e., one was fed the ground corn treatment and one was fed the ground barley treatment).

In conclusion, extrusion processing of cereal grains improved nutrient digestibility and efficiency of gain in finishing pigs. The greatest increase in nutrient digestibility was for pigs fed barley-based diets, and the greatest improvement in efficiency of gain was for pigs fed sorghum-based diets. This technology offers promise in terms of improved nutritional value of cereal grains, provided that costs of processing and equipment continue to decrease.

Table 1. Diet Composition[a]

Item	Corn	Sorghum	Wheat	Barley
Cereal grain[bc]	80.11	80.08	80.46	80.42
Extruded soybeans	16.81	16.81	16.81	16.81
Lysine-HCl	.15	.18	—	—
Monocalcium phosphate	1.21	1.21	1.02	.94
Limestone	.82	.82	.81	.93
Vitamins and minerals[d]	.70	.70	.70	.70
Antibiotic[e]	.20	.20	.20	.20
Total	100	100	100	100
Calculated values				
CP, %	13.0	13.3	16.2	15.3
Lysine, %	.70	.70	.70	.70
ME, kcal/lb	1,519	1,468	1,481	1,385
Fiber, %	2.7	2.7	3.0	4.9

[a]All diets were formulated to .65% Ca and .55% P.
[b]The grains were fed ground (mean particle sizes of 780, 720, 783, and 711 μm for corn, sorghum, wheat, and barley, respectively) and extruded. Extruded soybeans were blended with the grains before extrusion.
[c]The extruded grain-soybeans mixture replaced ground grain and extruded soybeans on an equal weight basis.
[d]KSU vitamin mix (.25%), KSU mineral mix (.10%), selenium mix (.05%), and salt (.3%).
[e]Supplied 100 g chlortetracycline per ton of diet.

Table 2. Effects of Extrusion on the Nutritional Value of Corn, Sorghum, Wheat, and Barley for Finishing Pigs[a]

	Corn		Sorghum		Wheat		Barley		
Item	Ground	Extruded	Ground	Extruded	Ground	Extruded	Ground	Extruded	CV
ADG, lb[bd]	2.22	2.22	2.19	2.13	2.12	2.09	1.97	1.95	5.0
ADFI, lb[g]	6.58	6.29	6.83	6.05	6.80	6.34	6.54	6.30	4.5
F/G[bdfg]	2.96	2.83	3.12	2.84	3.21	3.03	3.32	3.23	4.4
Dressing percentage[g]	72.4	74.7	73.2	74.7	73.3	74.4	72.6	73.8	1.9
Fat thickness, in.	1.21	1.27	1.17	1.28	1.30	1.29	1.18	1.23	10.8
DM digestibility, %[bdfgi]	86.7	91.4	88.8	90.2	86.0	85.9	75.9	82.4	3.4
N digestibility, %[bdegh]	81.8	88.0	79.7	84.4	85.4	85.4	70.5	78.8	4.8
Stomach keratinization[cg]	.92	1.37	1.07	1.25	.56	1.25	.17	1.09	17.1

[a]A total of 80 barrows (two pigs/pen and five pens/treatment) were fed from an average initial weight of 114 lb to an average final weight of 249 lb.
[b]Corn vs other grains ($P<.01$).
[cd]Sorghum and wheat vs barley ($P<.05$ and $P<.01$, respectively).
[ef]Sorghum vs wheat ($P<.10$ and $P<.05$, respectively).
[g]Ground vs extruded ($P<.05$).
[hi]Sorghum and wheat vs barley × ground vs extruded ($P<.10$ and $P<.05$, respectively).