NUTRITIONAL VALUE OF A TRANSGENIC HIGH-LYSINE, HIGH-OIL CORN FOR YOUNG PIGS [1]

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Summary

Two trials were conducted to compare the nutritional adequacy of high-lysine, high-oil corn (.408% lysine, 6.21% fat) and high-oil corn (.289% lysine, 5.97% fat) for young growing pigs. Experiment 1 used four barrows fitted with ileal T-cannulas in a crossover design digestion study. Diets contained 8.5% casein and an equal amount of lysine from the test corn. Apparent ileal digestibilities of amino acids, GE, DM, CP, and ash were similar between diets. Experiment 2 used segregated early-weaned barrows in a 2 × 2 factorially designed growth trial. Main effects were corn type and dietary lysine (.80 or 1.15% digestible lysine). Increasing digestible lysine increased ADG and improved F/G regardless of corn variety. Within each lysine level, corn type did not affect ADG, ADFI, or F/G. The results of these studies indicate that the lysine in high-lysine, high-oil corn is as available as the lysine in high-oil corn and that high-lysine, high-oil corn can be used successfully in swine diets.

(Key Words: Digestibility, Growth, High-Oil Corn, High-Lysine High-Oil Corn, Segregated Early-Weaned Pigs.)

Introduction

Advances in biotechnology have generated specialty grains, such as high-oil corn, which has a slightly higher lysine content and more oil content than conventional yellow dent corn. High-oil corn is generally accepted a suitable replacement for conventional corn and also can replace a portion of the oil or fat typically added to swine diets. Recently, a high-lysine, high-oil corn variety was developed that contains about 29% more lysine than high-oil corn and 36% more than conventional corn. This high-lysine, high-oil corn has not been evaluated as a feedstuff for swine. Therefore, the objectives of these studies were to compare the apparent ileal digestibility of the amino acids in high-lysine, high-oil corn and high-oil corn and to compare growth performance of pigs fed diets containing these grains formulated on a digestible amino acid basis.

Procedures

General. Two experiments were conducted to evaluate the nutritional adequacy of high-lysine, high-oil corn for growing pigs. Pigs used in Exp. 1 were terminal offspring of PIC L326 sows × C22 boars, and pigs used in Exp. 2 were PIC C22 barrows. Feedstuffs for both experiments were

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analyzed prior to the initiation of the trials, and complete diets were analyzed after the completion of both trials (Table 1). All procedures were approved by the Kansas State University Institutional Animal Care and Use Committee (Protocol Nos. 1438 and 1440).

Experiment 1. Four nonlittermate barrows each were fitted with a simple T-cannula approximately 15 cm anterior to the ileocecal valve. After a 10-d recovery period, the pigs were used in a crossover design digestion study to compare the apparent ileal digestibility of nutrients in high-oil corn and high-lysine, high-oil corn. Composition of the experimental diets is given in Table 2. Both diets were fed in meal form and were based on corn and casein and contained .2% chromic oxide as an indigestible marker. These diets were formulated to be isolysinic and isocaloric with equal fiber contents. This was accomplished by altering the amounts of cornstarch, corn oil, and cellulose in the high-lysine, high-oil corn diet. Both diets contained 8.5% casein and equal amounts of lysine from the test corn. The corn for both diets was ground to a mean particle size of 650 microns.

Each period consisted of 4 d of diet adjustment followed by 2 days (8.5 h/d) of ileal digesta collection. We waited 24 h between each day of ileal collection to prevent any possibility of dehydration with the relatively young pigs. Pigs were fed the same amount each day within each period. Each day's ration was divided equally between meals at 0630 and 1730. Daily feed intakes were 2.0 and 2.4 lb/d for periods 1 and 2, respectively. Water was provided manually at the rate of 2:1 water:feed (wt/wt) twice daily. Mean pig weights at the beginning of period 1 and at the end of period 2 were 44.1 and 58.3 lb, respectively.

Ileal digesta were collected between 0630 and 1500 by attaching a latex balloon to the opened cannula. Digesta in the balloon were collected every 15 min or more often if needed and stored on ice during the 8.5-h collection period. At the end of each day, a 200-g subsample was frozen. The two samples for each pig were combined, freeze-dried, and ground before chemical analyses for Cr, CP, ash, DM, GE, and individual amino acids. All nutrient digestibilities were calculated using chromic oxide as an indigestible marker.

Data from the digestion trial were analyzed initially as a crossover design that included the effects of pig, period, and pig within period. The effect of period and/or pig was significant only for ash (pig, P=.03; period, P=.09). Thus, the data were subsequently analyzed as a completely randomized design.

Experiment 2. One hundred segregated early-weaned barrows (initially 18.4 lb) were allotted randomly by body weight to one of five dietary treatments with four pigs per pen and five replicate pens per treatment. Pigs were weaned at 17 ± 2 d of age (average weaning weight of 12.84 lb) and were allotted to treatment when the trial was initiated 10 d later. Prior to the initiation of the trial, all pigs were fed a complex nutrient dense diet based on corn, soybean meal, fish meal, animal plasma, bloodmeal, and whey, which was formulated to contain 1.60% lysine, .90% total calcium, and .80% total phosphorus.

Five diets were evaluated (Table 3). Four diets were arranged in a 2 × 2 factorial with corn source and dietary lysine level as the main effects. Lysine levels were chosen to be either deficient (.80% digestible lysine) or adequate (1.15% digestible lysine). Within each lysine level, diets contained equal amounts of corn and all other ingredients, except L-lysine•HCl, which was added to the high-oil corn diets at the expense of cornstarch. Crystalline lysine was assumed to be 100% digestible, and high-oil corn and high-lysine, high-oil corn were estimated to have digestibilities of 68 and 72%, respectively, based on results of the digestion experiment. Crystalline methionine, tryptophan, and threonine were added to all diets to ensure their adequacy. Thus, within lysine level, any differences in pig performance should have been attributable to differences in bio-availability of lysine. The fifth diet consisted of the .80% lysine high-oil corn diet supplemented with additional L-lysine•HCl (.975% digestible lysine) to verify that lysine was the limiting amino acid in the low-lysine diets.

Corns were ground to a mean particle size of 725 microns. All diets were fed in meal form. Pigs were housed in an environmentally controlled nursery in 4 × 4 ft pens with tri-bar flooring and allowed ad libitum access to feed through a five-hole self-feeder and water through a single-nipple waterer. Weight gains and feed intakes were measured at d 10 of the trial and used to determine ADG, ADFI, and F/G.

Data were analyzed as a 2 × 2 factorial plus a control with main effects of corn type (high-oil corn or high-lysine, high-oil corn) and lysine level (.80 or 1.15% apparent digestible lysine). The control diet was compared to the average of the .80% apparent digestible lysine diets using a single degree of freedom contrast. Pen was the experimental unit in all analyses.

Results and Discussion

Experiment 1. Digestibility values of high-lysine, high-oil corn and high-oil corn for individual amino acids, DM, CP, ash, and GE were similar ($P>.40$; Table 4). Note that the digestibility values in Table 4 are for diets containing 8.5% casein. Casein generally is assumed to be 100% digestible. Thus, actual digestibility values for the individual amino acids for each corn type can be calculated by difference using the analyzed compositions of the corns and casein (Table 1), percentage composition of the diets (Table 2), and dietary digestibility values (Table 4). However, care must be taken when evaluating actual digestibility values for amino acids other than lysine. Because of the experimental design, the relative amounts of other amino acids in high-lysine, high-oil corn are less than those in high-oil corn; thus, digestibility values for other amino acids in high-lysine, high-oil corn will be lower than for those in high-oil corn. In reality, digestibility of all amino acids in both corn types are similar.

Experiment 2. The interactions of dietary lysine level and corn type were nonsignificant ($P\geq.15$) for ADG, ADFI, and F/G. Increasing dietary digestible lysine from .80 to 1.15% increased ($P<.001$) ADG and F/G; ADFI was not affected. Performance of pigs fed high-oil corn or high-lysine, high-oil corn was similar, indicating equal nutritional value for both types. This suggests that the lysine in high-lysine, high-oil corn is as available as the lysine in high-oil corn and the L-lysine•HCl in the high-oil corn diet.

Increasing lysine in the high-oil corn diet from .80 to .975% increased growth ($P=.17$) and improved F/G ($P=.15$) numerically. Although the responses were not significant, they fit the linear increase in performance found with increasing lysine (Figure 1), indicating that lysine was the limiting nutrient in the .80% lysine diets.

These results indicate that the lysine in high-lysine, high-oil corn is highly available and that high-lysine, high-oil corn can be used in place of conventional yellow dent corn or high-oil corn in swine diets without changing growth performance when substituted on a nutrient-for-nutrient basis. High-lysine, high-oil corn should offer the potential to formulate swine diets using less synthetic lysine and/or soybean meal and energy sources such as soybean oil, choice white grease, or poultry fat. However, care must be taken in formulating diets containing high-lysine, high-oil corn. All corn varieties typically have a poor amino acid profile, and the high-lysine level in high-lysine, high-oil corn increases this problem. This is because other amino acids have not been altered. Thus, tryptophan or threonine is more likely to be deficient when high-lysine, high-oil corn is used, because less soybean meal will be included in diets. However, when properly utilized, high-lysine, high-oil corn is an excellent grain source for swine that should offer the potential to lower diet costs.

Table 1. Analyzed Composition of Experimental Feedstuffs for Exp. 1 and 2 (As-Fed Basis)[a]

	High-Oil Corn Variety			Spray-Dried	SBM,
Item, %	Normal	High-lysine	Casein	Whey	46.5% CP
DM	85.60	89.20	89.78	97.20	88.10
CP	8.17	9.72	73.12	----	----
Crude fat	5.97	6.21	.25	----	----
Amino acids:					
Arginine	.419	.447	2.79	.263	3.407
Histidine	.241	.243	2.26	.210	1.240
Isoleucine	.261	.304	3.70	.650	2.192
Leucine	.970	1.247	7.16	1.163	3.772
Lysine	.289	.408	5.92	.927	3.024
Methionine	.163	.196	2.15	.166	.741
Phenylalanine	.387	.471	3.94	.318	2.391
Threonine	.287	.326	3.16	.737	1.871
Valine	.379	.434	4.75	.644	2.330
Alanine	.609	.761	2.34	.603	2.082
Aspartic acid	.609	.629	5.35	1.181	5.637
Cysteine	.182	.205	.38	.285	.720
Glutamic acid	1.527	1.827	16.79	1.996	9.127
Glycine	.339	.351	1.43	.163	1.928
Serine	.391	.464	4.18	.543	2.390
Tyrosine	.303	.373	4.27	.292	1.902

[a]Values are combined means of analysis from Optimum Quality Grains and a commercial laboratory.

Table 2. Composition of Diets for Exp. 1 (As-Fed Basis)[a]

	Dietary Treatment	
Item, %	High-oil corn	High-lysine, high-oil corn
High-oil corn	86.96	----
High-lysine, high-oil corn	----	61.60
Cornstarch	----	23.29
Casein	8.50	8.50
Monocalcium phosphate	1.60	1.94
Corn oil	----	1.37
Antibiotic[b]	1.00	1.00
Limestone	.99	.84
Cellulose[c]	----	.51
Salt	.35	.35
Vitamin premix	.25	.25
Chromic oxide	.20	.20
Trace mineral premix	.15	.15
Total	100.00	100.00

[a]Diets were formulated to be isolysinic (.80% total lysine) and contained .75% total Ca and .65% total P. Calorie and fiber contents were balanced across treatments by adding corn oil and cellulose to the high-lysine, high-oil corn diet.
[b]Provided 50 g/ton carbadox.
[c]Solka Floc® 300 powdered cellulose.

Table 3. Composition of Diets for Exp. 2 (As-Fed Basis)[a]

	Digestible Lysine Level				
	.80%		1.15%		.975%
Item, %	HOC	HLYSHOC	HOC	HLYSHOC	Control
High-oil corn	64.47	----	49.33	----	64.47
High-lysine high-oil corn	----	64.47	----	49.33	----
Soybean meal (46.5% CP)	20.92	20.92	36.50	36.50	20.92
Spray-dried whey	10.00	10.00	10.00	10.00	10.00
Antibiotic[b]	1.00	1.00	1.00	1.00	1.00
Monocalcium phosphate	1.47	1.47	1.20	1.20	1.47
Limestone	.84	.84	.87	.87	.84
Vitamin premix	.25	.25	.25	.25	.25
Trace mineral premix	.15	.15	.15	.15	.15
Salt	.35	.35	.35	.35	.35
L-Lysine•HCl	.08	----	.06	----	.31
DL-Methionine	.08	.08	.02	.02	.08
L-Tryptophan	.04	.04	----	----	.04
L-Threonine	.11	.11	.01	.01	.11
Cornstarch	.23	.31	.25	.31	.01
Total	100.00	100.00	100.00	100.00	100.00

[a]All diets contained .75% total Ca and .70% total P and were formulated to be isolysinic within each lysine level based on determined lysine digestibility values from Exp. 1. The total lysine levels for the .80, .975, and 1.15% digestible lysine levels were: .98-.99, 1.15, and 1.38-1.40%, respectively. [b]Provided 50 g/ton carbadox.

Table 4. Apparent Ileal Digestibility of Nutrients in Diets Containing Normal or High-Lysine, High-Oil Corn[a,b]

	High-Oil Corn Variety[c]		
Apparent Ileal Digestibility, %	Normal	High-lysine	CV
DM	82.5	84.7	4.54
CP	84.3	85.5	2.99
Ash	40.0	41.3	13.82
GE	83.8	85.8	4.29
Amino acids:			
Arginine	88.6	90.3	2.06
Histidine	89.9	91.3	2.28
Isoleucine	88.4	90.2	1.92
Leucine	92.8	93.4	1.60
Lysine	88.4	90.4	2.24
Methionine	93.5	94.6	1.27
Phenylalanine	90.6	91.4	1.96
Threonine	81.4	83.8	2.80
Valine	88.2	89.6	1.98
Alanine	87.1	89.3	3.17
Aspartic acid	85.8	88.4	2.53
Cysteine	76.8	78.7	4.82
Glutamic acid	91.4	93.0	2.03
Glycine	60.8	66.6	8.00
Serine	84.7	87.1	2.21
Tyrosine	87.5	89.2	2.73

[a]Values are means of four barrows used in a crossover design. The data were analyzed initially as a crossover design. The effect of period and/or pig was significant only for ash (pig, P=.03; period, P=.09). Thus, the data presented here were analyzed as a completely randomized design. [b]All diets contained 8.5% casein. [c]Diets did not differ (P>.10).

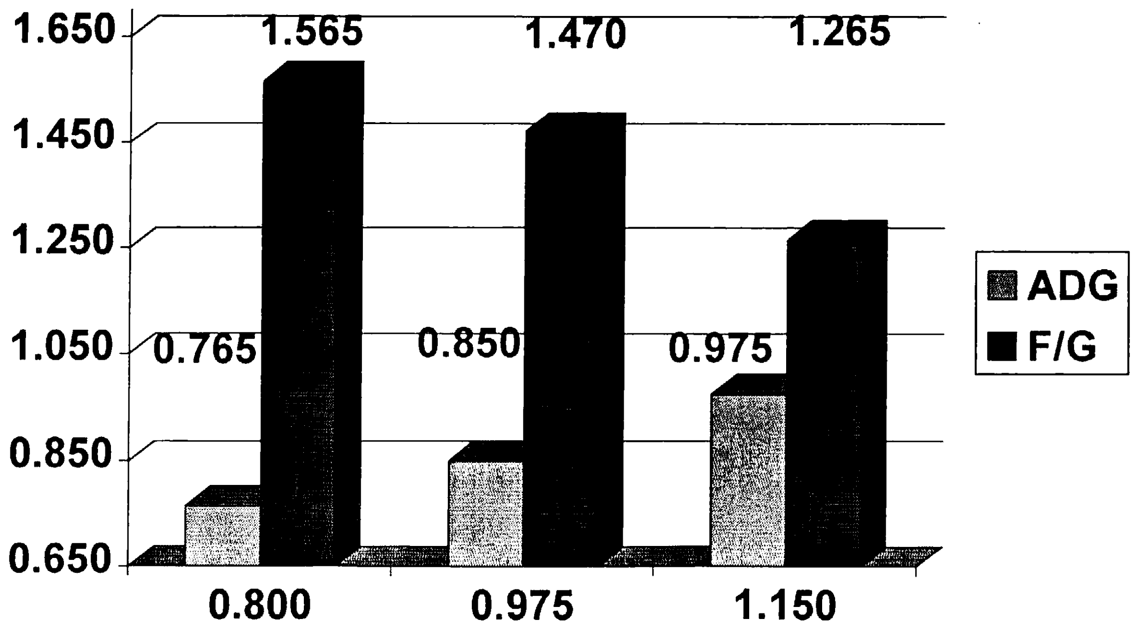
Table 5. Performance of Pigs Fed Diets Containing Normal (HOC) or High-Lysine (HLYSHOC) High-Oil Corn[a,b]

	Digestible Lysine Level, %									
	.80		1.15		.975		Probability Values			
Item,	HOC	HLYSHOC	HOC	HLYSHOC	Control	CV	Lysine	Corn	Lysine×Corn	Contrast[c]
ADG, lb	.80	.73	.97	.98	.85	9.14	.0001	.39	.44	.17
ADFI, lb	1.22	1.17	1.21	1.25	1.24	9.28	.42	.77	.56	.57
F/G	1.53	1.60	1.25	1.28	1.47	7.45	.0001	.43	.61	.15

[a]Values are means of four pigs per pen and five replicate pens per treatment. Pigs averaged 18.39 lb BW initially (d 10 postweaning) and 26.96 lb BW at the conclusion of the trial 10 d later.

[b]Within each lysine level, diets are identical except that L-lysine•HCl was added to the HOC diets to make them isolysinic. The .975% digestible lysine diet is identical to the .80% digestible lysine HOC diet, except that only additional L-lysine•HCl was added.

[c]Contrast refers to the comparison of the .975% digestible lysine diet to the average of the two .80% digestible lysine diets.



Dietary Digestible Lysine, %

Figure 1. Main Effects of Increasing Dietary Lysine on ADG and F/G of SEW Pigs.