Evaluation of Compensatory Growth of 200 lb Finishing Pigs Previously Fed a Low Lysine Diet

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Summary

A total of 346 pigs (241 × 600, DNA, Columbus, NE; initially 195.3 lb) were used in a 44-d trial to evaluate the compensatory growth of 200 lb finishing pigs previously fed a low lysine diet. Two diets were manufactured (control and corn diet) and arranged into 4 nutritional strategies. One group of pigs (control) was fed the control diet from d 0 to 44. The other three groups of pigs were fed the corn diet for 2, 3, or 4 weeks and then switched to the control diet until d 44. The control diet contained 13.0% crude protein (CP) and 0.70% standardized ileal digestible (SID) Lys. The corn diet contained 8.1% CP and 0.18% SID Lys. There were 9 to 10 pigs per pen and 9 pens per treatment. On average, pigs fed the corn diet grew 49% slower per day than those on the control treatment. The first week after the dietary switch from corn to control diet (recovery period), pigs previously fed the corn diet grew approximately 28% faster than those fed the control treatment, then had approximately 12% greater average daily gain (ADG) than those fed the control treatment for the rest of the recovery period. Despite this compensatory increase in ADG, final body weight (BW) was still lower compared to control pigs, with the exception of the pigs that were only fed the corn diet for 2 weeks and then followed with 4 weeks of recovery on the control diet. Weekly average daily feed intake (ADFI) was similar to the control treatment when pigs were fed the corn diet, but like ADG, was greater during the first week of recovery then returned to similar levels as the control treatment. Weekly feed efficiency (F/G) was worse when pigs were fed the corn diet compared to the control treatment, but improved compared to those on the control treatment during the first week of recovery then returned to a similar level as the control treatment. For the overall period (d 0 to 44), control pigs and pigs fed the corn diet for the first 2 of the 6 weeks had increased ($P < 0.05$) ADG compared to pigs fed the corn diet for the first 3 or 4 of the 6 weeks. Feed efficiency worsened ($P < 0.05$) as the length of time that pigs were fed the corn diet increased. Pigs fed the corn diet for the first 3 or 4 weeks had increased ($P < 0.05$) backfat and decreased ($P < 0.05$) loin depth compared to pigs fed the control diet. These data suggest that feeding pigs the corn diet for the first 3 or 4 weeks followed by the control diet within a 6-week-period prior to marketing reduced the growth performance and carcass characteristics compared to pigs fed the control diet the entire time. These results allow producers to estimate the reduction in growth rate when feeding a low lysine corn-based diet and to estimate the recovery time when switching back to a

control diet. This study provides insight into compensatory gain responses to dietary amino acid deficiencies.

Introduction

In spring 2020, the US pork industry experienced a substantial reduction in the ability to process market pigs due to plant closures attributed to the COVID-19 pandemic. Many producers used low lysine, all corn-based diets to reduce ADG of pigs in an attempt to hold pigs for a later marketing time. As processing plants re-opened or increased their processing capability and could accept more pigs, pigs were often switched from the corn-based diets formulated to restrict growth to more standard diets to increase the growth rate of the pigs. However, the effect of feeding late-finishing pigs Lys-sufficient diets after a period of low-Lys diets is not clear. Therefore, our objective was to evaluate the compensatory growth of 200 lb pigs previously fed a Lys-deficient diet, then switched to a Lys-sufficient diet over a 6-week period.

Procedures

The Kansas State University Institutional Animal Care and Use Committee approved the protocol used in this experiment. This study was conducted at the Kansas State University Swine Teaching and Research Center in Manhattan, KS. The facility was totally enclosed and environmentally regulated, containing 36 pens. Each pen was equipped with a two-hole dry single-sided feeder (Farmweld, Teutopolis, IL) and a 1-cup waterer. Pigs were stocked at a floor space of approximately 8.0 ft^2 per pig. Pens were equipped with adjustable gates to allow space allowances per pig to be maintained if a pig died or was removed from a pen during the experiment. Pens were located over a completely slatted concrete floor with a 4-ft pit underneath for manure storage. A robotic feeding system (FeedPro; Feedlogic Corp., Wilmar, MN) was used to deliver and record daily feed additions to each individual pen.

A total of 346 pigs (241 × 600, DNA, Columbus, NE; initially 195.3 lb) were used. Treatments were fed in four stages and the trial was 44 days in length. At the initiation of the study, pens of pigs were weighed and allotted to one of four treatment strategies in a randomized complete block design with average pen weight serving as the blocking factor. Pigs were housed in mixed gender pens with 9 to 10 pigs per pen and 9 pens per treatment. Two diets were manufactured (control and corn diet). The pigs of the control treatment were fed the control diet from day 0 to 44. For the other three treatments, pigs were fed the corn diet for 2, 3, or 4 weeks and then switched to the control diet for the remainder of the trial (d 44). Thus, these treatment groups were fed the control diet for 30, 23, or 16 days prior to marketing, respectively (Figure 1). The control diet contained 13.0% CP and 0.70% standardized ileal digestible (SID) Lys. The corn diet contained 8.1% CP, 0.18% SID Lys, and was 98% corn with vitamins and minerals (Table 1). All diets met the NRC[1] vitamin and mineral requirement estimates of the pigs with the only deficiency being amino acid levels.

Pigs were weighed approximately every 7 days from d 0 to 44 of the trial to determine ADG, ADFI, and F/G. On the last day of the trial, final pen weights were taken, and

[1] National Research Council. 2012. Nutrient Requirements of Swine: Eleventh Revised Edition. Washington, DC: The National Academies Press. https://doi.org/10.17226/13298.

the pigs were tagged with RFID ear tags and transported to a USDA-inspected packing plant (Triumph Foods, St Joseph, MO) for carcass data collection. Carcass measurements included hot carcass weight (HCW), loin depth, backfat depth, and percentage lean.

For the economic analysis, feed cost, feed cost per lb of gain, revenue per pig, and income over feed costs (IOFC) were calculated on a per pig placed basis. Corn was valued at $130/ton, soybean meal at $305/ton, L-lysine at $0.60/lb, DL-methionine at $1.15/ lb, L-threonine at $0.80/lb, and L-tryptophan at $4.00/lb. The feed costs were $169.61/ton for the control diet and $144.66/ton for the corn diet. Feed cost per pig was calculated by multiplying the feed cost per lb by ADFI and by the number of days in each phase, then adding up the values for each phase. Feed cost per lb of gain was calculated by dividing the feed cost per pig by the overall weight gain per pig. Revenue was obtained by multiplying carcass gain by using the typical market value ($0.65/lb; standard) and market value during the COVID-19 crisis ($0.30/lb; low). The IOFC was calculated by subtracting the feed cost per pig from revenue per pig.

Data were analyzed as a randomized complete block design for one-way ANOVA using the lmer function from the lme4 package in R program (version 3.5.2)[2] with pen considered the experimental unit, initial BW as blocking factor, and treatment as fixed effect. In stage 1 (d 0 to 14), data were analyzed as two treatments (control or corn diet). In stage 2 (d 14 to 21), data were analyzed as 3 treatments. In stage 3 (d 21 to 28) and 4 (d 28 to 44), data were analyzed as 4 treatments. Tukey adjustment was used for multiple comparisons. All results were considered significant at $P \leq 0.05$ and marginally significant between $P > 0.05$ and $P \leq 0.10$.

Results and Discussion

From d 0 to 14, pigs fed the corn diet had decreased ($P < 0.05$) ADG, ADFI, d 14 BW, Lys intake per day, and worsened ($P < 0.05$) F/G compared to pigs fed the control diet (Table 2). Day 14 BW was approximately 17 lb lighter for pigs fed the corn diet compared to pigs of the control group. There was no evidence of difference in Lys intake per kg of gain.

From d 14 to 21, pigs previously fed the corn diet for 2 weeks and then switched to the control diet exhibited compensatory gain with increased ($P < 0.05$) ADG, ADFI, and Lys intake per day, and improved ($P < 0.05$) F/G, and Lys intake per kg of gain, but still lower ($P < 0.05$) d 21 BW compared to pigs in the control group. Pigs that remained on the corn diet had decreased ($P < 0.05$) d 21 BW, Lys intake per day, and improved ($P < 0.05$) Lys intake per kg of gain compared to all other treatments, and decreased ($P < 0.05$) ADG compared the pigs previously fed the corn diet and switched to the control diet. There was no evidence of difference in ADFI and F/G between pigs in the control group and pigs fed the corn diet for 3 weeks.

From d 21 to 28, pigs previously fed the corn diet for 3 weeks and then switched to the control diet had compensatory gain with increased ($P < 0.05$) ADG and ADFI, but continued to have lower ($P < 0.05$) d 28 BW compared to pigs in the control group.

[2] R Core Team. 2018. R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing. Vienna, Austria. https://www.R-project.org/.

Pigs fed the corn diet for 3 weeks before being switched to the control diet also had decreased ($P < 0.05$) d 28 BW compared to pigs fed the corn diet for the first 2 weeks before being switched to the control diet thereafter. Pigs fed the corn diet for 2 of the 6 weeks continued to have decreased ($P < 0.05$) d 28 BW compared to pigs of the control group. Pigs fed the corn diet for 4 weeks had decreased ($P < 0.05$) ADG, d 28 BW, Lys intake per day, and improved ($P < 0.05$) Lys intake per kg of gain, and worsened ($P < 0.05$) F/G compared to all other treatments.

From d 28 to 44, pigs fed the corn diet for the first 4 of 6 weeks exhibited compensatory gain after being switched to the control diet, with increased ($P < 0.05$) ADG and improved ($P < 0.05$) F/G and Lys intake per kg of gain compared to all other treatments. Pigs in the control group had decreased ($P < 0.05$) ADG and worsened ($P < 0.05$) F/G and Lys intake per kg of gain compared to all other treatments. Pigs fed the corn diet for the first 3 or 4 of the 6 weeks had decreased ($P < 0.05$) d 44 BW compared the pigs in the control group and pigs fed the corn diet for the first 2 weeks. There was no evidence of difference in ADFI and Lys intake per day between all treatments.

For the overall period (d 0 to 44), there was no evidence of difference in ADFI between all treatments. Pigs in the control group and pigs fed the corn diet for the first 2 weeks had increased ($P < 0.05$) ADG compared to pigs fed the corn diet for the first 3 or 4 of the 6 weeks. Lys intake per day decreased ($P < 0.05$) and Lys intake per kg of gain improved ($P < 0.05$) as the length of time that pigs were fed the corn diet increased. Feed efficiency worsened ($P < 0.05$) as the length of time that pigs were fed the corn diet increased. There was no evidence of difference in removals and mortality (data not shown).

For carcass characteristics, pigs in the control group had increased ($P < 0.05$) HCW compared to pigs fed the corn diet for the first 4 of the 6 weeks. Pigs in the control group also had increased ($P < 0.05$) carcass yield compared to pigs fed the corn diet for the first 2 or 4 of the 6 weeks. Pigs in the control group had decreased ($P < 0.05$) backfat depth and increased ($P < 0.05$) loin depth compared to pigs fed the corn diet for the first 3 or 4 of the 6 weeks. However, there was no evidence of difference in percentage of lean among all treatments.

For economics, feed costs were $169.61 per ton for the control diet and $144.66 per ton for the corn diet. Pigs fed the control diet for the entire 44-day period had increased ($P < 0.05$) revenue (standard and low) and decreased ($P < 0.05$) feed cost per lb of gain compared to pigs fed the corn diet for the first 3 or 4 of the 6 weeks. Pigs fed the control diet for 44 days had increased ($P < 0.05$) feed cost but also IOFC (standard and low) compared to pigs fed the corn diet for the first 4 of the 6 weeks. Pigs fed the corn diet for the first 2 weeks had increased ($P < 0.05$) revenue (standard and low) and IOFC (standard), and decreased ($P < 0.05$) feed cost per lb of gain compared to pigs fed the corn diet for the first 4 of 6 weeks prior to marketing.

To better understand the differences in growth performance among treatment groups, weekly results are also shown in Figures 2, 3, and 4. The average difference in growth rate between pigs fed the control diet and pigs fed the corn diet was about 49% slower per day (Figure 2). After changing from the corn diet to the control diet, pigs previously fed the corn diet grew faster than pigs on the control treatment with a greater magnitude of response in the first week compared to the rest of the weeks. The average increase in ADG was 28% for the first week of recovery, and approximately 12% for the rest of the recovery period. The weekly differences of body weight compared to the control treatment are shown in Figure 3. Using these rates of recovery, in order for pigs fed the corn to achieve the same body weight as the control group, pigs fed the corn diet for 14 days would require 34 days of recovery, pigs fed the corn diet for 21 days would require 55 days of recovery, and pigs fed the corn diet for 28 days would require 75 days of recovery. This corresponds to approximately 2.5 days of recovery needed for every day the pigs were fed the Lys-deficient diet in order to have similar final BW as those fed the control diet. Weekly ADFI was similar to the control treatment when pigs were fed the corn diet, but increased during the first week of recovery before returning to similar levels as the control treatment thereafter (Figure 4).

In summary, these data suggest that feeding pigs the corn diet for the first 3 or 4 weeks followed by the control diet within a total of 6-week-period prior to marketing reduced growth performance and carcass characteristics compared to pigs fed the control diet for the full 6 weeks. The recovery of growth performance was better during the first week, and then gradually decreased to similar levels as the control group. These results allow producers to estimate the rate of reduction in growth rate and recovery time after feeding a corn diet. The study also provides insight to compensatory gain responses to dietary amino acid deficiencies.

Table 1. Composition of experimental diets (as-fed basis)[1]

Item	Control	Corn[3]
Ingredients, %		
Corn	86.41	98.22
Soybean meal	11.53	--
Limestone, ground	0.89	0.86
Monocalcium phosphate	0.26	0.43
Salt	0.35	0.35
L-Lysine-HCl	0.30	--
Methionine hydroxy analog, dry	0.01	--
L-Threonine	0.09	--
L-Tryptophan	0.02	--
Vitamin premix with phytase	0.08	0.08
Trace mineral premix	0.08	0.08
Total	100	100
Calculated analysis		
Standardized ileal digestible (SID) amino acids, %		
Lysine	0.70	0.18
Isoleucine:lysine	60	124
Leucine:lysine	156	452
Methionine:lysine	30	81
Methionine and cysteine:lysine	58	163
Threonine:lysine	65	117
Tryptophan:lysine	18.6	25.9
Valine:lysine	70	168
Lysine:net energy, g/Mcal	2.73	0.69
Net energy, kcal/lb	1,163	1,190
Crude protein, %	13.0	8.1
Calcium, %	0.47	0.45
STTD P,[2] %	0.24	0.24
Chemical analysis,[3] %		
Dry matter	88.4	87.7
Crude protein	12.5	7.9

[1]Experimental diets were fed for 44 days with 4 stages.
[2]STTD P = standardized total tract digestible phosphorus.
[3]A representative sample of each diet was collected from the feeders of each treatment, homogenized, and analyzed (Ward Laboratories, Inc., Kearney, NE).

Table 2. Evaluation of compensatory growth of 200 lb finishing pigs previously fed a low lysine diet [1,2,3]

Stage 1 (d 0 to 14):	Control	Corn			
Stage 2 (d 14 to 21):	Control	Control	Corn		
Stage 3 (d 21 to 28):	Control	Control	Control	Corn	
Stage 4 (d 28 to 44):	Control	Control	Control	Control	SEM
d 0 to 14 (stage 1)					
d 0 BW, lb	195.4	195.3			≤ 2.31[4]
d 14 BW, lb	219.7[a]	202.4[b]			≤ 2.22[4]
ADG, lb	1.74[a]	0.50[b]			≤ 0.056[4]
ADFI, lb	5.47[a]	4.81[b]			≤ 0.107[4]
F/G	3.17[b]	10.78[a]			≤ 0.849[4]
Lys intake, g/d	17.37[a]	3.96[b]			≤ 0.286[4]
Lys intake, g/kg gain	22.2	19.6			≤ 1.51[4]
d 14 to 21 (stage 2)					
d 21 BW, lb	233.7[a]	223.0[b]	214.2[c]		≤ 2.22[4]
ADG, lb	1.96[b]	2.95[a]	1.68[b]		≤ 0.109[4]
ADFI, lb	5.81[b]	6.64[a]	6.03[b]		≤ 6.642[4]
F/G	3.08[a]	2.26[b]	3.72[a]		≤ 0.218[4]
Lys intake, g/d	18.4[b]	21.1[a]	5.0[c]		≤ 0.45[4]
Lys intake, g/kg gain	21.6[a]	15.8[b]	6.8[c]		≤ 1.52[4]
d 21 to 28 (stage 3)					
d 28 BW, lb	248.5[a]	239.7[b]	233.1[c]	223.0[d]	2.32
ADG, lb	2.09[b]	2.39[ab]	2.72[a]	1.24[c]	0.136
ADFI, lb	5.72[b]	6.32[ab]	6.57[a]	6.14[ab]	0.201
F/G	2.78[b]	2.66[b]	2.46[b]	5.43[a]	≤ 0.116[4]
Lys intake, g/d	18.2[a]	20.1[a]	20.9[a]	5.1[b]	≤ 0.88[4]
Lys intake, g/kg gain	19.4[a]	18.6[a]	17.2[a]	9.9[b]	0.82
d 28 to 44 (stage 4)					
d 44 BW, lb	277.8[a]	273.2[a]	266.4[b]	261.2[b]	2.472
ADG, lb	1.83[c]	2.07[b]	2.06[b]	2.35[a]	0.046
ADFI, lb	5.89	6.17	6.06	6.28	0.122
F/G	3.23[a]	2.98[b]	2.93[b]	2.68[c]	0.047
Lys intake, g/d	18.7	19.6	19.2	19.9	0.386
Lys intake, g/kg gain	22.6[a]	20.9[b]	20.5[b]	18.7[c]	0.331
d 0 to 44					
ADG, lb	1.86[a]	1.76[a]	1.60[b]	1.48[b]	0.039
ADFI, lb	5.71	5.84	5.71	5.76	0.089
F/G	3.08[d]	3.32[c]	3.57[b]	3.89[a]	0.040
Lys intake, g/d	18.1[a]	14.9[b]	12.3[c]	10.1[d]	0.238
Lys intake, g/kg gain	21.6[a]	18.7[b]	17.0[c]	15.0[d]	≤ 0.36[4]

continued

Table 2. Evaluation of compensatory growth of 200 lb finishing pigs previously fed a low lysine diet [1,2,3]

Stage 1 (d 0 to 14):	Control	Corn			
Stage 2 (d 14 to 21):	Control	Control	Corn		
Stage 3 (d 21 to 28):	Control	Control	Control	Corn	
Stage 4 (d 28 to 44):	Control	Control	Control	Control	SEM
Carcass characteristics					
HCW, lb	208.0[a]	203.8[ab]	200.6[ab]	193.6[b]	≤ 3.43[4]
Carcass yield, %	74.7[a]	73.8[bc]	74.3[ab]	73.5[c]	≤ 0.26[4]
Backfat depth, in	0.571[b]	0.597[ab]	0.609[a]	0.622[a]	≤ 0.0096[4]
Loin depth, in	2.47[a]	2.39[ab]	2.31[b]	2.27[b]	≤ 0.023[4]
Lean, %	54.9	54.5	54.1	54.0	≤ 0.24[4]

[a,b,c,d] Means within a row with different superscripts differ ($P \le 0.05$).
[1]A total of 346 pigs (initially 195.3 lb) were used with 9 to 10 pigs per pen and 9 replicates per treatment.
[2]BW = body weight. ADG = average daily gain. ADFI = average daily feed intake. F/G = feed efficiency. HCW = hot carcass weight.
[3]SID lysine (%) was 0.70 for Control diet and 0.18 for Corn diet.
[4]Heterogenous variance.

Table 3. Evaluation of compensatory growth of 200 lb finishing pigs previously fed a low lysine diet[1]

Stage 1 (d 0 to 14):	Control	Corn			
Stage 2 (d 14 to 21):	Control	Control	Corn		
Stage 3 (d 21 to 28):	Control	Control	Control	Corn	
Stage 4 (d 28 to 44):	Control	Control	Control	Control	SEM
Economics (per pig placed), $[2]					
Revenue (standard)[3]	135.11[a]	131.81[ab]	129.44[bc]	125.05[c]	≤ 1.479[8]
Revenue (low)[4]	62.36[a]	60.84[ab]	59.74[bc]	57.72[c]	≤ 0.683[8]
Feed cost[5]	21.10[a]	20.80[ab]	19.71[ab]	19.54[b]	0.386
Feed cost per lb of gain[6]	0.261[c]	0.271[c]	0.284[b]	0.301[a]	0.0032
IOFC (standard)[7]	113.96[a]	111.02[a]	109.64[ab]	105.49[b]	≤ 1.467[8]
IOFC (low)	41.21[a]	40.05[ab]	39.94[ab]	38.15[b]	≤ 0.688[8]

[a,b,c] Means within a row with different superscripts differ ($P \le 0.05$).
[1] A total of 346 pigs (initially 195.3 lb) were used with 9 to 10 pigs per pen and 9 replicates per treatment.
[2]Removal rates were similar between all treatments.
[3]Revenue (standard) = $0.65 × (live weight × carcass yield).
[4]Revenue (low) = $0.30 × (live weight × carcass yield).
[5]Feed cost per ton: $169.61 (control diet) and $144.66 (corn diet).
[6]Feed cost/lb gain = (total feed cost) / (total pen gain).
[7]IOFC (Income over feed cost) = revenue – feed cost.
[8]Heterogenous variance.

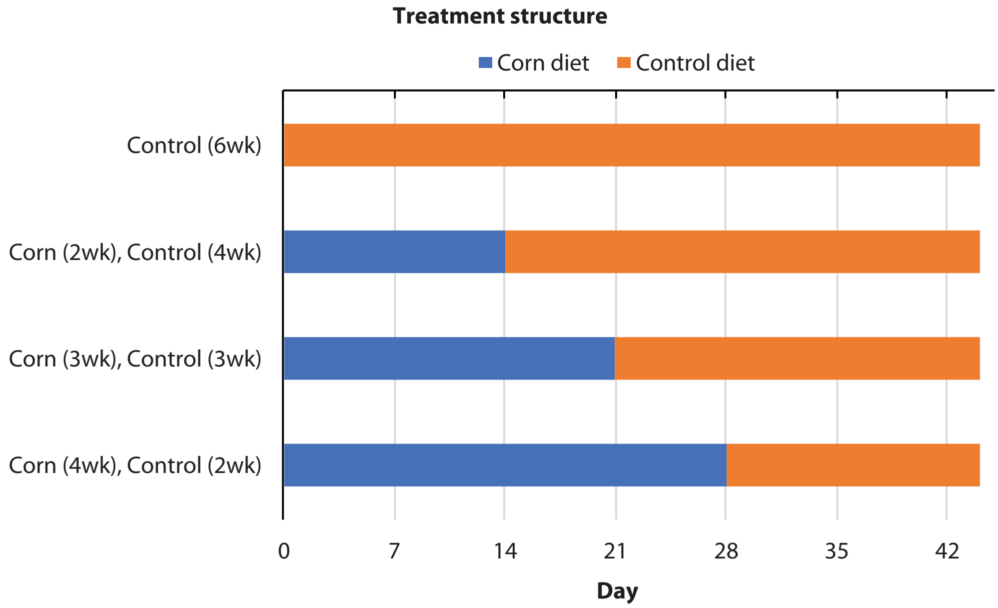

Figure 1. Experimental treatment design. A total of 2 diets were manufactured (control and corn). Nine pens of pigs were in the control group and fed the control diet from day 0 to 44. The other three treatments also consisted of 9 pens per treatment and were fed corn diets for the first 2, 3, or 4 weeks and then fed the control diet until d 44.

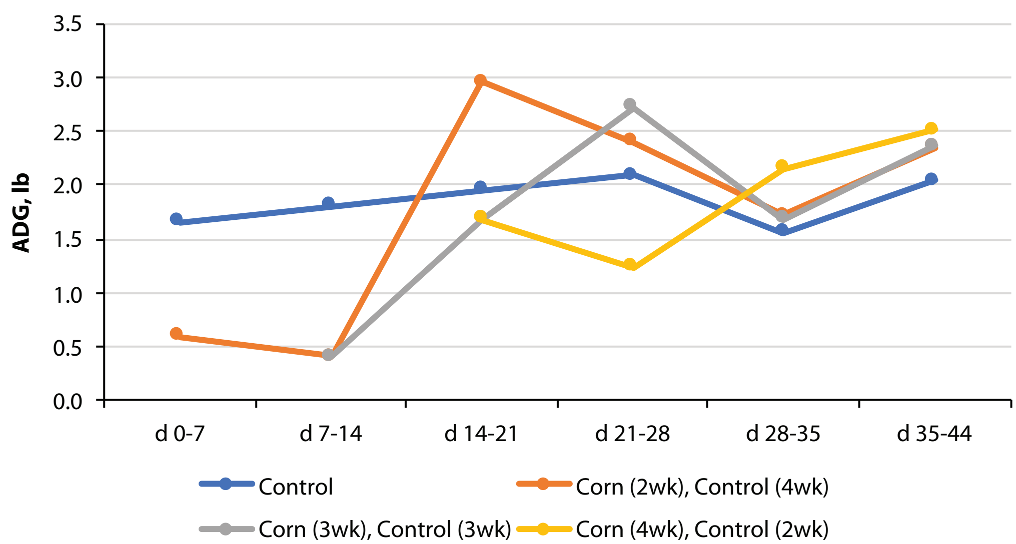

Figure 2. Weekly average daily gain (ADG) of the 4 nutritional strategies. A total of 346 pigs (initially 195.3 lb) were used with 9 to 10 pigs per pen and 9 replicates per treatment.

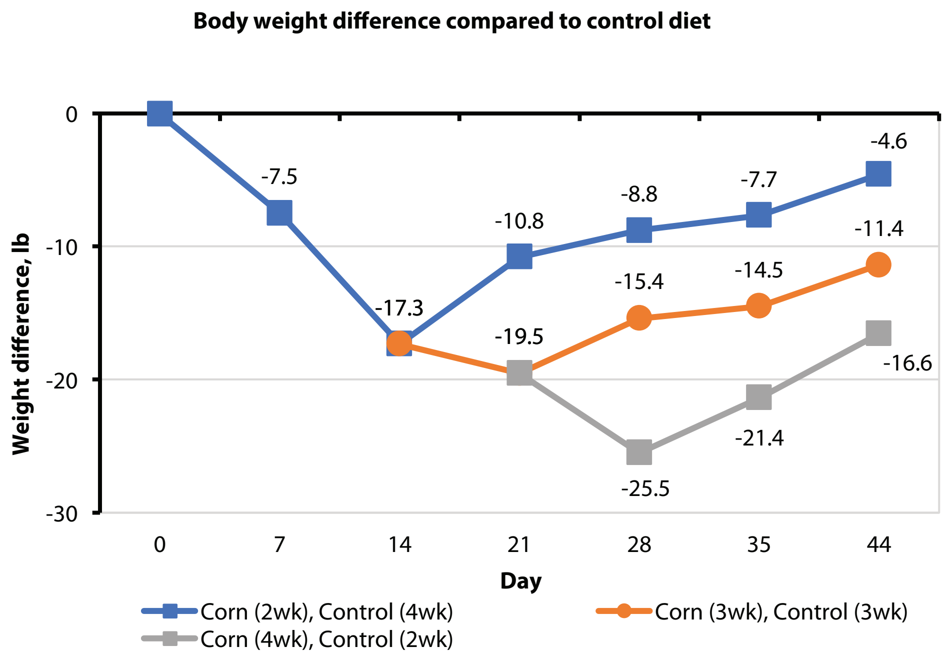

Figure 3. Body weight (BW) difference compared to control diet. A total of 346 pigs (initially 195.3 lb) were used with 9 to 10 pigs per pen and 9 replicates per treatment. The weekly BW differences were calculated by subtracting the BW of pigs fed the control diet from BW of pigs fed other nutritional strategies.

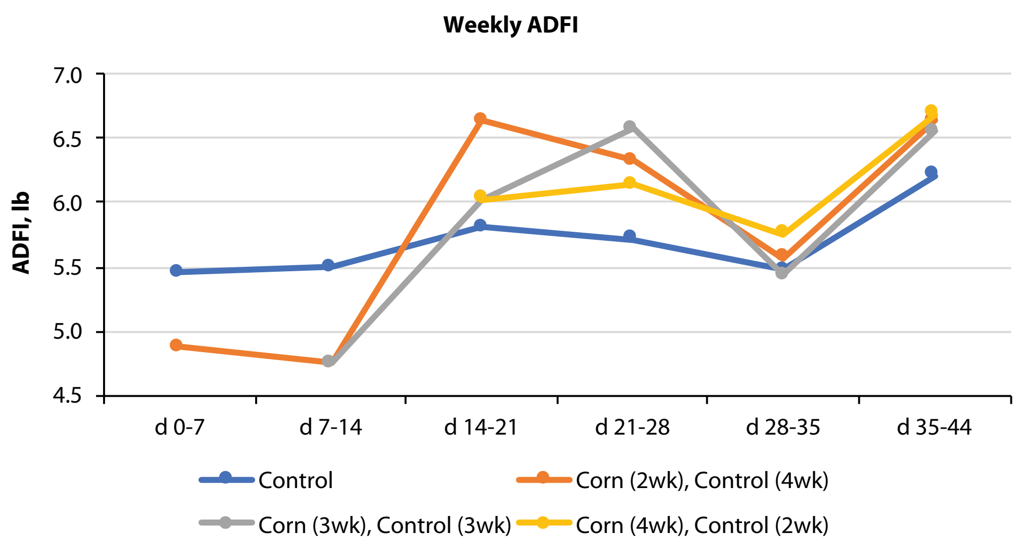

Figure 4. Weekly average daily feed intake (ADFI) of the 4 nutritional strategies. A total of 346 pigs (initially 195.3 lb) were used with 9 to 10 pigs per pen and 9 replicates per treatment.