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J. Soto
Kansas State University, Manhattan, josesoto@k-state.edu

M. D. Tokach
Department of Animal Science and Industry, Kansas State University, mtokach@ksu.edu

S. S. Dritz
Kansas State University, Manhattan, dritz@k-state.edu

See next page for additional authors

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Determination of the Optimum Standardized Ileal Digestible Lysine Concentration for Finishing Pigs from 225 to 280 lb

J.A. Soto, M.D. Tokach, S.S. Dritz,[1] J.C. Woodworth, J.M. DeRouchey, and R.D. Goodband

Summary

The objective of this study was to determine the standardized ileal digestible (SID) Lys requirement for growth and carcass performance of 225- to 280-lb finishing pigs. A total of 253 pigs (DNA 600 × 241, initially 224.9 lb BW) were used in a 23-d trial. Pens were blocked by BW and were randomly assigned to diets with 7 or 8 pigs per pen and 8 pens per treatment in a randomized complete block design. Diets were corn and soybean meal-based and fed in meal form. Dietary treatments consisted of 0.45, 0.55, 0.65, or 0.75% SID Lys. Increasing SID Lys increased (quadratic, $P < 0.05$) ADG and ADFI, resulting in pigs fed 0.55% SID Lys having the greatest final BW. A marginal significant improvement (quadratic, $P < 0.10$) was observed in F/G and caloric efficiency with increasing SID Lys. A marginal significant increase in carcass yield (linear, $P < 0.10$) and reduction (quadratic, $P < 0.10$) in backfat was also observed with increasing SID Lys. Carcass ADG increased (linear, $P < 0.05$) and carcass G:F was marginally improved (quadratic, $P = 0.063$), resulting in pigs fed 0.55% SID Lys having the greatest HCW. Furthermore, there was a marginal significant improvement (quadratic, $P = 0.053$) in carcass caloric efficiency on NE basis with increasing SID Lys. For ADG, quadratic polynomial (QP) model resulted in the best fit (BIC = 361.7) predicting 95, 98, and 100% of maximum growth at 0.50, 0.55, and 0.62% SID Lys, respectively. The QP and broken line linear (BLL) models had a comparable fit for F/G (BIC = 278.2 vs. 279.3, QP and BLL, respectively) with the QP model predicting 95, 98, and 100% of maximum feed efficiency at 0.48, 0.54, and 0.63% SID Lys, respectively. The BLL model predicted no further improvement in F/G over 0.55% SID Lys. In summary, the SID Lys requirement to obtain 100% of maximum response in this experiment was 0.62 and 0.63% for ADG and feed efficiency, respectively.

Introduction

Continuous advancements in the genetics of modern pigs have resulted in superior growth performance and protein accretion, and potentially altering dietary nutrient

[1] Department of Diagnostic Medicine/Pathobiology, College of Veterinary Medicine, Kansas State University.

requirements.[2] For growing-finishing pigs, providing optimum dietary Lys is crucial for maximum lean growth and optimizing feed cost.[3] Although considerable research has been conducted to determine the optimum Lys requirement for swine, there are limited data reporting the Lys requirements at heavier market weights.[4] In addition, more advanced dose-response models have provided the means for better requirements estimation.[5] Therefore, the objective of this study was to determine the optimum levels of dietary standardized ileal digestible Lys for growth performance and carcass characteristics of finishing pigs from 225 to 280 lb.

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 32 pens. Each pen was equipped with a dry, single-sided feeder (Farmweld, Teutopolis, IL) and a 1-cup waterer. 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 253 pigs (DNA 600 × 241, initially 224.9 lb) were used in a 23-d trial. There were 7 or 8 mixed-gender pigs per pen at a floor space of 7.83 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. Pigs were allotted by BW and randomly assigned to 1 of 4 dietary treatments in a complete randomized block design. The dietary treatments included 4 SID Lys concentrations (0.45, 0.55, 0.65, and 0.75%), with 8 replications per treatment. Pigs were provided ad libitum access to water and to feed in meal form. Prior to the trial, from 200 to 225 lb, pigs were fed a corn-soybean meal-based diet with 14.2% CP, 0.72% SID Lys, and 1,150 kcal/lb of NE.

To formulate the experimental diets, a corn-soybean meal diet with 0.45% SID Lys was formulated without L-lysine HCL. Then, a 0.75% SID Lys corn-soybean meal diet was formulated including 0.23% L-lysine HCl and other feed-grade amino acids as necessary to maintain ratios relative to Lys. Ratios were maintained well above requirement estimates to ensure that other amino acids were not limiting. The 0.45 and 0.75% SID Lys diets were blended to create the 0.55 and 0.65% SID Lys diets (Table 1).

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[2] O'Connell, M., Lynch, P., O'Doherty, J. 2005. Determination of the optimum dietary lysine concentration for growing pigs housed in pairs and in groups. Animal Science, v. 81, p. 249-255.

[3] Wei, R. and Zimmerman, D. 2001. Lysine requirements of PIC barrows during growing-finishing period. Iowa State University. Swine research report, 6 (38-41).

[4] Gebhardt, J., Gonçalves, M., Tokach, M., DeRouchey, J., Goodband, R., Woodworth, J., and Dritz, S. 2015. Effects of standardized ileal digestible lysine content in low crude protein diets on finishing pig performance and economics from 230 to 280. *Kansas State University Swine Day Report*. Kansas Agricultural Experiment Station and Cooperative Extension Service. Manhattan, KS.

[5] Gonçalves, M. A. D., N. M. Bello, S.S. Dritz, M.D. Tokach, J. M. DeRouchey, J. C. Woodworth, and R. D. Goodband. 2015. An update on modeling dose-response relationships: accounting for correlated data structures and heterogeneous variance in linear and non-linear mixed models. J. Anim. Sci. 94: 1940-1950.

Pigs were weighed on d 0, 7, 14, and 23 of the trial to determine ADG, ADFI, and F/G. At d 23, pigs were individually tattooed with a unique ID number to allow for carcass measurements to be recorded on a pig basis. On d 23, final pen weights and individual pig weights were taken, and pigs were transported to a commercial packing plant (Triumph St. Joseph, MO) for processing and determination of HCW.

Diet samples were taken from 6 feeders per dietary treatment 3 d after the beginning of the trial and 3 d prior to the end of the trial and stored at -20°C until they were homogenized, subsampled, and submitted for total AA analysis (except Lys; method 994.12; AOAC Int.,[6]) and Lys (method 994.13; AOAC Int.,[6]) by Ajinomoto Heartland, Inc. (Chicago, IL). Samples of the diets were also submitted to Cumberland Valley Analytical Service (Hagerstown, MD) for analysis of DM, CP, Ca, P, ether extract, and ash.

Data were analyzed using the GLIMMIX procedure of SAS version 9.4 (SAS Institute, Inc., Cary, NC) in a randomized complete block design with pen serving as the experimental unit and initial BW serving as the blocking factor. Dietary treatments were the fixed effect and block served as the random effect in the analysis. Preplanned linear and quadratic orthogonal contrast were built using coefficients for equally spaced treatment and used to determine the main effects of increasing SID Lys. Hot carcass weight served as a covariate for the analysis of backfat, loin depth, and lean percentage. In addition, PROC GLIMMIX and PROC NLMIXED were used to predict the SID lysine dose response curves to optimize ADG and G:F. Dose response models evaluated were quadratic (QP), broken-line linear (BLL), and broken-line quadratic (BLQ) models. Best fit was determined using Bayesian Information Criterion (BIC), with a lower number being indicative of an improved fit. A decrease in BIC greater than 2.0 among models for a response criterion was considered an improved fit. Results from the experiment were considered significant at $P < 0.05$ and marginally significant between $P > 0.05$ and $P \leq 0.10$.

Results and Discussion

The analyzed total amino acids, DM, CP, Ca, P, ether extract, and ash contents of experimental diets (Table 2) were reasonably consistent with formulated estimates.

For overall growth performance (d 0 to 23), increasing SID Lys increased (quadratic, $P < 0.05$) ADG and ADFI, resulting in pigs fed 0.55% SID Lys having the greatest final BW (Table 3). Increasing SID Lys increased (linear, $P < 0.05$) grams of SID Lys intake per kg of gain and SID Lys intake with pigs consuming 16.6 and 17.0 g/kg of gain at 0.55% SID Lys and 18.5 and 19.8 g/kg of gain at 0.65% SID Lys. Marginal significant improvement (quadratic, $P < 0.10$) was observed in feed efficiency and caloric efficiency on NE basis with increasing SID Lys.

For carcass characteristics, a marginal significant increase in carcass yield (linear, $P = 0.051$) and decrease (quadratic, $P = 0.074$) in backfat was observed when increasing SID Lys. Carcass ADG increased (quadratic, $P = 0.014$) and carcass feed efficiency was marginally improved (quadratic, $P = 0.063$), resulting in pigs fed 0.55% SID Lys having

[6] AOAC International. 2012. Official Methods of Analysis of AOAC Int. 19th ed. Assoc. Off. Anal. Chem., Gaithersburg, MD.

the greatest HCW. Furthermore, there was a marginally significant improvement (quadratic, $P = 0.053$) in carcass caloric efficiency on NE basis with increasing SID Lys.

The QP model for ADG resulted in the best fit, predicting 95, 98, and 100% of maximum response at 0.50, 0.55, and 0.62% SID Lys, respectively (Figure 1). The QP model equation was: ADG, g = -350.1334 + 4236.996 × (% SID Lys) – 3414.007 × (% SID Lys)^2. The QP and BLL models had a comparable fit for feed efficiency (BIC = 278.2 vs. 279.3, QP and BLL, respectively) with the QP model predicting 95, 98, and 100% of maximum feed efficiency at 0.48, 0.54, and 0.63% SID Lys, respectively. The QP model equation was: G:F = 71.91685 + 809.6716 × (% SID Lys) – 639.2415 × (% SID Lys)^2. The BLL model predicted no further improvement in G:F over 0.55% SID Lys (95% CI: [0.43, 0.67]%). The BLL model equation was: G:F = 324.09 – 163.24 × (0.5544 - % SID Lys) if SID Lys < 0.5544%, and 324.09 if SID Lys > 0.5544 (Figure 2).

In summary, the SID Lys requirement to obtain 100% of maximum response in this experiment was 0.62 and 0.63% for ADG and feed efficiency, respectively.

Table 1. Diet composition (as-fed basis)[1]

	SID Lys, %			
Ingredient, %	0.45	0.55	0.65	0.75
Corn	86.66	84.87	83.18	81.38
Soybean meal (46.5% CP)	11.00	12.71	14.31	16.02
Choice white grease	0.50	0.50	0.50	0.50
Monocalcium P (21% P)	0.35	0.33	0.32	0.30
Limestone	0.95	0.94	0.93	0.93
Salt	0.35	0.35	0.35	0.35
L-Lys-HCl	---	0.08	0.15	0.23
DL-Met	---	---	0.01	0.01
L-Thr	---	0.03	0.05	0.08
L-Trp	---	0.01	0.01	0.02
Trace mineral premix	0.10	0.10	0.10	0.10
Vitamin premix	0.08	0.08	0.08	0.08
Phytase[2]	0.02	0.02	0.02	0.02
Total	100.00	100.00	100.00	100.00
Calculated analysis				
Standardized ileal digestible amino acids, %				
Lys	0.45	0.55	0.65	0.75
Ile:Lys	91	79	71	66
Leu:Lys	239	202	177	159
Met:Lys	43	38	33	31
Met and Cys:Lys	87	75	66	60
Thr:Lys	80	75	70	68
Trp:Lys	23.9	22.2	20.9	20.0
Val:Lys	107	93	83	75
His:Lys	67	57	51	46
Total lysine, %	0.54	0.65	0.75	0.86
SID Lys:NE, g/Mcal	1.74	2.14	2.53	2.93
NE NRC, kcal/lb	1,171	1,167	1,163	1,159
CP, %	12.4	13.2	13.9	14.6
Ca, %	0.47	0.47	0.47	0.47
P, %	0.38	0.38	0.39	0.39
Available P, %	0.22	0.22	0.22	0.22
Standardized digestible P, %	0.27	0.27	0.27	0.27

[1]Diets were fed from d 0 to 23.
[2] Ronozyme Hiphos (GT) 2700 (DSM Nutritional Products, Inc, Parsippany, NJ). Provided 181.8 phytase units (FYT) per lb of diet, with a release of 0.10% available P.

Table 2. Chemical analysis of experimental diets (as-fed basis)[1]

	SID Lys, %			
Item	0.45	0.55	0.65	0.75
DM, %	87.7	87.7	87.7	87.8
CP, %	12.1	12.3	12.9	14.2
Ca, %	0.66	0.68	0.72	0.76
P, %	0.40	0.39	0.39	0.40
Ether extract, %	4.2	3.7	3.4	3.5
Ash, %	3.57	4.35	4.04	4.18
Total amino acids, %				
Lys	0.54	0.65	0.76	0.82
Ile	0.47	0.54	0.57	0.60
Leu	1.16	1.29	1.33	1.36
Met	0.21	0.24	0.25	0.26
Met and Cys	0.45	0.50	0.53	0.54
Thr	0.46	0.50	0.57	0.58
Trp	0.12	0.14	0.16	0.17
Val	0.59	0.65	0.69	0.70
His	0.30	0.33	0.36	0.36
Phe	0.61	0.69	0.74	0.74
Free Lys	0.01	0.05	0.09	0.11

[1]Diet samples were taken from 6 feeders per dietary treatment 3 d after the beginning of the trial and 3 d prior to the end of the trial and stored at -20°C, then amino acid analysis was conducted on composite samples by Ajinomoto Heartland, Inc. (Chicago, IL). Samples of the diets were also submitted to Cumberland Valley Analytical Service (Hagerstown, MD) for analysis of DM, CP, Ca, P, ether extract, and ash.

Table 3. Determination of the optimum standardized ileal digestible (SID) lysine level for growth performance and carcass characteristics of finishing pigs from 225 to 280 lb[1]

	SID Lys, %					Probability, *P* <	
Item	0.45	0.55	0.65	0.75	SEM	Linear	Quadratic
BW, lb							
d 0	224.9	224.9	224.9	225.0	0.97	0.856	0.692
d 23	268.9	275.3	273.4	272.6	2.61	0.423	0.167
d 0 to 20							
ADG, lb	1.89	2.15	2.07	2.02	0.059	0.260	0.015
ADFI, lb	6.15	6.65	6.28	6.32	0.107	0.769	0.041
G:F	0.307	0.323	0.329	0.319	0.0077	0.191	0.058
SID Lys g/kg gain	14.7	17.0	19.8	23.6	0.46	0.001	0.110
SID Lys g/d	12.6	16.6	18.5	21.5	0.28	0.001	0.074
NE caloric efficiency[2]	3,822	3,617	3,546	3,650	82.1	0.098	0.058
Carcass characteristics							
HCW, lb	198.3	204.3	202.7	203.0	2.14	0.173	0.182
Carcass yield, %	73.7	74.2	74.1	74.5	0.25	0.051	0.666
Backfat,[3] in.	0.62	0.64	0.62	0.59	0.014	0.154	0.074
Loin depth,[3] in.	2.51	2.47	2.53	2.54	0.044	0.455	0.611
Lean,[3] %	54.9	54.5	54.9	55.3	0.236	0.128	0.121
Carcass performance							
Carcass ADG,[4] lb	1.39	1.59	1.53	1.50	0.044	0.179	0.014
Carcass G:F[5]	0.226	0.240	0.244	0.238	0.005	0.095	0.063
NE caloric efficiency[6]	5,189	4,875	4,784	4,906	115.0	0.057	0.053

[1]A total of 253 pigs (DNA 600 × 241) were used with 8 pigs per pen and 8 replications per treatment.
[2]Caloric efficiency is expressed as kcal/lb of gain.
[3]Adjusted using HCW as a covariate.
[4]Carcass average daily gain = overall ADG × carcass yield.
[5]Carcass G:F = carcass average daily gain/overall average feed intake.
[6]Caloric efficiency = Kcal of NE per pound of gain ((ADFI × NE/lb) /ADG).

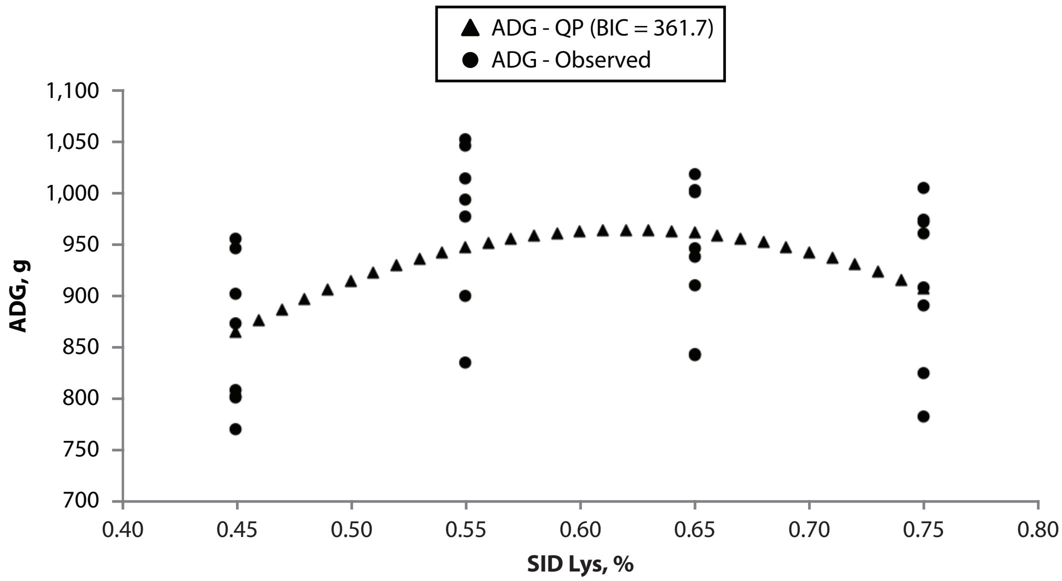

Figure 1. Estimation of standardized ileal digestible (SID) lysine to maximize growth for 225- to 280-lb mixed gender finishing pigs.
A total of 253 pigs (DNA 600 × 241, initially 224.9 lb) were used in a 23-d trial. Quadratic polynomial (QP), broken-line linear (BLL), and broken-line quadratic (BLQ) models were fit to estimate SID Lys level to maximize ADG. The QP model predicted 95, 98, and 100% of maximum growth at 0.50, 0.55, and 0.62% SID Lys, respectively. The QP model equation was: ADG, g = -350.1334 + 4236.996 × (% SID Lys) – 3414.007 × (% SID Lys)^2.

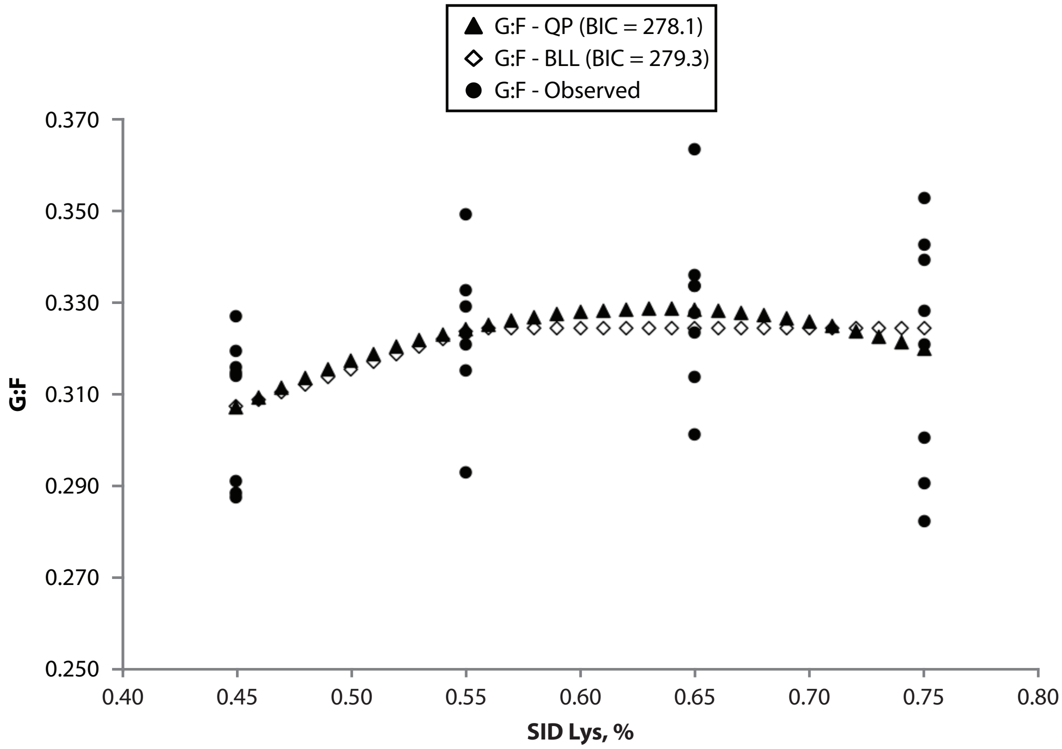

Figure 2. Estimation of standardized ileal digestible (SID) lysine to maximize feed efficiency for 225- to 280-lb mixed gender finishing pigs.

A total of 253 pigs (DNA 600 × 241, initially 224.9 lb) were used in a 23-d trial. Quadratic polynomial (QP), broken-line linear (BLL), and broken-line quadratic (BLQ) models were fit to estimate SID Lys level to maximize G:F. The QP model for G:F resulted in the best fit (BIC = 278.2) with the QP model predicting 95, 98, and 100% of maximum feed efficiency at 0.48, 0.54, and 0.63% SID Lys, respectively. The QP model equation was: G:F = 71.91685 + 809.6716 × (% SID Lys) – 639.2415 × $(\% \text{ SID Lys})^2$.