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EXTRUDED CORN, SORGHUM, AND SOYBEAN MEAL FOR NURSERY PIGS

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Summary

Two experiments were conducted to determine the nutritional value of extruded corn, sorghum, and soybean meal (SBM) for nursery-age pigs. Experiment 1 involved 180 weanling pigs, with an average age of 22 d and average weight of 13.2 lb. Treatments were 1) corn-SBM-dried whey-based control, 2) extruded corn (Ecorn)-SBM, 3) Ecorn-extruded SBM (ESBM), 4) sorghum-SBM, 5) extruded sorghum (Esorghum)-SBM, 6) Esorghum-ESBM. Extrusion of the grains improved feed to gain (F/G) but reduced average daily feed intake (ADFI) in phase 1 (d 0 to 10). For phase 2 (d 10 to 24), phase 3 (d 24 to 38), and overall, corn supported greater average daily gain (ADG) and ADFI compared to sorghum. Extrusion of the grain reduced ADG and ADFI. Extrusion of SBM improved ADG and ADFI of pigs fed the extruded grains. Corn had greater DM and N digestibilities than sorghum, and extrusion increased DM and N digestibilities compared to ground grains. In Exp. 2, 192 pigs were used (average age of 22 d and 12.6 lb initial weight). Treatments were arranged as a 2 × 2 × 2 factorial, with main effects of grain source (corn vs sorghum), processing method (grinding vs extrusion), and soybean meal treatment (SBM vs ESBM). Contrary to Exp. 1, sorghum supported greater ADG and ADFI compared to corn for phase 1. Extrusion of the grains reduced ADFI in phase 1, phase 3, and overall and reduced ADG in phase 3 and overall. Extrusion of SBM improved ADG and ADFI with ground grains but reduced ADG and ADFI with extruded grains. Extrusion of the grains and SBM improved DM and N digestibilities. In conclusion, extruded corn and sorghum improved performance for d 0 to 10 postweaning, but reduced growth performance if fed for the entire nursery period.

(Key Words: Extrusion, Sorghum, Soybean Meal, Corn, Process, Nursery.)

Introduction

Data in the 1990 and 1991 KSU Swine Day Reports of Progress (pages 76 and 92, respectively) indicated that extrusion of sorghum improved feed efficiency and digestibility of nutrients in finishing pigs. Thus, extrusion could improve the nutritional value of sorghum grain to a level more comparable to that of corn. This might be true especially in young pigs with their limited ability to digest proteins and carbohydrates (e.g., starch) of plant origin. Likewise, extrusion of a defatted soy flour yielded a product of greater nutritional value than toasted soybean meal for nursery pigs (1990 KSU Swine Day Report of Progress No. 610, page 37). Thus, extrusion of diet ingredients offers potential for increased nursery pig performance compared to ground grain and SBM. Therefore, two experiments were conducted to determine the effects of extruding cereal grains and SBM on growth performance and nutrient digestibility in nursery-age pigs.

Procedures

In Exp. 1, 180 weanling pigs, averaging 22 d of age and 13.2 lb initial weight, were used in a 38-d growth assay to determine the effects of extruding corn, sorghum, and SBM on growth performance and nutrient digestibility. Pigs were blocked by weight and randomly allotted to treatment based on sex and ancestry. Treatments were 1) corn-SBM-dried whey-based control, 2) extruded corn (Ecorn) to replace the corn in Diet 1, 3) Ecorn and extruded SBM (ESBM) to replace the corn and SBM in Diet 1, 4) sorghum to replace the corn in Diet 1, 5) extruded sorghum (Esorghum) to replace the corn in Diet 1, and 6) Esorghum and ESBM to replace the corn and SBM in Diet 1. Phase 1 diets (d 0 to 10) were formulated to 1.5% lysine, .9% Ca, and .8% P. Phase 2 diets (d 10 to 24) were formulated to 1.25% lysine, .8% Ca, and .7% P, and phase 3 diets (d 24 to 38) were formulated to 1.1% lysine, .8% Ca, and .7% P (Table 1).

Ground grains were prepared by grinding through a Jacobson Pulverator® hammermill equipped with a screen having 3/16 in. openings. For the extrusion treatments, ground grains and SBM were extruded through a single-screw extruder (Insta Pro®, Model 2000). Grains and SBM were adjusted to 18% moisture prior to extrusion, and one-half the dietary oil was added to the SBM to aid in the extrusion process. Extruder barrel temperatures were 148°F for corn, 146°F for sorghum, and 183°F for SBM. Following extrusion, all products were coarsely ground through a roller mill. Phase 1 diets were pelleted through a 5/32 in. die. Phase 2 and phase 3 diets were pelleted through a 3/16 in. die.

Table 1. Diet Composition (Exp. 1 and 2), %

Item	Phase 1[a]	Phase 2[b]	Phase 3[c]
Grain source[d]	36.41	43.22	62.85
Soybean meal (48%CP)	16.60	30.58	30.23
Spray-dried porcine plasma	10.00	—	—
Dried whey (edible grade)	30.00	20.00	—
Lysine-HCl	—	.01	.02
D,L-methionine	.10	—	—
Soybean oil	3.00	3.00	3.00
Monocalcium phosphate (21% P)	1.87	1.27	1.80
Limestone	.37	.62	.75
Vitamins and minerals[e]	.55	.55	.55
Salt	—	.25	.30
Antibiotic[f]	1.00	.50	.50
Chromic oxide	.10	—	—
Total	100	100	100

[a]Phase 1 diets (d 0 to 10) were formulated to 1.50% lysine, 22% CP, .9% Ca, and .8% P.
[b]Phase 2 diets (d 10 to 24) were formulated to 1.25% lysine, 21% CP, .8% Ca, and .7% P.
[c]Phase 3 diets (d 24 to 38) were formulated to 1.10% lysine, 20% CP, .8% Ca, and .7% P.
[d]Grain sources (i.e., corn, sorghum, extruded corn, and extruded sorghum) were substituted on an equal weight basis with lysine-HCl added to the sorghum diets to equalize lysine concentrations. Soybean meal treatments (nonextruded or extruded) were added on an equal weight basis.
[e]KSU vitamin premix (.25%), KSU mineral premix (.15%), Se premix (.05%), and copper sulfate (.10%).
[f]Phase 1 antibiotic supplied 200 g furazolidone, 100 g oxytetracycline, and 90 g arsanilic acid per ton of diet. Phases 2 and 3 antibiotic supplied 100 g chlortetracycline, 100 g sulfathiazole, and 50 g penicillin per ton of diet.

Pigs were housed in 4 ft × 5 ft pens with wire-mesh flooring. Room temperatures were 87, 84, 80, and 75°F for wk 1 to 5, respectively. Each pen had a self-feeder and nipple waterer to allow ad libitum consumption of feed and water. There were six pigs per pen with five pens per treatment. Pigs and feeders were weighed on d 10, 24, and 38 to allow calculation of ADG, ADFI, and F/G. On d 9, fecal samples were collected from four pigs per pen; dried; pooled; and analyzed for Cr, DM, and N to allow calculation of apparent nutrient digestibilities.

In Exp. 2, 192 weanling pigs, averaging 22 d of age and 12.6 lb, were used in a 38-d experiment to determine the effects of feeding Ecorn and Esorghum, with and without ESBM, on growth performance of weanling pigs. At weaning, pigs were blocked by weight and randomly allotted to treatment based on sex and ancestry. Treatments were 1) corn-SBM-dried whey-control, 2) Ecorn to replace the corn in Diet 1, 3) ESBM to replace the SBM in Diet 1, 4) Ecorn and ESBM to replace the corn and SBM in Diet 1, 5) sorghum to replace the corn in Diet 1, 6) Esorghum to replace the corn in Diet 1, 7) sorghum and ESBM to replace the corn and SBM in Diet 1, and 8) Esorghum and ESBM to replace the corn and SBM in Diet 1. Nutrient concentrations were the same as in Exp. 1 (Table 1).

The grains and SBM were processed as in Exp. 1, but barrel temperatures varied somewhat (i.e., 151°F for corn, 133°F for sorghum, and 140°F for SBM). Phase 1 diets were pelleted through a 5/32 in. die and phase 2 and 3 diets were fed in meal form.

Pigs were housed and managed as in Exp. 1, with four pens per treatment. Fecal samples were collected and analyzed as in Exp. 1. Blood samples were collected on d 9 and analyzed for serum urea N concentrations and antisoy antibody titers.

Results and Discussion

For Exp. 1 (Table 2), phase 1 treatment did not affect ADG ($P > .10$). Extrusion of corn and sorghum resulted in decreased ADFI ($P < .06$) and improved F/G ($P < .001$). Apparent digestibilities of DM and N were greater for corn than sorghum ($P < .001$), and extruded grains had greater DM ($P < .05$) and N ($P < .05$) digestibilities than ground grains.

In phase 2, diets with corn supported improved ADG ($P < .001$), ADFI ($P < .001$), and F/G ($P < .01$) compared to diets with sorghum. Extrusion of the grains decreased ADG and ADFI ($P < .001$) compared to diets with ground grains. However, adding ESBM to diets with extruded grains improved ADG ($P < .001$) to levels similar to those of the ground grain-SBM diets and improved efficiencies of gain compared to other treatments.

For phase 3 and overall, pigs fed corn had greater ADG ($P < .001$) and ADFI ($P < .001$) than those fed sorghum. In contrast with phase 1 effects, extrusion of corn and sorghum resulted in decreased ADG ($P < .01$) compared to grinding the grains. Use of ESBM in diets with the extruded grains improved ($P < .001$) ADG and ADFI, but not to levels comparable to the ground grain-SBM treatments.

For Exp. 2, sorghum supported greater ($P < .01$) ADG and ADFI compared to corn during phase 1 (Table 3). Also, diets with sorghum had greater DM digestibility ($P < .05$) than diets with corn. Extrusion of corn gave improved F/G ($P < .05$); however, F/G was not changed by extrusion of the sorghum. Furthermore, pigs fed extruded grains had increased serum urea N ($P < .001$) with reduced ADFI, suggesting that extruding the grain may have complexed some of the amino acids (e.g., lysine) in an undigestible form, creating a less desirable amino acid balance. Extrusion of SBM increased DM ($P < .05$) and N ($P < .01$) digestibilities, especially in diets with corn. However, extrusion of the SBM did not reduce serum antisoy antibody titers compared to SBM (P>.10).

During Phase 2, pigs fed extruded grains had improved F/G (P<.06) compared to pigs fed ground grains. However, there was an interaction between the effects of ESBM and grain source, i.e., when ESBM was fed with corn, it gave a trend for improved ADG (P<.06) and F/G (P<.08), but when fed with sorghum, it gave poorer ADG and F/G. During phase 3 and overall, ADG (P<.01) and ADFI (P<.001) were reduced by extrusion of the grains. Use of ESBM increased ADG (P<.05) and ADFI (P<.01), but only when fed with ground grains and not with extruded grains.

In conclusion, extrusion of corn and sorghum improved diet utilization for the initial postweaning period (d 0 to 10), but was of no benefit from d 10 to 38. Extrusion of SBM improved growth performance of pigs fed extruded grains in Exp. 1 and pigs fed ground grains in Exp. 2, but the inconsistencies in response necessitate further investigation before this application of extrusion technology can be recommended.

Table 2. Effects of Extruded Grain and Soybean Meal on Nursery Pigs (Exp. 1)[a]

Item	Corn-SBM[b]	Ecorn-SBM	Ecorn-ESBM	Sorg-SBM	Esorg-SBM	Esorg-ESBM	CV
d 0 to 10							
ADG, lb	.58	.59	.56	.52	.52	.57	15.4
ADFI, lb[e]	.65	.60	.56	.59	.52	.57	13.5
F/G[g]	1.12	1.02	1.00	1.13	1.00	1.00	4.1
d 10 to 24							
ADG, lb[dfi]	.98	.65	.93	.77	.49	.80	14.4
ADFI, lb[dgi]	1.39	1.06	1.30	1.19	.87	1.22	10.1
F/G[ci]	1.42	1.63	1.40	1.55	1.78	1.53	10.3
d 24 to 38							
ADG, lb[dgi]	1.46	.95	1.24	1.13	.88	1.05	12.0
ADFI, lb[dgi]	2.27	1.56	1.93	1.83	1.37	1.66	8.7
F/G	1.55	1.64	1.56	1.62	1.56	1.58	8.2
d 0 to 38							
ADG, lb[dgi]	1.03	.74	.93	.82	.63	.82	10.2
ADFI, lb[dgi]	1.48	1.10	1.30	1.24	.94	1.19	7.9
F/G[h]	1.44	1.49	1.40	1.51	1.49	1.45	5.3
Digestibilities (d 9), %							
DM[dej]	92.1	91.4	92.4	88.3	90.6	90.5	1.4
N[de]	87.9	88.4	90.0	82.1	85.8	84.7	2.7

[a]A total of 180 pigs (six pigs/pen and five pens/treatment) with an average initial weight of 13.2 lb.
[b]SBM=soybean meal, Ecorn=extruded corn, ESBM=extruded soybean meal, Sorg=sorghum, and Esorg=extruded sorghum.
[cd]Corn vs sorghum (P<.01 and P<.001, respectively).
[efg]Ground grain vs extruded grain (P<.06, P<.01, and P<.001, respectively).
[hi]Extruded grain vs extruded grain with extruded SBM (P<.05 and P<.001, respectively).
[j]Corn vs sorghum × ground grain vs extruded grain (P<.02).

Table 3. Effects of Extruded Grain and Soybean Meal on Nursery Pigs (Exp. 2)[a]

	Corn[b]		Ecorn		Sorghum		Esorghum		
Item	SBM	ESBM	SBM	ESBM	SBM	ESBM	SBM	ESBM	CV
d 0 to 10									
ADG, lb[dk]	.57	.52	.58	.47	.63	.66	.52	.63	11.5
ADFI, lb[dek]	.59	.57	.58	.47	.63	.67	.56	.61	8.8
F/G[im]	1.04	1.10	1.00	1.00	1.00	1.02	1.08	.97	5.3
d 10 to 24									
ADG, lb[jm]	.60	.70	.73	.72	.71	.71	.76	.58	14.7
ADFI, lb[im]	1.06	1.17	1.22	1.12	1.22	1.17	1.14	.96	9.0
F/G	1.77	1.67	1.67	1.56	1.72	1.65	1.50	1.66	9.8
d 24 to 38									
ADG, lb[em]	1.11	1.26	1.16	.96	1.23	1.27	1.01	.95	12.0
ADFI, lb[fn]	1.82	2.07	1.88	1.65	2.03	2.18	1.77	1.66	9.1
F/G	1.64	1.64	1.62	1.72	1.65	1.72	1.75	1.75	6.1
d 0 to 38									
ADG, lb[ein]	.78	.86	.85	.74	.88	.90	.79	.73	8.6
ADFI, lb[fin]	1.22	1.34	1.29	1.14	1.36	1.41	1.22	1.13	7.2
F/G	1.56	1.56	1.52	1.54	1.55	1.57	1.54	1.55	3.9
Digestibilities (d 9), %									
DM[cglo]	90.9	93.8	91.3	92.8	93.9	92.0	92.8	93.2	.9
N[hl]	86.0	91.8	86.3	91.1	90.8	87.6	88.9	90.1	2.4
Serum urea N (d 9),									
mg/dL[f]	8.3	7.8	9.4	9.4	8.0	6.7	10.7	9.7	14.2
Antisoy titers (d 9),									
log_2	10.25	10.00	10.00	9.75	10.25	9.50	9.50	9.75	5.8

[a]A total of 192 pigs (six pigs/pen and four pens/treatment) with an average initial weight of 12.6 lb.
[b]SBM = soybean meal, ESBM = extruded soybean meal, Ecorn = extruded corn, and Esorghum = extruded sorghum.
[cd]Corn vs sorghum ($P < .05$ and $P < .01$, respectively).
[ef]Ground grain vs extruded grain ($P < .01$ and $P < .001$, respectively).
[gh]SBM vs ESBM ($P < .05$ and $P < .01$, respectively).
[i]Corn vs sorghum × ground grain vs extruded grain ($P < .05$).
[jkl]Corn vs sorghum × SBM vs ESBM ($P < .06$, $P < .01$, and $P < .001$, respectively).
[mn]Ground grain vs extruded grain × SBM vs ESBM ($P < .06$ and $P < .01$, respectively).
[o]Corn vs sorghum × ground grain vs extruded grain × SBM vs ESBM ($P < .01$).