EFFECTS OF EXPANDER CONDITIONING ON THE NUTRITIONAL VALUE OF DIETS WITH DRIED DISTILLERS GRAINS WITH SOLUBLES IN NURSERY AND FINISHING PIGS

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Summary

Three experiments were conducted to determine the effects of expander conditioning on nutritional value of diets without and with corn- and sorghum-based dried distillers grains with solubles (DDGS). In Exp. 1, 180 nursery pigs (average weight 29 lb) were assigned to 30 pens. Treatments were arranged as a 3 × 2 factorial with main effects of diet formulation (corn-soybean meal vs. 30% corn- or sorghum-based DDGS) and conditioning (standard steam vs. expander) prior to pelleting. Pigs fed corn-soybean meal diets had better ($P < 0.005$) ADG, F/G, and digestibility of DM, N, and GE than pigs fed diets with DDGS. Diets with corn-based DDGS supported better ($P < 0.03$) ADG, F/G, and digestibility of DM and N than diets with sorghum-based DDGS. Expander processing improved ($P < 0.009$) ADG, F/G, and digestibility of DM, N, and GE compared with standard conditioning. Pigs fed diets with sorghum-based DDGS showed the greatest response in F/G to expander conditioning leading to a DDGS source × conditioning interaction ($P < 0.008$). In Exp. 2, 176 finishing pigs (average weight 164 lb) were assigned to 16 pens. Treatments were arranged as a 2 × 2 factorial with main effects of diet formulation (corn-soybean meal vs. 40% sorghum-based DDGS) and conditioning (standard steam vs. expander) prior to pelleting. Net electrical energy required for feed processing was lower ($P < 0.001$) and production rate was greater ($P < 0.005$) for the corn-soybean meal diets than for diets with DDGS. However, pellet durability was improved ($P < 0.001$) by addition of DDGS to the diets. Pigs fed corn-soybean meal diets had better ($P < 0.03$) overall ADG and F/G than pigs fed diets with DDGS. Expander conditioning did not affect ADG ($P > 0.83$) but improved overall F/G and dressing percentage ($P < 0.007$). In Exp. 3, 192 finishing pigs (average weight 222 lb) were assigned to 16 pens to determine nutrient digestibility. Treatments were the same as in Exp. 2. Feed and water was consumed ad libitum during a 6-d adjustment period; then, feces were collected for 2 d. Corn-soybean meal diets had greater ($P < 0.001$) digestibility of DM, N, and GE than diets with DDGS, and expander conditioning improved ($P < 0.02$) digestibility of DM, N, and GE compared with standard conditioning. However, the improved digestibility of DM with expander conditioning was apparent primarily for the DDGS diets (diet × conditioning interaction, $P < 0.01$). In conclusion, expanding diets improved ADG, F/G, and nutrient digestibility in nursery pigs and F/G, dressing percentage, and nutrient digestibility in finishing pigs fed diets without and with DDGS.

Key words: digestibility, dried distillers grains with solubles, expander conditioning

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Introduction

The U.S. Renewable Fuel Standard mandates that 15 billion gal of ethanol from grain starch will be needed by 2015. Thus, it seems certain that coproducts from the ethanol industry, such as dried distillers grains with solubles (DDGS), will continue to increase in supply and use in diets for pigs. Dried distillers grains with solubles have about three times as much fiber as the cereals from which they are produced. In the 2007 Swine Day Report of Progress, (Feoli et al., page 126 and Feoli et al., page 131), we suggested that addition of high levels of DDGS in diets for nursery and finishing pigs had negative effects on nutrient digestibility and growth rate. Previous experiments from our laboratory have shown that conditioning wheat midds-based diets high in fiber in an expander prior to pelleting improved nutrient digestibility in nursery and finishing pigs. Therefore, the objective of the present experiments was to determine the effects of expander conditioning on the nutritional value of diets with and without DDGS.

Procedures

For Exp. 1, 180 nursery pigs (42 d old and initially 29 lb) were used in a 14-d growth assay. The pigs were sorted by sex and ancestry, blocked by weight, and assigned to pens. There were 3 gilts and 3 barrows in each pen and 5 pens per treatment. The pigs were housed in an environmentally controlled nursery having 4-ft × 4-ft pens with woven-wire flooring. Each pen had a self-feeder and nipple waterer to allow ad libitum consumption of feed and water.

Treatments were arranged as a 3 × 2 factorial with main effects of diet formulation (Table 1; corn-soybean meal vs. diets with 30% corn-based DDGS from Sioux River Ethanol, Hudson, SD, and 30% sorghum-based DDGS from U.S. Energy Partners, Russell, KS) and conditioning (standard steam vs. expander) prior to pelleting. All diets (Table 1) were formulated to 1.4% lysine, 0.75% Ca, and 0.65% P.

Table 1. Composition of nursery diets

Ingredient, %	Corn-soybean meal	DDGS[1]
Corn	62.86	42.97
DDGS	---	30.00
Soybean meal (47.5% CP)	32.60	22.85
Limestone	1.11	1.36
Monocalcium phosphate (21% P)	1.30	0.67
Salt	0.36	0.35
L-lysine HCl	0.32	0.53
DL-methionine	0.12	0.02
L-threonine	0.09	0.05
Vitamin premix	0.11	0.11
Mineral premix	0.08	0.05
Antibiotic[2]	0.70	0.70
Chromic oxide[3]	0.25	0.25
Copper sulfate	0.10	0.09
Calculated analysis		
Lysine	1.40	1.40
Ca	0.75	0.75
Total P	0.65	0.65

[1] Dried distillers grains with solubles.
[2] To supply 140 g/ton oxytetracycline and 140 g/ton neomycin.
[3] Used as an indigestible marker.

Diets were either steam conditioned to 180°F or expanded conditioned (302°F, 200 PSI) before passing into a pelleting press (30 HD Master Model, California Pellet Mill, San Francisco, CA) equipped with a 7/8-in.-thick die having 5/32-in. openings. Samples of the processed diets were collected, and pellet durability index (PDI) was determined by using the tumbling-box technique (ASAE S269.4 DEC1991). Additionally, the PDI procedure was modified to induce more stress on the pellets by adding 5 hexagonal nuts into the tumbling box.

Pigs and feeders were weighed on d 0 and 14 to allow calculation of ADG, ADFI, and F/G. Feces were collected on d 4 and 5 from

no less than 3 pigs per pen to allow determination of apparent digestibility for DM, N, and GE.

Data were analyzed as a randomized complete block design (initial weight as a covariate) by using the MIXED procedure of SAS. Orthogonal contrasts were used to separate treatment means with comparisons of (1) control vs. DDGS diets, (2) corn- vs. sorghum-based DDGS, 3) standard vs. expander conditioning, (4) corn-soy vs. DDGS × standard vs. expander conditioning, and (5) corn- vs. sorghum-based DDGS × standard vs. expander conditioning.

For Exp. 2, 176 finishing pigs (initially 164 lb) were used in a 54-d growth assay. The pigs were sorted by sex and ancestry, blocked by weight, and assigned to pens. There were 11 pigs per pen and 4 pens per treatment. The pigs were housed in an environmentally controlled finishing facility having 6-ft × 16-ft pens with half solid and half slatted concrete flooring. Each pen had a self-feeder and nipple waterer to allow ad libitum consumption of feed and water.

Treatments were arranged as a 2 × 2 factorial with main effects of diet formulation (corn-soybean meal vs. 40% sorghum-based DDGS) and conditioning (standard steam vs. expander) prior to pelleting. All diets (Table 2) were formulated to 0.90% lysine, 0.60% Ca, and 0.50% P. Feed was processed as in Exp. 1, but 6 batches of feed were made, and more extensive processing data were collected. Voltage and cone pressure of the expander were kept constant at 250 volts and 200 PSI, respectively. Then, motor load and production rate for the pellet mill, net electrical consumption for the pellet mill and the expander, and PDI were measured and analyzed as a randomized complete block design by using the MIXED procedure of SAS with batch as the blocking criterion. Orthogonal contrasts for a 2 × 2 factorial were used to separate means for the main effects of diet formulation and conditioning.

Pigs and feeders were weighed on d 0, 26, and 54 to allow calculation of ADG, ADFI, and F/G. The pigs were slaughtered (average weight 287 lb) at a commercial slaughter facility, and carcass data were collected. Growth performance and carcass data were analyzed as a randomized complete block design by using the MIXED procedure of SAS with initial weight as the blocking criterion and pen as the experimental unit. Hot carcass weight was used as a covariate in analysis of data for dressing percentage, carcass lean percentage, backfat thickness, and loin depth. Orthogonal contrasts for a 2 × 2 factorial were used to separate treatment means with main effects of diet formulation and conditioning.

For Exp. 3, 176 finishing pigs (initially 222 lb) were used in an 8-d digestibility study. The pigs were sorted by sex and ancestry, blocked by weight, and assigned to pens. There were 11 pigs per pen and 4 pens per treatment. The pigs were housed in an environmentally controlled finishing facility having 6-ft × 16-ft pens with half solid and half slatted concrete flooring. Each pen had a self-feeder and nipple waterer to allow ad libitum consumption of feed and water with pigs and feeders weighed on d 0 and 8. Feces were collected on d 7 and 8 from no less than 6 pigs per pen. Concentrations of DM, N, GE, and Cr in the diets and feces were determined to allow for calculation of apparent digestibilities. Treatments and diets were the same as in the growth assay (Exp. 2).

Data were analyzed as a randomized complete block design by using the MIXED procedure of SAS with initial weight as the blocking criterion and pen as the experimental unit. Orthogonal contrasts for a 2 × 2 factorial were used to separate means for the main effects of diet formulation and conditioning.

Results and Discussion

In Exp. 1 (Table 3), the corn-soybean meal diets supported better ($P < 0.005$) ADG, ADFI, F/G, and digestibility of DM, N, and GE, than diets with DDGS. Also, pigs fed diets with corn-based DDGS had better ($P < 0.03$) ADG, F/G, and digestibility of DM and N than pigs fed diets with sorghum-based DDGS. Expander conditioning improved ($P < 0.009$) ADG, F/G, and digestibility of DM, N, and GE compared with standard conditioning. However, expander conditioning tended to improve digestibility of DM most in diets with DDGS as indicated by the corn-soybean meal vs. DDGS × standard vs. expander conditioning interaction ($P < 0.08$). Finally, pigs fed diets with sorghum-based DDGS had greater improvement in F/G with expander conditioning than pigs fed diets with corn-based DDGS (corn- vs. sorghum-based DDGS × standard vs. expander; $P < 0.008$).

Milling data (Table 4) for the finishing diets used in Exp. 2 indicated that addition of 40% DDGS decreased pellet mill throughput (i.e., production rate) and increased energy used in the pelleting process ($P < 0.005$). However, contrary to some reports, high inclusion of DDGS improved PDI ($P < 0.001$). As for pig growth (Table 5), adding 40% DDGS to diets for finishing pigs reduced ($P < 0.02$) overall ADG and ADFI and increased ($P < 0.03$) overall F/G. Expander conditioning improved ($P < 0.002$) F/G, but this response was consistent for diets with and without DDGS (i.e., no diet formulation × expander conditioning interaction; $P > 0.41$).

Pigs had lower ($P < 0.001$) HCW when fed diets with 40% DDGS. Even when corrected to a constant HCW (via covariate analysis), dressing percentage ($P < 0.03$) and loin depth ($P < 0.06$) were greater for pigs fed the corn-soybean meal diets than for pigs fed the DDGS treatments. However, half the loss in HCW and all the loss in dressing percentage were recovered when diets with DDGS were expander processed prior to pelleting.

Nutrient digestibility in finishing pigs (Table 6) was greater ($P < 0.001$) for pigs fed diets without DDGS. Expander conditioning improved ($P < 0.02$) digestibility of N and GE compared with standard conditioning, but digestibility of DM was improved with expander conditioning only in the DDGS diets (diet × conditioning interaction, $P < 0.01$).

In conclusion, adding 30 and 40% DDGS to nursery and finishing diets decreased growth performance and nutrient digestibility compared with a corn-soybean meal control. However, expanding diets improved ADG, F/G, and nutrient digestibility in nursery pigs and F/G, dressing percentage, and nutrient digestibility in finishing pigs fed diets without and with DDGS.

Table 2. Composition of finishing diets

	d 0 to 26		d 26 to 54	
Ingredient, %	Corn-soybean meal	DDGS[1]	Corn-soybean meal	DDGS
Corn	79.63	52.67	81.47	54.54
DDGS	---	40.00	---	40.00
Soybean meal (47.5% CP)	17.80	4.95	16.20	3.30
Limestone	1.09	1.34	1.06	1.24
Monocalcium phosphate (21% P)	0.73	0.05	0.54	---
Salt	0.30	0.30	0.38	0.30
L-lysine HCl	0.20	0.47	0.13	0.40
L-threonine	0.03	---	---	---
Vitamin premix	0.12	0.12	0.12	0.12
Mineral premix	0.05	0.05	0.05	0.05
Antibiotic [2]	0.05	0.05	0.05	0.05
Calculated analysis				
Lysine	0.90	0.90	0.80	0.80
Ca	0.60	0.60	0.55	0.55
Total P	0.50	0.50	0.45	0.45

[1] Dried distillers grains with solubles.
[2] To provide 40 g/ton tylosin.

Table 3. Effects of expander conditioning of diets with corn- and sorghum-based dried distillers grains with solubles (DDGS) on growth performance and nutrient digestibility in nursery pigs[1]

	Corn-soybean meal		Corn-based DDGS		Sorghum-based DDGS			Contrasts[2]				
Item	Std[3]	Exp[4]	Std	Exp	Std	Exp	SE	1	2	3	4	5
PDI, %[5]	88.5	94.9	93.0	95.0	91.9	96.6						
ADG, lb	1.48	1.59	1.33	1.44	1.21	1.39	0.04	0.001	0.02	0.002	---[6]	---
ADFI, lb	2.15	2.23	1.93	2.04	2.06	2.07	0.05	0.001	0.09	---	---	---
F/G	1.45	1.40	1.45	1.42	1.70	1.50	0.03	0.005	0.001	0.009	---	0.008
Digestibility of DM, %[7]	82.5	83.7	76.9	79.9	76.4	78.3	0.4	0.001	0.03	0.001	0.08	---
Digestibility of N, %	78.3	81.5	76.4	79.6	70.1	73.4	0.7	0.001	0.001	0.001	---	---
Digestibility of GE, %	81.2	83.8	76.5	78.4	75.6	77.3	0.5	0.001	0.09	0.001	---	---

[1] A total of 180 nursery pigs (initially 29 lb) with 6 pigs per pen and 5 pens per treatment.
[2] Contrasts were (1) control vs. DDGS diets, (2) corn- vs. sorghum-based DDGS, (3) standard vs. expander conditioning, (4) corn-soybean meal vs. DDGS × standard vs. expander conditioning, and (5) corn- vs. sorghum-based DDGS × standard vs. expander conditioning.
[3] Standard conditioning prior to pelleting.
[4] Expander conditioning prior to pelleting.
[5] Pellet durability index (ASAE S269.4 DEC1991).
[6] Dashes indicate $P > 0.15$.
[7] Fecal samples collected on d 4 and 5 with chromic oxide used as an indigestible marker.

Table 4. Effects of expander conditioning of finishing diets with corn- and sorghum-based dried distillers grains with solubles (DDGS) on production efficiency (Exp. 2)[1]

	Corn-soybean meal		DDGS			*P* value		
Item	Std[2]	Exp[3]	Std	Exp	SE	Diet effect	Condit. effect	Diet × Cond.
Conditioning temp, °F[4]	181	244	182	315	4	0.001	0.001	0.001
Amperage, amps	19.0	18.9	17.4	16.2	0.3	0.001	0.03	0.04
Motor load, %	33.5	30.0	29.8	28.2	1.4	0.05	0.07	---[5]
Production rate, lb/h	2,553	2,550	2,213	2,312	113	0.005	---	---
Net energy, kWh/t	9.6	41.9	10.1	53.8	1.6	0.001	0.001	0.001
Pellet durability								
Standard, %[6]	76.3	90.8	87.7	96.0	1.3	0.001	0.001	0.007
Modified, %[7]	69.6	88.8	85.2	95.5	1.6	0.001	0.001	0.002

[1] Each diet was replicated by manufacturing a new batch of feed 6 times.
[2] Standard conditioning prior to pelleting.
[3] Expander conditioning prior to pelleting.
[4] Measured at the exit of the standard conditioner and at the expander cone.
[5] Dashes indicate $P > 0.15$.
[6] Pellet durability index (ASAE S269.4 DEC1991).
[7] Modified by adding 5 hexagonal nuts (1/2-in. diameter) to the tumbling box.

Table 5. Effects of expander conditioning of diets with corn- and sorghum-based dried distillers grains with solubles (DDGS) on growth performance and carcass characteristics in finishing pigs[1]

	Corn-soybean meal		DDGS			*P* value		
Item	Std[2]	Exp[3]	Std	Exp	SE	Diet effect	Condit. effect	Diet × Cond.
d 0 to 26								
ADG, lb	2.43	2.46	2.22	2.25	0.08	0.02	---[4]	---
ADFI, lb	6.78	6.46	6.22	6.07	0.30	0.004	0.09	---
F/G	2.79	2.63	2.80	2.70	0.07	---	0.02	---
d 0 to 54								
ADG, lb	2.37	2.32	2.16	2.23	0.05	0.004	---	0.14
ADFI, lb	7.13	6.63	6.60	6.59	0.26	0.02	0.03	0.04
F/G	3.01	2.86	3.06	2.96	0.06	0.03	0.002	---
HCW, lb	215.3	215.6	204.0	210.0	5.6	0.001	0.10	0.13
Dressing, %[5]	73.5	74.3	72.7	73.7	0.3	0.03	0.007	---
Carcass lean, %[5]	53.8	53.6	54.0	53.3	0.7	---	---	---
Backfat thickness, in[5]	0.80	0.81	0.77	0.82	0.04	---	---	---
Loin depth, in[5]	2.38	2.42	2.31	2.31	0.04	0.06	---	---

[1] A total of 176 finishing pigs (initially 164 lb) with 11 pigs per pen and 4 pens per treatment.
[2] Standard conditioning prior to pelleting.
[3] Expander conditioning prior to pelleting.
[4] Dashes indicate $P > 0.15$.
[5] HCW used as a covariate.

Table 6. Effects of expander conditioning of diets with corn- and sorghum-based dried distillers grain with solubles (DDGS) on nutrient digestibility in finishing pigs[1]

	Corn-soybean meal		DDGS			*P* value		
Item	Std[2]	Exp[3]	Std	Exp	SE	Diet effect	Condit. effect	Diet × Cond.
Pellet durability								
Standard, %[4]	74.6	94.7	90.9	97.2				
Modified, %[5]	67.7	94.4	89.2	97.1				
ADG, lb	1.77	2.02	1.83	1.80	0.11	---[6]	---	---
ADFI, lb	6.81	6.57	6.57	6.34	0.30	---	---	---
F/G	3.85	3.25	3.59	3.52	0.27	---	0.15	---
Digestibility of DM, %[7]	86.8	86.7	79.5	81.9	0.4	0.001	0.02	0.01
Digestibility of N, %	83.2	85.4	72.5	76.5	0.7	0.001	0.001	---
Digestibility of GE, %	86.1	87.7	77.5	81.1	0.8	0.001	0.02	---

[1] A total of 176 finishing pigs (initially 222 lb) with 11 pigs per pen and 4 pens per treatment.
[2] Standard conditioning prior to pelleting.
[3] Expander conditioning prior to pelleting.
[4] Pellet durability index (ASAE S269.4 DEC1991).
[5] Modified by adding five hexagonal nuts (1/2-in. diameter) to the tumbling box.
[6] Dashes indicate $P > 0.15$.
[7] Fecal samples collected on d 7 and 8 with chromic oxide used as an indigestible marker.