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Abstract

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Keywords

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EXPANDER PROCESSING CONDITIONS AFFECT NUTRIENT DIGESTIBILITY IN FINISHING PIGS FED CORN-, SORGHUM-, WHEAT-, AND WHEAT MIDDS-BASED DIETS

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Summary

Expander processing of corn-, sorghum-, wheat-, and wheat midds-based diets improved nutrient digestibility in growing pigs and, thus, the apparent digestible energy concentration in the diets. This new feed manufacturing technology was especially beneficial to the feedstuff with the highest fiber content (i.e., wheat midds).

(Key Words: Expander, Corn, Sorghum, Wheat Midds.)

Introduction

Expander and extrusion processing have similar processing principles; however, expanders have been designed for increased throughput, decreased energy consumption, and lower installation costs compared to extrusion processing. Because expander technology is relatively new to the US feed industry, few data are available that illustrate the effects of expander processing on growth performance and nutrient digestibility in pigs. Thus, we designed a series of experiments to determine the effects of expander processing conditions on nutrient digestibility with several cereal grains commonly used in diets for finishing pigs.

Procedures

Corn was hammermilled through a 1/8 in. screen and blended into diets. The diets were corn-soybean meal-based with .85% lysine, .65% Ca, .55% P, and 1.57 Mcal of DE/lb (Table 1.). They were steam conditioned to 160°F; processed through a 100 horsepower expander (Amandus-Kahl, Model OE15.2); and pelleted with a 30 horsepower California Pellet Mill. The pellet mill had a 1.5in.-thick die with 3/16 in.-diameter holes. The diets were processed with no pressure and 166, 333, and 500 psi cone pressure before pelleting. Production rate was held constant at .9 tons/h. The pellet mill and expander motors were equipped with a recording volt-amp meter to allow calculation of electrical energy consumption. Specific energy consumption was calculated as the difference between total energy during processing and idle energy consumption.

Pellet samples were collected immediately after exiting the pellet die and cooled with ambient air. The cooled pellets were analyzed for pellet durability index (PDI) using the standard procedures and also using the standard procedures with five ½ in. hexagonal nuts added to the pellets before tumbling. Processing treatments were replicated three times for each experiment to allow statistical analyses.

A total of 32 pigs (average initial BW of 158 lb) was used in the digestibility assay. The pigs were blocked by weight and sorted by sex and ancestry into pens (6 ft × 16 ft) in a modified open-front finishing facility. There were eight pigs per pen and four pens per treatment. Feed and water were consumed on an ad libitum basis. The pigs were fed diets with .20% chromic oxide for 4 d, and grab samples of feces were collected at 6:00 p.m. on d 4 and 6:00 a.m. on d 5. The

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fecal samples were dried; pooled within pen; and analyzed for DM, N, GE, and Cr to allow calculation of apparent nutrient digestibility using the indirect ratio method.

In the second experiment, 136 pigs (average initial BW of 92 lb) were used. There were 17 pigs per pen and four pens per treatment. A sorghum-soybean meal-based diet was formulated to 1.1% lysine, .65% Ca, .55% P, and 1.53 Mcal of DE/lb. In the third experiment, 136 pigs (average initial BW of 91 lb) were used. There were 17 pigs per pen and four pens per treatment. The wheat-soybean meal-based diet was formulated to 1.1% lysine, .65% Ca, .55% P, and 1.53 Mcal of DE/lb. In the fourth experiment, 32 pigs (average initial BW of 159 lb) were used. There were eight pigs per pen and four pens per treatment. The diet had 50% wheat midds and was formulated to .85% lysine, .65% Ca, .55% P, and 1.47 Mcal of DE/lb. For Exps. 2, 3, and 4, feed manufacturing processes, pig management, and sample collection and analyses were the same as in Exp 1.

All data were analyzed as a randomized complete block design with pen as the experimental unit. Polynomial regression was used to characterize the shape of the response curve as cone pressure was increased.

Results and Discussion

For the corn-based diet (Table 2), total and specific energies for expanding increased as cone pressure were increased (linear and quadratic effects, P<.002). Pellet durability index was increased from 68.5% with no cone pressure (i.e., standard steam conditioning at atmospheric pressure) to 95.5% at 500 psi of cone pressure (P<.001). Starch damage (i.e., gelatinization and shear) increased with increased cone pressure and seemed to plateau at 333 psi.

Maximum digestibilities of DM (P<.07), N (P<.003), and GE (P<.10) were achieved at 333 psi. This cone pressure (31.6 kWh/ton of specific energy into the feed) yielded a diet with 1.54 kcal/lb of DE.

For the sorghum-based diet (Table 3), total and specific energies for expanding increased as cone pressure was increased (linear and quadratic effects, P<.001). Pellet durability index was increased from 77.2% with no cone pressure to 92.8% with 333 psi cone pressure (quadratic effect, P<.06). Starch damage was increased from 26 % with no cone pressure to 62% at 500 psi. Maximum nutrient digestibility was achieved at 166 psi (9.1 kWh/ton of specific energy into the feed), yielding a diet with 1,618 kcal/lb of DE (quadratic effect, P<.001).

For the wheat-based diet (Table 4), total and specific energy usages responded as they did for corn and sorghum-based diets. However, with no cone pressure, the PDI of wheat-based diets was 92.6% (compared to 68.5% and 77.2% for the corn- and sorghum-based diets). Wheat is known for its contribution toward pellet durability, and 5 to 10% wheat sometimes is added to a problematic formulation to bolster pellet quality.

Another difference between this wheat-based diet and the corn- and sorghum-based diets was the general lack of response (P>.15) in digestibilities of DM, N, and GE with increased cone pressure. Nonetheless, a linear increase (P<.006) in DE of the wheat-based diet occurred as cone pressure was increased, with 1,549 kcal/lb of DE at 500 psi (32.1 kWh/ton of specific energy into the feed).

For the wheat midds-based diet (Table 5), total and specific energy usages increased with increased cone pressure (linear effect, P<.001). Pellet durability index increased from 84.2% to 89.2% as cone pressure was increased but seemed to plateau at 166 psi. Digestibilities of DM, N, and GE and the actual DE of the diet all increased with increasing cone pressure (linear effects, P<.02). Indeed, increasing cone pressure from none to 500 psi (i.e., up to 34 kWh/ton of specific energy into the feed) increased the DE content of the diet by nearly 200 kcal/lb (i.e., from 1,233 to 1,417). This response suggests that fibrous feedstuffs (e.g., wheat midds) may have more to gain from expander processing than low-fiber cereal grains (e.g., corn and wheat).

In conclusion, expander processing tended to increase nutrient digestibility and, therefore, the energy value of all diets we tested. The DEs of corn-, sorghum-, wheat-, and wheat midds-based diets were increased by 70, 100, 50, and 200 kcal/lb, respectively.

Table 1. Diet Compositions for Exp. 1, 2, 3, and 4[a]

Ingredient, %	Exp. 1[a]	Exp. 2[b]	Exp. 3[b]	Exp. 4[c]
Corn	80.28	--	--	41.35
Grain sorghum	--	70.14	--	--
Hard red winter wheat	--	--	78.10	--
Wheat middlings	--	--	--	50.00
Soybean meal (46.5% CP)	15.43	25.48	17.49	4.81
Soybean oil	1.00	1.00	1.00	1.00
Monocalcium phosphate	1.07	.89	.70	--
Limestone	1.03	1.04	1.17	1.47
Salt	.30	.30	.30	.30
Vit/Min/AA/Ab[d]	.69	.95	1.04	.87
Chromic oxide[e]	.20	.20	.20	.20

[a]Formulated to .85% lysine, .65% Ca, .55% P, and 1.57 Mcal of DE/kg.
[b]Formulated to 1.1% lysine, .65% Ca, .55% P, and 1.53 Mcal of DE/kg.
[c]Formulated to .85% lysine, .65% Ca, .55% P, and 1.47 Mcal of DE/kg.
[d]Provided 100 g/ton tylosin.
[e]Used as an indigestible marker.

Table 2. Effects of Cone Pressure on Diet Characteristics and Nutrient Digestibility of Corn-Based Diets in Finishing Pigs

	Cone Pressure, psi					Probability, P <		
Item	0	166	333	500	SE	Linear	Quadratic	Cubic
Electrical energy consumption, kWh/t								
Expander								
Total	24.7	34.0	57.4	82.4	1.5	.001	.002	.12
Specific[a]	.4	9.4	31.6	57.0	1.2	.001	.001	.11
Pellet mill	13.9	11.0	10.6	11.3	.2	.001	.001	.09
Overall	38.6	45.0	68.0	93.7	1.5	.001	.001	.09
Pellet durability index, %[b]								
Standard[c]	68.5	90.7	93.3	95.5	.3	.001	.001	.001
Modified[d]	44.7	85.2	92.0	94.7	.3	.001	.001	.001
Starch damage, %	32.0	44.3	48.9	49.9	-	-	-	-[g]
Apparent nutrient digestibility, %[e]								
DM	81.4	84.3	86.5	85.9	.8	.005	.07	-
N	77.5	81.1	83.8	82.8	.5	.001	.003	-
GE	82.5	85.3	87.2	86.5	.9	.02	.10	-
DE of diet, k/cal/lb[f]	1,469	1,483	1,540	1,510	15	.04	-	.11

[a]Difference between total and idle energy consumption
[b]Three replicates/treatment.
[c]Am. Soc. Agric. Engin. method.
[d]Am. Soc. Agric. Engin. method with the addition of five 1/2 in. hexagonal nuts prior to tumbling.
[e]A total of 36 pigs (eight pigs/pen with an average initial BW of 158 lb) with three pens/treatment.
[f]Calculated as apparent GE digestibility (%) × GE of the diet (Mcal/kg).
[g]Dashes indicate P>.15

Table 3. Effects of Cone Pressure on Diet Characteristics and Nutrient Digestibility of Sorghum-Based Diets in Finishing Pigs

	Cone Pressure, psi					Probability, P <		
Item	0	166	333	500	SE	Linear	Quadratic	Cubic
Electrical energy consumption, kWh/t								
Expander								
Total	23.2	31.9	38.1	55.8	.5	.001	.001	.001
Specific[a]	.2	9.1	15.6	33.1	.6	.001	.001	.003
Pellet mill	12.8	10.8	10.0	11.1	.3	.006	.002	-
Overall	36.0	42.7	48.1	66.9	.5	.001	.001	.001
Pellet durability index, %[b]								
Standard[c]	77.2	90.6	92.8	90.8	3.2	.04	.06	-[g]
Modified[d]	60.6	84.5	90.2	87.6	6.0	.03	.07	-
Starch damage, %	26.0	37.3	41.9	61.7	NA	NA	NA	NA
Apparent nutrient digestibility, %[e]								
DM	85.5	87.1	86.2	86.2	.3	-	.006	.006
N	78.3	80.3	81.0	80.3	.6	.01	.02	-
GE	85.5	87.8	86.5	86.6	.3	.09	.001	.001
DE of diet, kcal/lb[f]	1,516	1,618	1,555	1,572	4	.001	.001	.001

[a]Difference between total and idle energy consumption. [b]Three replicates/treatment. [c]Am. Soc. Agric. Engin. method. [d]Am. Soc. Agric. Engin. method with the addition of five 1/2 in. hexagonal nuts prior to tumbling. [e]A total of 136 pigs (17 pigs/pen with an average initial BW of 92 lb) and four replicates/treatment. [f]Calculated as apparent GE digestibility (%) × GE of the diet (Mcal/kg). [g]Dashes indicate P>.15.

Table 4. Effects of Cone Pressure on Diet Characteristics and Nutrient Digestibility of Wheat-Based Diets in Finishing Pigs

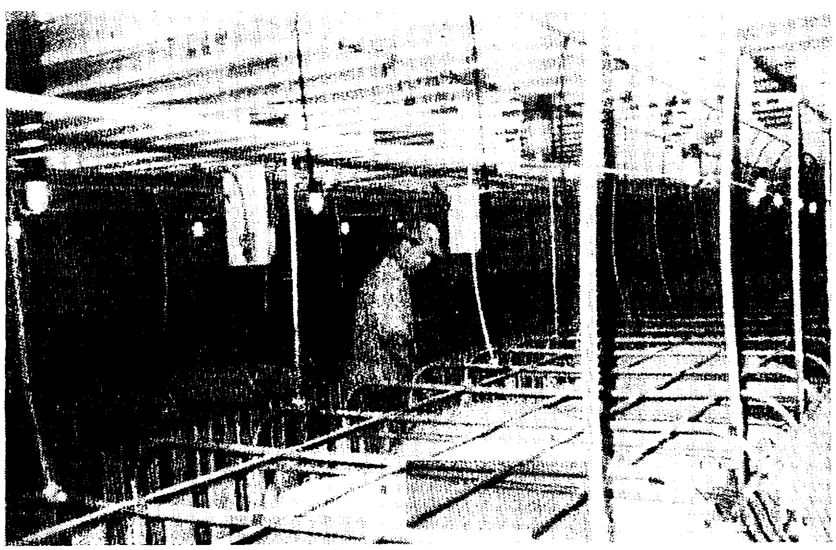
	Cone Pressure, psi					Probability, P <		
Item	0	166	333	500	SE	Linear	Quadratic	Cubic
Electrical energy consumption, kWh/t								
Expander								
Total	22.9	31.7	37.4	54.5	.7	.001	.001	.005
Specific[a]	.2	8.7	14.8	32.1	.5	.001	.001	.002
Pellet mill	14.8	10.6	10.2	11.0	.2	.001	.001	.05
Overall	37.7	42.3	47.6	65.5	.8	.001	.001	.02
Pellet durability index, %[b]								
Standard[c]	92.6	95.3	95.5	94.5	.3	.004	.001	-[g]
Modified[d]	88.5	91.9	93.3	92.5	.2	.001	.001	-
Starch damage, %	16.8	28.7	31.5	49.1	-	-	-	-
Apparent nutrient digestibility %[e]								
DM	85.7	84.5	85.1	85.2	.6	-	-	-
N	83.7	83.2	83.5	83.8	.7	-	-	-
GE	85.8	84.6	85.1	85.6	.7	-	-	-
DE of diet, kcal/lb[f]	1,499	1,517	1,529	1,549	11	.006	-	-

[a]Difference between total and idle energy consumption. [b]Three replicates/treatment. [c]Am. Soc. Agric. Engin. method. [d]Am. Soc. Agric. Engin. method with the addition of five 1/2" hexagonal nuts prior to tumbling. [e]A total of 136 pigs (17 pigs/pen with an average initial BW of 91 lb) with four pens/treatment. [f]Calculated as apparent GE digestibility (%) × GE of the diet (Mcal/kg). [g]Dashes indicate P>.15.

Table 5. Effects of Cone Pressure on Diet Characteristics and Nutrient Digestibility of Wheat Midds-Based Diets in Finishing Pigs

	Cone Pressure, psi					Probability, P <		
Item	0	166	333	500	SE	Linear	Quadratic	Cubic
Electrical energy consumption, kWh/t								
Expander								
Total	25.5	33.8	43.6	60.0	2.2	.001	.12	-
Specific[a]	.3	8.5	18.3	34.0	2.2	.001	.14	-[g]
Pellet mill	12.6	10.4	9.9	10.0	.2	.001	.001	-
Overall	38.1	44.2	53.5	70.0	2.2	.001	.06	-
Pellet durability index, %[b]								
Standard[c]	84.2	89.1	87.0	89.2	1.1	.05	-	.09
Modified[d]	73.0	83.9	76.7	87.6	4.6	.13	-	.13
Starch damage, %	33.8	51.7	51.9	69.9	-	-	-	-
Apparent nutrient digestibility, %[e]								
DM	70.0	72.6	72.4	75.6	1.2	.02	-	-
N	69.2	74.5	77.1	78.3	1.2	.001	-	-
GE	69.8	73.8	74.5	77.0	.9	.002	-	-
DE of diet, kcal/lb[f]	1,233	1,347	1,357	1,417	17	.001	-	-

[a]Difference between total and idle energy consumption.
[b]Three replicates/treatment.
[c]Am. Soc. Agric. Engin. method.
[d]Am. Soc. Agric. Engin. method with the addition of five 1/2" hexagonal nuts prior to tumbling.
[e]A total of 36 pigs (eight pigs/pen with an average initial BW of 159 lb) with three pens/treatment.
[f]Calculated as apparent GE digestibility (%) × GE of the diet (Mcal/kg).
[g]Dashes indicate P>.15.



Eldo Heller, Breeding Barn Manager.