

# Evaluation of nutritional strategies to slow growth rate then induce compensatory growth in 90-kg finishing pigs

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**ABSTRACT:** Two 44-d experiments were conducted to evaluate nutritional strategies with different concentrations of dietary lysine (and other amino acids) on growth rate and subsequent compensatory gain of 90-kg finishing pigs. Three diets were formulated to contain 0.70 (control), 0.50% and 0.18% standardized ileal digestible (SID) Lys. In Exp. 1, 356 pigs (Line 241 × 600, DNA; initially 89.0 ± 1.10 kg) were used with four treatments. From d 0 to 28, pigs received either the control or the 0.50%-Lys diet. On d 28, pigs either remained on these diets or were switched the 0.18%-Lys diet until d 44. There were 18 pens per treatment from d 0 to 28 and 9 pens per treatment from d 28 to 44. From d 0 to 28, pigs fed the 0.50%-Lys diet had decreased ( $P < 0.001$ ) ADG and G:F compared to those fed the control diet. From d 28 to 44, pigs switched to the 0.18%-Lys diet had decreased ( $P < 0.05$ ) ADG and G:F compared to pigs that remained on the control or 0.50%-Lys diets. From d 0 to 44, pigs fed 0.50%-Lys diet for 44-d had decreased ( $P < 0.05$ ) ADG, G:F, and percentage carcass lean compared to pigs fed the control diet. Pigs fed the 0.50%-Lys diet then the 0.18%-Lys diet had decreased ( $P < 0.05$ ) ADG and G:F compared to other treatments. Pigs

fed the 0.50%-Lys diet for 44-d and pigs fed the control diet then 0.18%-Lys diet had decreased ( $P < 0.05$ ) ADG, G:F, and percentage carcass lean compared to control pigs. In Exp. 2, 346 pigs (Line 241 × 600, DNA; initially 88.6 ± 1.05 kg) were used to evaluate compensatory growth after varying durations of dietary lysine restriction. A total of four treatments were used including pigs fed the control diet for 44-d or fed the 0.18%-Lys diet for 14, 21, or 28-d and then fed the control diet until the conclusion of the experiment on d 44. There were nine pens per treatment. On average, pigs fed the 0.18%-Lys diet grew 49% slower than the control. Compared to the control, ADG of pigs previously fed the 0.18%-Lys diet increased ( $P < 0.05$ ) 28% during the first week after switching to the control diet and 12% for the rest of the trial. Despite this improvement, overall ADG, G:F, final BW, and percentage carcass lean decreased (linear,  $P < 0.05$ ) as the duration of Lys restriction increased. In summary, feeding Lys-restricted diets reduced the ADG and G:F of finishing pigs. Compensatory growth can be induced in Lys-restricted finishing pigs, but the duration of restriction and recovery influences the magnitude of compensatory growth.

**Key words:** compensatory growth, finishing pigs, growth rate, lysine

**Abbreviations:** AA = amino acid, ADG = average daily gain, ADFI = average daily feed intake, BW = body weight, CP = crude protein, DM = dry matter, G:F = gain-to-feed ratio, HCW = hot carcass weight, IOFC = income over feed cost, Lys = lysine, NE = net energy, SBM = soybean meal, SID = standardized ileal digestible.

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## INTRODUCTION

The U.S. pork industry experienced a substantial reduction in the ability to process market pigs due to packing plant closures attributed to the 2020 COVID-19 pandemic. With the reduced capacity for processors to accept market animals, pigs grew beyond their intended market weight making them too large for the infrastructure of the facility. Therefore, producers were forced to utilize a variety of strategies to reduce the growth rate of pigs and minimize economic hardship. Because lysine (Lys) is the first limiting amino acid (AA) for corn-soybean meal-based diets, reducing dietary SID Lys in the late-finishing period has been shown to reduce the ADG and ADFI of pigs beyond 100-kg body weight (Soto et al., 2019). Therefore, feeding finishing pigs SID Lys (as well as other AA) concentrations below their estimated requirements can reduce the growth rate, but the magnitude of the reduction is not fully researched. Recently, Helm et al. (2021) evaluated nutrient restriction to slow growth rate of finishing pigs in response to processing plant closures or reduced capacity. In that study, restricting Lys and other AAs dramatically decreased ADG and G:F. To the best of our knowledge, there is little additional information available in the literature regarding using severely deficient SID Lys concentrations as a nutritional strategy to intentionally limit the growth rate of late-finishing pigs. In addition, as processing plants re-opened or increased their processing capability, pigs were often switched from the Lys-restricted corn-based diets formulated to restrict growth, to more standard diets with sufficient Lys concentrations to attempt to recover growth rates. For growing-finishing pigs, switching from Lys-restricted diets to Lys-sufficient diets can induce compensatory growth, a physiological process of animals having accelerated growth rate after a period of restriction (Hornick et al., 2000; Menegat et al., 2020). Therefore, our objectives were to determine the effects of feeding diets with severely deficient SID Lys and other AA concentrations to reduce growth rates, and second, to

evaluate the effects of Lys-induced compensatory gain on growth performance and carcass characteristics of late-finishing pigs beyond 90-kg BW.

## MATERIALS AND METHODS

### General

The Kansas State University Institutional Animal Care and Use Committee approved the protocol used in these experiments. These studies were conducted at the Kansas State University Swine Teaching and Research Center in Manhattan, KS. The facility was totally enclosed and environmentally regulated. Each pen was equipped with a two-hole dry single-sided feeder (Farmweld, Teutopolis, IL) and a 1-cup waterer to provide ad libitum access to feed and water. Pigs were stocked at a floor space of approximately 0.65 m<sup>2</sup> per pig for Exp. 1 and 0.74 m<sup>2</sup> per pig for Exp. 2. 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 1.2-m 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. At the initiation of the studies, pens of pigs were weighed and allotted to 1 of 4 treatments for each experiment in a randomized complete block design with average pen weight serving as the blocking factor. Pigs were housed in mixed-gender pens with 9–10 pigs per pen. Pens of pigs were weighed approximately every 7 days from d 0 to 44 of the experiments to determine average daily gain (ADG), average daily feed intake (ADFI), and gain-to-feed ratio (G:F). On the last day of both experiments, final pen weights were taken, and the remaining 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.

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

Items	Control	0.50%-Lys	0.18%-Lys <sup>b</sup>
<b>Ingredients, %</b>			
Corn	86.41	92.99	98.22
Soybean meal	11.53	5.00	–
Limestone, ground	0.89	0.88	0.86
Monocalcium phosphate	0.26	0.36	0.43
Salt	0.35	0.35	0.35
L-Lysine-HCl	0.30	0.25	–
Methionine hydroxy analog, dry	0.01	–	–
L-Threonine	0.09	0.03	–
L-Tryptophan	0.02	0.01	–
Vitamin and trace mineral premixes <sup>a</sup>	0.16	0.16	0.16
Total	100	100	100
<b>Calculated analysis</b>			
<b>Standardized ileal digestible (SID) amino acids, %</b>			
Lysine	0.70	0.50	0.18
Isoleucine:lysine	60	62	124
Leucine:lysine	156	187	452
Methionine:lysine	30	34	81
Methionine and cysteine:lysine	58	68	163
Threonine:lysine	65	61	117
Tryptophan:lysine	18.6	15.9	25.9
Valine:lysine	70	77	168
Lysine:net energy, g/Mcal	2.73	1.93	0.69
Net energy, kcal/kg	2,564	2,599	2,623
Crude protein, %	13.0	10.3	8.1
Ca, %	0.47	0.46	0.45
STTD P, %	0.24	0.24	0.24
<b>Chemical analysis,<sup>b</sup> %</b>			
Dry matter	88.7	88.7	88.9
Crude protein	12.6	10.2	8.1

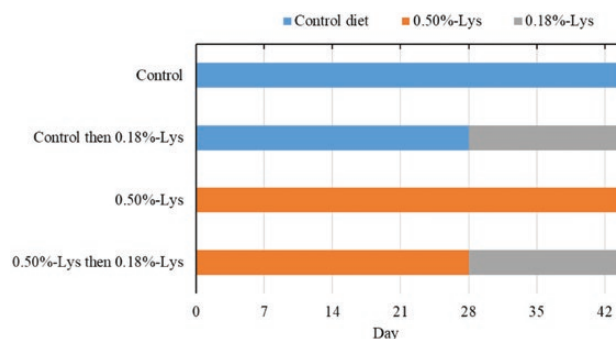
STTD P = standardized total tract digestible phosphorus.

<sup>a</sup>Provided per kg of diet: 1,240.10 IU vitamin A; 496.04 IU vitamin D; 13.23 IU vitamin E; 0.99 mg vitamin K; 0.01 mg vitamin B12; 14.88 mg niacin; 8.27 mg pantothenic acid; 2.48 mg riboflavin; 55 mg Zn from zinc sulfate; 55 mg Fe from iron sulfate; 17 mg Mn from manganese oxide; 8 mg Cu from copper sulfate; 0.15 mg I from calcium iodate; 0.15 mg Se from sodium selenite; and 375 FTU Ronozyme HiPhos GT 2700 (DSM Nutritional Products, Basel, Switzerland) with an expected STTD P release of 0.08%.

<sup>b</sup>A representative sample of each diet was collected from the feeders of each treatment, homogenized, and analyzed (Ward Laboratories, Inc., Kearney, NE).

**Diets**

A total of 3 diets were manufactured (control, 0.50%-Lys and 0.18%-Lys; Table 1). The control diet was corn–soybean meal-based and formulated to contain 0.70% SID Lys and 13.0% CP. The 0.50%-Lys diet included 5% soybean meal and contained 10.3% CP. The 0.18%-Lys diet was made up of 98% corn and 2% vitamins and minerals. It was calculated to have 8.1% CP and was the lowest SID Lys (and other AAs) concentration possible for an



**Figure 1.** Experimental treatment design of Exp. 1. A total of 3 diets were manufactured (control [0.70% SID Lys], 0.50%-Lys, and 0.18%-Lys). From d 0 to 28, pens received one of two dietary treatments (control or 0.50%-Lys). On d 28, pens previously fed the control diet were divided into two groups, half continued to be fed the control diet and the other half were fed to the 0.18%-Lys diet, which was fed until d 44. Pens previously fed the 0.50%-Lys diet were divided into two groups, half continued to be fed the 0.50%-Lys diet and the other half were fed the 0.18%-Lys diet, which was fed until d 44.

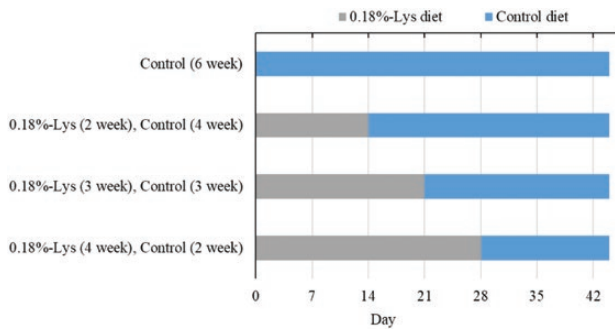
all corn-based diet. The control diet was formulated to meet requirement estimates established by NRC (2012) for pigs in this weight range. The other two diets were formulated to be deficient in SID Lys and other AAs to restrict growth rate. All diets met NRC (2012) requirement estimates for vitamins and minerals.

**Experiment 1**

A total of 356 pigs (Line 241 × 600, DNA; Columbus, NE; initially 89.0 ± 1.10 kg) were used with 4 treatments in a 44-d study. From d 0 to 28, pens of pigs were fed 1 of 2 dietary treatments (control or 0.50%-Lys; Figure 1). On d 28, pens of pigs previously fed the control diet were divided into two groups, half continued to be fed the control diet and the other half were fed the 0.18%-Lys diet until d 44. Pens previously fed the 0.50%-Lys diet were divided into two groups, half continued to be fed the 0.50%-Lys diet and the other half were fed the 0.18%-Lys diet until d 44. On d 28, one or two of the heaviest pigs in each pen were selected and marketed resulting in 8 remaining pigs per pen until d 44. The adjustable gates were moved to maintain a constant floor space per pig when the heaviest pigs were removed. These pigs were included in the d 0–28 growth performance data but not carcass data.

**Experiment 2**

A total of 346 pigs (Line 241 × 600, DNA, Columbus, NE; initially 88.6 ± 1.05 kg) were used with 4 treatments in a 44-d study. The first treatment consisted of pigs fed the control diet from d 0 to 44



**Figure 2.** Experimental treatment design of Exp. 2. A total of 2 diets were manufactured (control [0.70% SID Lys] and 0.18%-Lys). Nine pens of pigs were in the control group and fed the control diet from d 0 to 44. The other three treatments also consisted of 9 pens per treatment and were fed 0.18%-Lys diets for the first 14, 21, or 28-d and then fed the control diet until d 44.

(Figure 2). For the other three treatments, pigs were fed the 0.18%-Lys diet for 14, 21, or 28 days and then switched to the control diet for the remainder of the trial. Thus, these treatment groups were fed the control diet for 30, 23, or 16 days prior to marketing, respectively. The restriction period was defined as the period when pigs were fed the 0.18%-Lys diet, and the recovery period was defined as the period when pigs were switched from the 0.18%-Lys diet to the control diet. Like Exp. 1, pigs were marketed for carcass data collection at the same packing plant; however, all pigs were marketed on d 44 (no pigs were marketed on day 28).

### Economic Analysis

For both experiments, economic analysis including feed cost, feed cost per kg of gain, revenue per pig, and income over feed cost (IOFC) was calculated on a per pig placed basis. Ingredient cost (USD per kg) at the time of the study were used with corn valued at \$0.12, soybean meal at \$0.336, L-lysine HCl at \$1.32, DL-methionine at \$2.54, L-threonine at \$1.76, and L-tryptophan at \$8.82. Diet cost was \$0.17 per kg for the control diet, \$0.15 per kg for the 0.50%-Lys diet, and \$0.14 per kg for the 0.18%-Lys diet. Feed cost per pig was calculated by multiplying the diet cost per kg by ADFI and by the number of days in each period. Feed cost per kg of gain was calculated by dividing the feed cost per pig by the overall weight gain per pig. Revenue was obtained by multiplying HCW by either a low carcass market value (\$0.66/kg; low) or a more typical market value (\$1.43/kg; standard). The IOFC was calculated by subtracting the feed cost per pig from revenue per pig.

Representative diet samples of both experiments were obtained from the feeders of each treatment, homogenized, and analyzed for dry matter

(method 935.29; AOAC Int., 2019) and crude protein (method 990.03; AOAC Int., 2019; Ward Laboratories Inc., Kearney, NE; Table 1).

### Statistical Analysis

Data were analyzed as a randomized complete block design for one-way ANOVA using the lme function from the nlme package (Pinheiro et al., 2020) in R program (R Core Team, 2019). Pen was considered the experimental unit, initial pen average BW as the blocking factor, and treatment as a fixed effect. For every response, two analytical models were constructed by assuming 1) equal variance across all treatments, or 2) assuming a unique estimate of variance for each treatment group. Similar procedures have been implemented by Rao et al. (2020a, 2020b) building upon the concepts outlined by Goncalves et al. (2016). Both models were fit, and model selection was based on the ANOVA test ( $P \leq 0.05$ ) via Bayesian information criterion. Tukey adjustment was used for multiple comparisons using the emmeans package (Lenth, 2020). All results were considered significant at  $P \leq 0.05$  and marginally significant at  $0.05 < P \leq 0.10$ . For Exp. 1, data were analyzed as two treatments (control or 0.50%-Lys) with 18 pens per treatment from d 0 to 28 and as 4 treatments with 9 pens per treatment for d 28 to 44 and the overall period. For Exp. 2, data were analyzed as two treatments (control or 0.18%-Lys diet) from d 0 to 14, 3 treatments from d 14 to 21, and 4 treatments from d 21 to 44, and d 0 to 44. Polynomial contrasts were constructed to evaluate the linear and quadratic effects for feeding duration of the 0.18%-Lys diet for d 28–44, and d 0–44.

## RESULTS

### Experiment 1

From d 0 to 28, pigs fed the 0.50%-Lys diet had decreased ( $P < 0.001$ ) ADG, G:F, d 28 BW, Lys intake per day, and Lys intake per kg of gain compared to pigs fed the control diet (Table 2). On d 28, one or two of the heaviest pigs in each pen were selected and marketed. Day 28 pre-marketing BW was approximately 3.7 kg lighter and when the one or two heaviest pigs in a pen were removed, d 28 post-marketing BW was approximately 4.8 kg lighter for pigs fed the 0.50%-Lys diet compared to pigs fed the control diet. There was no evidence of difference in ADFI.

From d 28 to 44, regardless of the previous diets fed from d 0 to 28, pigs fed the 0.18%-Lys diet



**Table 2.** Effect of nutritional strategies to reduce growth rate of pigs beyond 90-kg body weight, Exp. 1\*

d 0–28	Control <sup>†</sup>		0.50%-Lys		Probability, <sup>‡</sup> <i>P</i> <
	Control	0.18%-Lys	0.50%-Lys	0.18%-Lys	
d 0–28					
ADG, kg	0.84 ± 0.016		0.71 ± 0.009		< 0.001
ADFI, kg	2.77 ± 0.028		2.78 ± 0.028		0.832
G:F	0.301 ± 0.004		0.254 ± 0.002		< 0.001
Lys intake, g/d	19.4 ± 0.21		13.9 ± 0.15		< 0.001
Lys intake, g/kg gain	23.3 ± 0.28		19.7 ± 0.14		< 0.001
d 0 BW, kg	89.1 ± 1.10		89.0 ± 1.10		0.708
d 28 BW, kg (pre-marketing) <sup>  </sup>	112.5 ± 1.22		108.8 ± 1.13		< 0.001
d 28–44					
ADG, kg	0.86 ± 0.032 <sup>a</sup>	0.48 ± 0.032 <sup>c</sup>	0.71 ± 0.032 <sup>b</sup>	0.44 ± 0.032 <sup>c</sup>	< 0.001
ADFI, kg	2.60 ± 0.058 <sup>a</sup>	2.42 ± 0.058 <sup>ab</sup>	2.46 ± 0.058 <sup>ab</sup>	2.26 ± 0.058 <sup>b</sup>	0.005
G:F	0.331 ± 0.0150 <sup>a</sup>	0.197 ± 0.0100 <sup>b</sup>	0.289 ± 0.0066 <sup>a</sup>	0.195 ± 0.0065 <sup>b</sup>	< 0.001
Lys intake, g/d	18.2 ± 0.42 <sup>a</sup>	4.4 ± 0.12 <sup>c</sup>	12.3 ± 0.29 <sup>b</sup>	4.1 ± 0.09 <sup>c</sup>	< 0.001
Lys intake, g/kg gain	21.6 ± 1.16 <sup>a</sup>	9.5 ± 0.56 <sup>c</sup>	17.4 ± 0.44 <sup>b</sup>	9.4 ± 0.31 <sup>c</sup>	< 0.001
d 28 BW, kg (post-marketing) <sup>  </sup>	111.2 ± 1.41 <sup>a</sup>	111.2 ± 1.41 <sup>a</sup>	106.4 ± 1.41 <sup>b</sup>	106.5 ± 1.41 <sup>b</sup>	< 0.001
d 44 BW, kg	125.3 ± 1.47 <sup>a</sup>	118.9 ± 1.98 <sup>b</sup>	117.8 ± 1.69 <sup>b</sup>	113.5 ± 1.25 <sup>c</sup>	< 0.001
d 0–44					
ADG, kg	0.86 ± 0.018 <sup>a</sup>	0.71 ± 0.018 <sup>b</sup>	0.72 ± 0.018 <sup>b</sup>	0.61 ± 0.018 <sup>c</sup>	< 0.001
ADFI, kg	2.72 ± 0.039	2.66 ± 0.039	2.69 ± 0.039	2.61 ± 0.039	0.221
G:F	0.315 ± 0.0042 <sup>a</sup>	0.268 ± 0.0042 <sup>b</sup>	0.267 ± 0.0042 <sup>b</sup>	0.235 ± 0.0042 <sup>c</sup>	< 0.001
Lys intake, g/d	19.0 ± 0.22 <sup>a</sup>	14.7 ± 0.22 <sup>b</sup>	13.5 ± 0.22 <sup>c</sup>	10.8 ± 0.22 <sup>d</sup>	< 0.001
Lys intake, g/kg gain	22.3 ± 0.33 <sup>a</sup>	20.7 ± 0.33 <sup>b</sup>	18.8 ± 0.33 <sup>c</sup>	17.6 ± 0.33 <sup>c</sup>	< 0.001
Carcass characteristics					
HCW, kg	93.5 ± 1.29 <sup>a</sup>	88.9 ± 1.24 <sup>b</sup>	87.5 ± 1.35 <sup>bc</sup>	84.5 ± 1.26 <sup>c</sup>	< 0.001
Carcass yield, %	74.8 ± 0.20	74.2 ± 0.19	74.2 ± 0.21	74.1 ± 0.20	0.096
Backfat depth, mm <sup>§</sup>	13.9 ± 0.34 <sup>b</sup>	15.2 ± 0.30 <sup>a</sup>	15.3 ± 0.34 <sup>a</sup>	15.8 ± 0.32 <sup>a</sup>	0.002
Loin depth, mm <sup>§</sup>	62.0 ± 0.60 <sup>a</sup>	59.1 ± 0.53 <sup>b</sup>	59.8 ± 0.60 <sup>ab</sup>	58.1 ± 0.56 <sup>b</sup>	< 0.001
Lean, % <sup>  </sup>	55.5 ± 0.20 <sup>a</sup>	54.5 ± 0.18 <sup>b</sup>	54.6 ± 0.20 <sup>b</sup>	54.0 ± 0.19 <sup>b</sup>	< 0.001

ADFI = average daily feed intake, ADG = average daily gain, BW = body weight, G:F = feed efficiency, HCW = hot carcass weight.

<sup>a,b,c,d</sup> Means within a row with different superscripts differ (*P* < 0.05).

\*A total of 356 pigs (initially 89 kg) were used with 10 pigs per pen and 9 replicates per treatment. On d 28, one or two heaviest pigs in each pen were selected and marketed as standard farm marketing protocol. These heavy pigs were included in the d 0–28 growth performance data and d 28 pre-marketing BW, but not in d 28 post-marketing BW and carcass data.

<sup>†</sup>SID lysine (%) was 0.70 for the control diet, 0.50 for the 0.50%-Lys diet, and 0.18 for the 0.18%-Lys diet.

<sup>‡</sup>Treatment *F*-test based on ANOVA.

<sup>||</sup>On d 28, one or two of the heaviest pigs in each pen were selected and marketed resulting in eight remaining pigs per pen for all pens until d 44. These pigs were included in the d 0–28 growth performance data but not carcass data.

<sup>§</sup>Adjusted using HCW as covariate.

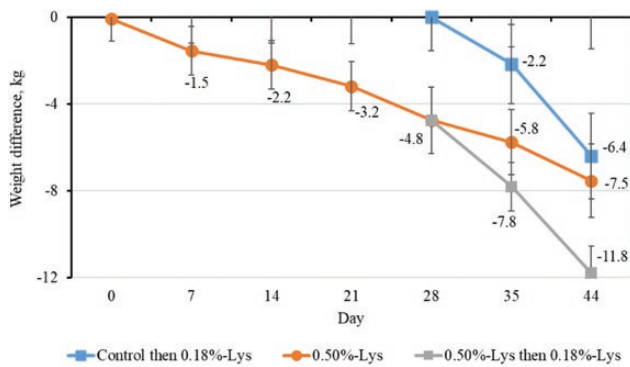
had decreased (*P* < 0.05) ADG, G:F, Lys intake per day, and Lys intake per kg of gain compared to pigs fed the control or 0.50%-Lys diets (Table 2). Pigs fed the 0.50%-Lys diet for 44-d had decreased (*P* < 0.05) ADG, G:F, Lys intake per day, and Lys intake per kg of gain compared to pigs fed the control diet for the entire 44-d study.

For the overall period (d 0–44), there was no evidence of difference in ADFI between treatments (Table 2). Pigs fed the 0.50%-Lys diet (d 0–28) then the 0.18%-Lys diet (d 28–44) had decreased (*P* < 0.05) ADG, G:F, final BW, and Lys intake per day compared to the three other treatments, and were approximately 11.8 kg lighter than pigs

fed the control diet (Figure 3). There was no evidence of difference between pigs fed the 0.50%-Lys diet for 44-d and pigs fed the control diet (d 0–28) then the 0.18%-Lys diet (d 28–44) in ADG, G:F, and final BW. Pigs on these two treatments had decreased (*P* < 0.05) ADG and G:F, and final BW (~7 kg lighter), compared to pigs fed the control diet for 44-d. All pigs fed the 0.50%-Lys diet from d 0 to 28 had decreased (*P* < 0.05) overall Lys intake per kg of gain compared to pigs fed the control diet from d 0 to 28. There were no differences in removals, mortality, or incidences of tail-biting or other vices (data not shown). Overall, pig health was very good throughout the study.

For carcass characteristics, there was no evidence of difference in carcass yield between treatments (Table 2). Pigs fed the 0.50%-Lys diet (d 0–28) then the 0.18%-Lys diet (d 28–44) had decreased ( $P < 0.05$ ) HCW, percentage lean, loin depth, and increased ( $P < 0.05$ ) backfat depth compared to pigs fed the control diet for 44-d. There was no evidence of a difference in backfat depth, loin depth, and percentage lean between the pigs fed the 0.50%-Lys for 44 days, the pigs fed the control diet (d 0–28) then the 0.18%-Lys diet (d 28–44), and the pigs fed the 0.50%-Lys diet (d 0–28) then 0.18%-Lys diet (d 28–44).

Revenue per pig was calculated using either the low market value at the time of the study (\$0.66/kg; low) or a more typical market value (\$1.43/kg;



**Figure 3.** Exp. 1 body weight difference compared to control diet (horizontal axis at 0). A total of 346 pigs (initially 89.0 kg) were used with 9–10 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 treatments. Two diets (control [0.70% SID Lys] and 0.50%-Lys) were fed to pigs from d 0 to 28. Four treatments were used from d 28 to 44. Error bar represents 1 SE.

standard; Table 3). Pigs fed the 0.50%-Lys diet (d 0–28) then the 0.18%-Lys diet (d 28–44) had decreased ( $P < 0.05$ ) revenue, using either the low or standard pricing model, compared to all other treatments, and had increased ( $P < 0.05$ ) feed cost per kg of gain and decreased IOFC (low pricing) compared to pigs fed the control or the 0.50%-Lys treatments for 44 d. Pigs fed the 0.18%-Lys diets from d 28 to 44 had decreased ( $P < 0.05$ ) IOFC (low and standard pricing) per pig placed and feed cost compared to pigs fed the control diet for 44-d. There was no evidence of a difference in all economic criteria between pigs fed the control diet (d 0–28) then 0.18%-Lys diet (d 28–44) and pigs fed the 0.50%-Lys diet for 44 d.

## Experiment 2

From d 0 to 14, pigs fed the 0.18%-Lys diet had decreased ( $P < 0.05$ ) ADG, ADFI, G:F, d 14 BW, and Lys intake per day compared to pigs fed the control diet (Table 4). Day 14 BW was approximately 8 kg lighter for pigs fed the 0.18%-Lys diet compared to pigs of the control group (Figure 4). There was no evidence of a difference in Lys intake per kg of gain.

From d 14 to 21, pigs previously fed the 0.18%-Lys diet for 14-d and then switched to the control diet exhibited compensatory gain with increased ( $P < 0.05$ ) ADG, ADFI, G:F Lys intake per day, and improved ( $P < 0.05$ ) Lys intake per kg of gain, but still lower ( $P < 0.05$ ) d 21 BW compared to

**Table 3.** Effect of nutritional strategies to reduce growth rate of pigs beyond 90-kg body weight, Exp. 1\*

d 0–28	Control†		0.50%-Lys		Probability,‡ $P <$
d 28–44	Control	0.18%-Lys	0.50%-Lys	0.18%-Lys	
Economics (per pig placed), \$					
Revenue (low)§	17.28 ± 0.355 <sup>a</sup>	14.26 ± 0.355 <sup>b</sup>	14.41 ± 0.355 <sup>b</sup>	12.30 ± 0.355 <sup>c</sup>	< 0.001
Revenue (standard)¶	37.44 ± 0.769 <sup>a</sup>	30.90 ± 0.769 <sup>b</sup>	31.23 ± 0.769 <sup>b</sup>	26.65 ± 0.769 <sup>c</sup>	< 0.001
Feed cost**	18.59 ± 0.257 <sup>a</sup>	17.24 ± 0.257 <sup>b</sup>	16.62 ± 0.257 <sup>bc</sup>	15.68 ± 0.257 <sup>c</sup>	< 0.001
Feed cost per kg of gain††	0.53 ± 0.009 <sup>c</sup>	0.59 ± 0.009 <sup>ab</sup>	0.57 ± 0.009 <sup>bc</sup>	0.63 ± 0.009 <sup>a</sup>	< 0.001
IOFC (low)‡‡	-1.32 ± 0.232 <sup>a</sup>	-2.98 ± 0.232 <sup>bc</sup>	-2.21 ± 0.232 <sup>b</sup>	-3.38 ± 0.232 <sup>c</sup>	< 0.001
IOFC (standard)	18.84 ± 0.598 <sup>a</sup>	13.66 ± 0.598 <sup>b</sup>	14.61 ± 0.598 <sup>b</sup>	10.97 ± 0.598 <sup>c</sup>	< 0.001

<sup>a,b,c</sup> Means within a row with different superscripts differ ( $P < 0.05$ ).

\*A total of 356 pigs (initially 89 kg) were used with 10 pigs per pen and 9 replicates per treatment.

†SID lysine (%) was 0.70 for the control diet, 0.50 for the 0.50%-Lys diet, and 0.18 for the 0.18%-Lys diet.

‡Treatment  $F$ -test based on ANOVA.

||Removal rates were similar between all treatments.

§Revenue (low) = \$0.66 × (total live weight gain × carcass yield).

¶Revenue (standard) = \$1.43 × (total live weight gain × carcass yield).

\*\*Feed cost per kg: \$0.17 (control diet); \$0.15 (0.50%-Lys diet); and \$0.14 (0.18%-Lys diet).

††Feed cost per kg gain = (total pen feed cost)/(total pen gain).

‡‡IOFC (income over feed cost) = revenue – feed cost.

**Table 4.** Evaluation of compensatory growth of 90-kg finishing pigs previously fed a reduced Lys diet, Exp. 2\*†

d 0–14	Control		0.18%-Lys		Probability, <i>P</i> <		
d 14–21	Control	Control	0.18%-Lys				
d 21–28	Control	Control	Control	0.18%-Lys			
d 28–44	Control	Control	Control	Control	Treatment‡	Linear <sup>  </sup>	Quadratic <sup>  </sup>
d 0–14							
d 0 BW, kg	88.6 ± 1.05		88.6 ± 0.94		0.963	–	–
d 14 BW, kg	99.7 ± 1.00 <sup>a</sup>		91.8 ± 0.93 <sup>b</sup>		< 0.001	–	–
ADG, kg	0.79 ± 0.025 <sup>a</sup>		0.23 ± 0.015 <sup>b</sup>		< 0.001	–	–
ADFI, kg	2.48 ± 0.048 <sup>a</sup>		2.18 ± 0.029 <sup>b</sup>		< 0.001	–	–
G:F	0.317 ± 0.0093 <sup>a</sup>		0.103 ± 0.0054 <sup>b</sup>		< 0.001	–	–
Lys intake, g/d	17.4 ± 0.29 <sup>a</sup>		4.0 ± 0.05 <sup>b</sup>		< 0.001	–	–
Lys intake, g/kg gain	22.2 ± 0.57		19.6 ± 1.54		0.121	–	–
d 14–21							
d 21 BW, kg	106.0 ± 1.00 <sup>a</sup>	101.1 ± 1.00 <sup>b</sup>	97.2 ± 0.93 <sup>c</sup>		< 0.001	–	–
ADG, kg	0.89 ± 0.050 <sup>b</sup>	1.34 ± 0.050 <sup>a</sup>	0.76 ± 0.036 <sup>b</sup>		< 0.001	–	–
ADFI, kg	2.63 ± 0.076 <sup>b</sup>	3.01 ± 0.076 <sup>a</sup>	2.73 ± 0.054 <sup>b</sup>		< 0.001	–	–
G:F	0.336 ± 0.0179 <sup>b</sup>	0.446 ± 0.0179 <sup>a</sup>	0.280 ± 0.0137 <sup>c</sup>		< 0.001	–	–
Lys intake, g/d	18.4 ± 0.45 <sup>b</sup>	21.1 ± 0.39 <sup>a</sup>	5.0 ± 0.11 <sup>c</sup>		< 0.001	–	–
Lys intake, g/kg gain	21.6 ± 1.52 <sup>a</sup>	15.8 ± 0.42 <sup>b</sup>	6.8 ± 0.38 <sup>c</sup>		< 0.001	–	–
d 21–28							
d 28 BW, kg	112.7 ± 1.05 <sup>a</sup>	108.7 ± 1.05 <sup>b</sup>	105.7 ± 1.05 <sup>c</sup>	101.2 ± 1.05 <sup>d</sup>	< 0.001	–	–
ADG, kg	0.95 ± 0.062 <sup>b</sup>	1.09 ± 0.062 <sup>ab</sup>	1.23 ± 0.062 <sup>a</sup>	0.56 ± 0.062 <sup>c</sup>	< 0.001	–	–
ADFI, kg	2.59 ± 0.091 <sup>b</sup>	2.87 ± 0.091 <sup>ab</sup>	2.98 ± 0.091 <sup>a</sup>	2.78 ± 0.091 <sup>ab</sup>	0.040	–	–
G:F	0.365 ± 0.0152 <sup>a</sup>	0.378 ± 0.0152 <sup>a</sup>	0.412 ± 0.0152 <sup>a</sup>	0.201 ± 0.0152 <sup>b</sup>	< 0.001	–	–
Lys intake, g/d	18.2 ± 0.88 <sup>a</sup>	20.1 ± 0.51 <sup>a</sup>	20.9 ± 0.58 <sup>a</sup>	5.1 ± 0.13 <sup>b</sup>	< 0.001	–	–
Lys intake, g/kg gain	19.4 ± 0.82 <sup>a</sup>	18.6 ± 0.82 <sup>a</sup>	17.2 ± 0.82 <sup>a</sup>	9.9 ± 0.82 <sup>b</sup>	< 0.001	–	–
d 28–44							
d 44 BW, kg	126.0 ± 1.12	123.9 ± 1.12	120.8 ± 1.12	118.5 ± 1.12	< 0.001	< 0.001	0.123
ADG, kg	0.83 ± 0.021	0.94 ± 0.021	0.94 ± 0.021	1.06 ± 0.021	< 0.001	< 0.001	0.200
ADFI, kg	2.67 ± 0.122	2.80 ± 0.122	2.75 ± 0.122	2.85 ± 0.122	0.168	0.053	0.904
G:F	0.311 ± 0.0053	0.336 ± 0.0053	0.342 ± 0.0053	0.374 ± 0.0053	< 0.001	< 0.001	0.083
Lys intake, g/d	18.7 ± 0.386	19.6 ± 0.386	19.2 ± 0.386	19.9 ± 0.386	0.168	0.053	0.904
Lys intake, g/kg gain	22.6 ± 0.331	20.9 ± 0.331	20.5 ± 0.331	18.7 ± 0.331	< 0.001	< 0.001	0.227
d 0–44							
ADG, kg	0.85 ± 0.018	0.80 ± 0.018	0.73 ± 0.018	0.67 ± 0.018	< 0.001	< 0.001	0.111
ADFI, kg	2.59 ± 0.041	2.65 ± 0.041	2.59 ± 0.041	2.61 ± 0.041	0.717	0.858	0.544
G:F	0.325 ± 0.040	0.301 ± 0.040	0.280 ± 0.040	0.257 ± 0.040	< 0.001	< 0.001	0.028
Lys intake, g/d	18.1 ± 0.238	14.9 ± 0.238	12.3 ± 0.238	10.1 ± 0.238	< 0.001	< 0.001	0.024
Lys intake, g/kg gain	21.6 ± 0.36	18.7 ± 0.18	17.0 ± 0.18	15.0 ± 0.12	< 0.001	< 0.001	0.097
Carcass characteristics							
HCW, kg	94.3 ± 1.55	92.4 ± 1.19	91.0 ± 1.35	87.8 ± 1.38	0.017	0.004	0.292
Carcass yield, %	74.7 ± 0.26	73.8 ± 0.21	74.3 ± 0.23	73.5 ± 0.23	0.003	0.003	0.913
Backfat depth, mm	14.5 ± 0.24	15.2 ± 0.24	15.5 ± 0.24	15.8 ± 0.24	0.007	< 0.001	0.919
Loin depth, mm	62.8 ± 0.58	60.7 ± 0.57	58.6 ± 0.59	57.6 ± 0.58	< 0.001	< 0.001	0.651
Lean, %	54.9 ± 0.24	54.5 ± 0.18	54.1 ± 0.20	54.0 ± 0.21	0.048	0.007	0.792

ADFI = average daily feed intake, ADG = average daily gain, BW = body weight, G:F = feed efficiency, HCW = hot carcass weight.

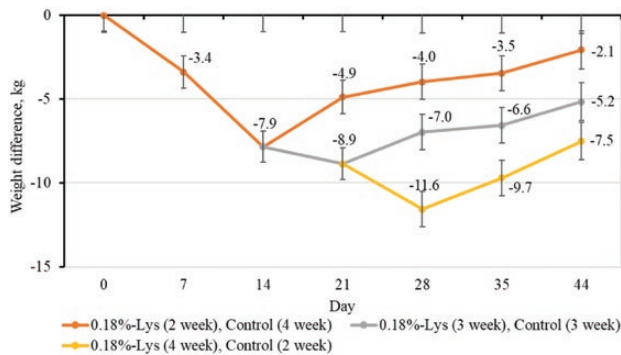
<sup>a,b,c,d</sup> Means within a row with different superscripts differ (*P* ≤ 0.05).

\*A total of 346 pigs (initially 88.6 kg) were used with 9 to 10 pigs per pen and 9 replicates per treatment.

†SID lysine (%) was 0.70 for the control diet and 0.18 for the 0.18%-Lys diet.

‡Treatment *F*-test based on ANOVA.

<sup>||</sup>Polynomial contrasts were constructed to evaluate the effects of duration of feeding pigs the 0.18%-Lys diet for d 28–44 and overall period.



**Figure 4.** Exp. 2 body weight difference compared to control diet (horizontal axis at 0). A total of 346 pigs (initially 88.6 kg) were used with 9–10 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 treatments. Error bar represents 1 SE.

pigs in the control group. Pigs that remained on the 0.18%-Lys 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. They also had decreased ( $P < 0.05$ ) ADG compared to the pigs previously fed the 0.18%-Lys diet and switched to the control diet. There was no evidence of a difference in ADFI and G:F between pigs in the control group and pigs fed the 0.18%-Lys diet for 21-d.

From d 21 to 28, pigs previously fed the 0.18%-Lys diet for 21-d and then switched to the control diet had compensatory gain with increased ( $P < 0.05$ ) ADG and ADFI. However, d 28 BW was decreased ( $P < 0.05$ ) compared to pigs in the control group. Pigs fed the 0.18%-Lys diet for 21-d before being switched to the control diet also had decreased ( $P < 0.05$ ) d 28 BW compared to pigs fed the 0.18%-Lys diet for the first 14-d before being switched to the control diet thereafter. Pigs fed the 0.18%-Lys diet for 14 of the 44-d continued to have decreased ( $P < 0.05$ ) d 28 BW compared to pigs in the control group. Pigs fed the 0.18%-Lys diet for 28-d had decreased ( $P < 0.05$ ) ADG, G:F, d 28 BW, and Lys intake per day, and improved ( $P < 0.05$ ) Lys intake per kg of gain compared to all other treatments.

On d 44, pigs fed the 0.18%-Lys diet for 28-d had been switched to and provided the control diet for the final 16-d, pigs fed the 0.18%-Lys diet for 21-d had been provided with the control diet for 23-d, and pigs fed the 0.18%-Lys diet for 14-d had been provided with the control diet for 30-d. From d 28 to 44, ADG, G:F, and Lys intake per kg of gain improved (linear,  $P < 0.001$ ) as time since switching to the control diet increased. Average daily feed intake and Lys intake per day tended to increase (linear,  $P = 0.053$ ) as time since switching to the control

diet increased. All treatments which were provided with the 0.18%-Lys diet demonstrated compensatory growth following the transition to the control diet at the respective time points, and the rate of improvement in growth performance by compensatory growth was reduced over time.

For the overall period (d 0–44), there was no evidence of a difference in ADFI between all treatments (Table 4). Average daily gain and Lys intake per kg of gain decreased (linear,  $P < 0.001$ ), and G:F and Lys intake per day decreased (quadratic,  $P < 0.028$ ) as the duration of Lys restriction increased. There were no differences in removals, mortality, or incidences of tail-biting or other vices (data not shown). Overall, pig health was very good throughout the study.

For carcass characteristics, HCW, carcass yield, loin depth, and percentage lean decreased (linear,  $P \leq 0.007$ ) as the duration of Lys restriction increased (Table 4). Backfat depth increased (linear,  $P < 0.001$ ) as the duration of Lys restriction increased.

Revenue (standard and low), feed cost, and IOFC (standard and low) were decreased (linear,  $P < 0.001$ ) as the duration of Lys restriction increased (Table 5). Feed cost per kg of gain was increased (linear,  $P < 0.001$ ; quadratic,  $P = 0.018$ ) as the duration of Lys restriction increased.

## DISCUSSION

The 2020 COVID-19 pandemic caused an abnormal market scenario where the US pork industry had a substantial reduction in the ability to process market pigs due to packing plant closures. The reduced processing capacity resulted in a longer growth period which led to the risk of pigs becoming too heavy for the infrastructure of the packing facility. Therefore, we conducted these two experiments to provide producers with a variety of strategies with Lys-deficient diets to reduce the growth rate of pigs and minimize economic hardship.

### *Dietary Standardized Ileal Digestible Lysine Requirement Estimates*

The NRC (2012) SID Lys requirement estimate is 0.73% for 75- to 100-kg pigs and 0.61% for 100- to 135-kg pigs. Soto et al. (2019) reported that the predicted maximum ADG and G:F for pigs beyond 100-kg BW was achieved at 0.62% and 0.63% SID Lys, respectively. Distinct from regular Lys titration studies, we used diets (0.50%-Lys and 0.18%-Lys



**Table 5.** Evaluation of compensatory growth of 90-kg finishing pigs previously fed a reduced Lys diet, Exp. 2\*

d 0–14	Control		0.18%-Lys				
d 14–21	Control	Control	0.18%-Lys				
d 21–28	Control	Control	Control	0.18%-Lys	Probability, $P <$		
d 28–44	Control	Control	Control	Control	Treatment <sup>†</sup>	Linear <sup>‡</sup>	Quadratic <sup>‡</sup>
Economics (per pig placed), \$ <sup>  </sup>							
Revenue (low) <sup>§</sup>	18.12 ± 0.433	17.02 ± 0.433	15.52 ± 0.433	14.31 ± 0.433	< 0.001	< 0.001	0.182
Revenue (standard) <sup>¶</sup>	39.27 ± 0.937	36.87 ± 0.937	33.62 ± 0.937	31.01 ± 0.937	< 0.001	< 0.001	0.182
Feed cost <sup>**</sup>	18.91 ± 0.343	18.44 ± 0.343	17.36 ± 0.343	17.08 ± 0.343	0.002	< 0.001	0.501
Feed cost per kg of gain <sup>††</sup>	0.516 ± 0.0062	0.529 ± 0.0062	0.551 ± 0.0062	0.579 ± 0.0062	< 0.001	< 0.001	0.018
IOFC (low)	-0.78 ± 0.191	-1.43 ± 0.191	-1.84 ± 0.191	-2.76 ± 0.191	< 0.001	< 0.001	0.060
IOFC (standard) <sup>‡‡</sup>	20.36 ± 0.929	18.42 ± 0.399	16.26 ± 0.696	13.94 ± 0.391	< 0.001	< 0.001	0.068

\*A total of 346 pigs (initially 88.6 kg) were used with 9–10 pigs per pen and 9 replicates per treatment.

<sup>†</sup>Treatment  $F$ -test based on ANOVA.

<sup>‡</sup>Polynomial contrasts were constructed to evaluate the effects of duration of feeding pigs the 0.18%-Lys diet for d 28–44 and overall period.

<sup>||</sup>Removal rates were similar between all treatments.

<sup>§</sup>Revenue (low) =  $\$0.66 \times (\text{total live weight gain} \times \text{carcass yield})$ .

<sup>¶</sup>Revenue (standard) =  $\$1.43 \times (\text{total live weight gain} \times \text{carcass yield})$ .

<sup>\*\*</sup>Feed cost per kg: \$0.17 and \$0.14 (0.18%-Lys diet).

<sup>††</sup>Feed cost per kg gain =  $(\text{total pen feed cost})/(\text{total pen gain})$ .

<sup>‡‡</sup>IOFC (income over feed cost) = revenue – feed cost.

diet) that were severely deficient in Lys and other AAs for this weight range to evaluate the effects on growth performance. In both experiments, control pigs had greater Lys intake per day and ADG compared to pigs fed Lys-restricted diets. On average, control pigs consumed approximately 18–20 g/d SID Lys where pigs fed 0.18% SID Lys diets consumed approximately 10–12 g/d. Similarly, Soto et al. (2019) reported a decrease in ADG and G:F as SID Lys intake per day decreased in 100- to 135-kg pigs, but the magnitude of reduction was less than what we observed in our experiments with severely deficient Lys diets. Goncalves et al. (2017) reported that the optimal performance for ADG and G:F of 100- to 135-kg pigs was associated with a SID Lys intake per day of 19.5 and 19.7 g/d, respectively. Whereas the NRC (2012) requirement estimate for SID Lys is 16.9 g/d for this same weight range.

In response to COVID 19 induced abnormal marketing situations, Helm et al. (2021) observed that late-finishing pigs fed a diet containing 97% corn (0.16% SID Lys) had decreased ADG, G:F, and increased ( $P < 0.05$ ) backfat depth compared to pigs fed a control diet. Our findings are consistent with Helm et al. (2021) in that severe Lys restriction will dramatically decrease growth performance and carcass leanness. In both of our experiments, pigs restricted in Lys and other AAs had increased backfat depth and decreased percentage lean compared to the nonrestricted pigs.

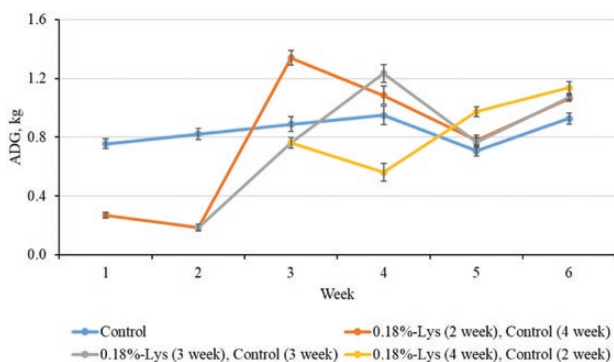
### Compensatory Growth

Compensatory growth has been categorized into complete, incomplete, and no compensatory growth (Menegat et al., 2020). It can be affected by several factors, such as the stage of growth at restriction, severity of restriction, and duration of restriction and recover periods (Skiba, 2005; Hector and Nakagawa, 2012; Menegat et al., 2020). Complete compensatory growth refers to previously restricted pigs having faster growth rates during recovery and obtaining a similar BW compared to nonrestricted pigs at a similar age. Incomplete compensatory growth refers to previously restricted pigs having faster growth rates during recovery, but the magnitude of improvement is not enough to obtain a similar BW compared to nonrestricted pigs at a similar age. No compensatory growth refers to previously restricted pigs having similar or reduced growth rates during recovery compared to nonrestricted pigs. According to Menegat et al. (2020), compensatory growth seems to happen if: 1) Lys restriction is between 10% and 30%; 2) Lys restriction is induced before pigs reach maximum protein deposition; 3) duration of Lys restriction is short (<45% of overall period) and duration of recovery is long (>55% of overall period); and 4) Lys concentration during recovery needs to be close to or above the estimated requirements. In our study, all restricted pigs showed compensatory growth,

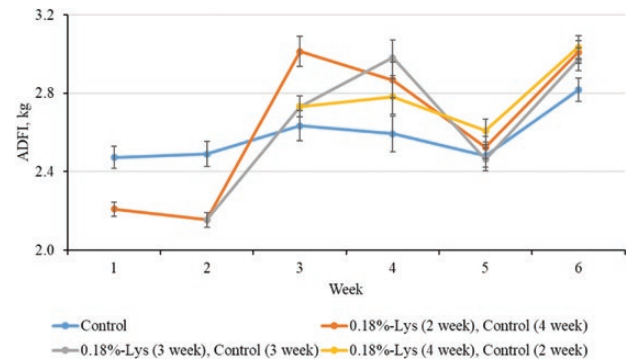
especially during the first week of recovery. The compensatory growth would be characterized as incomplete compensatory growth, because the restricted pigs did not reach a similar d 44 BW as the non-restricted pigs (Figure 4). However, the magnitude of compensatory growth was greater as the period of restriction was shorter and the period of recovery was greater. Restricted pigs had increasing backfat depth and decreasing lean percentage as the duration of restriction increased, indicating that restricted pigs had greater fat deposition and lower lean deposition compared to the control pigs.

The average difference in growth rate between pigs fed the control diet and pigs fed the 0.18%-Lys diet was about 49%, which resulted in the reduced BW during restriction. During the recovery period, previously restricted pigs grew faster than control pigs with a greater improvement in ADG during the first week (28% increase) compared to subsequent weeks (12% increase; Figure 5). Using these rates of recovery, for the restricted pigs to achieve similar BW as the control, pigs restricted for 14 d would require 34 d of recovery, pigs restricted for 21 d would require 55 d of recovery, and pigs restricted for 28 d would require 75 d of recovery.

Physiological changes that can explain the compensatory growth during the recovery are observed throughout the literature. For Lys restricted grow-finish pigs, the main driver for compensatory growth is an improvement in G:F because ADFI does not appear to change (Menegat et al., 2020). The improved G:F can be explained by the improvement in nitrogen utilization, Lys efficiency, protein deposition, and lean growth in the restricted pigs for reaching target body composition as the nonrestricted pigs at a similar age (Menegat et al., 2020). Sun et al. (2020) observed that liver metabolic function and small intestinal absorptive function of the restricted pigs were increased during a



**Figure 5.** Exp. 2 weekly ADG of the 4 treatments. A total of 346 pigs (initially 88.6 kg) were used with 9–10 pigs per pen and 9 replicates per treatment. Error bar represents 1 SE.



**Figure 6.** Exp. 2 weekly ADFI of the 4 treatments. A total of 346 pigs (initially 88.6 kg) were used with 9–10 pigs per pen and 9 replicates per treatment. Error bar represents 1 SE.

recovery period. Insulin-like growth factor (IGF), IGF-binding protein, cortisol, and corticosterone, regulators of protein deposition, were also increased during the recovery period (Martínez-Ramírez et al., 2009; Ishida et al., 2012). These changes in hormone status suggest an improvement in protein deposition and growth rate. Therefore, these improvements may contribute to the improved G:F of the restricted pigs in our study. In Exp. 2, d 0–14 ADFI was lower for pigs fed 0.18%-Lys diet compared with the control pigs (Figure 6). However, we observed greater ADFI during the recovery period, especially the first week. The decreased ADFI might be the result of an AA imbalance, then ADFI increased when pigs were switched to an AA balanced control diet.

### Economic Significance of Reducing Growth Rate

Even though Lys-restricted diets are lower cost, feeding late-finishing pig diets with sub-optimal Lys concentrations would not be economical because of the reduced grow rate and poor feed efficiency. However, under abnormal market scenarios when processing plants lack capacity to keep up with the number of pigs produced, these pigs will need to stay at the farm for an extended period and may grow to weights beyond the maximum market weight feasible for processing plants. Pigs marketed greater than the packer's preferred weight range are often severely discounted in price. If excessive weight gain becomes a detriment, such as the situation with COVID-19 shutting down processing plants, feeding Lys restricted diets will reduce ADG resulting in more acceptable BWs, which would increase the chances that the pigs could generate more income in this abnormal scenario. These nutritional strategies provide an estimate of growth rate for producers to have a more flexible timeline to manage the BW of their finishing pigs based on the availability of the

processing plants. This in turn has the potential to minimize the economic loss of these pigs.

In conclusion, using nutritional strategies to reduce growth rates of finishing pigs allows producers to cope with the dynamic changes in processing plant capacity to minimize economic losses during abnormal market scenarios. Moreover, compensatory growth can be observed in Lys-restricted late-finishing pigs, but the duration of restriction and recovery periods are crucial factors influencing the magnitude of compensatory growth.

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*Conflict of interest statement.* The authors declare no conflict of interest.

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