Effects of Standardized Ileal Digestible Lysine on Growth Performance and Economic Return of 200 to 300 lb Grow-Finish Pigs[1]

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Summary

A total of 2,099 barrows and gilts (PIC 1050 × DNA 600; initially 198.6 ± 3.72 lb) were used in a 57-d study to determine the optimal dietary standardized ileal digestible (SID) Lys level for approximately 200 to 300 lb pigs in a commercial setting. Pigs were randomly allotted to 1 of 4 dietary treatments with 24 to 27 pigs per pen and 20 replications per treatment. A similar number of barrows and gilts were placed in each pen. Diets were fed over 2 phases (199 to 233 and 233 to 299 lb respectively). Dietary treatments were corn-soybean meal-based. Diets were formulated to 85, 93, 100, or 110% of the 2016 PIC[4] (Hendersonville, TN) SID Lys gilt recommendations with phase 1 SID Lys levels of 0.65, 0.71, 0.77, 0.84%, and phase 2 levels of 0.60, 0.66, 0.71, 0.78%, respectively. Overall (d 0 to 57), increasing SID Lys increased (linear, $P < 0.05$) overall market weight, F/G, hot carcass weight, Lys intake/d, and Lys intake/kg of gain with an increase in ADG (quadratic, $P = 0.020$). For economics (d 0 to 57), feed cost per lb of gain increased (linear, $P < 0.05$) with increased SID Lys. Revenue per pig placed and income over feed cost (IOFC) increased (quadratic, $P < 0.10$) as the amount of SID Lys increased, and marginally significant evidence of a quadratic response for feed cost per pig placed ($P = 0.073$). Projecting IOFC for phase 1, the quadratic polynomial (QP) and broken-line linear models estimated the requirement at 110.9% and 96.9%, respectively, to achieve maximum IOFC. For phase 2, the QP estimated the requirement at 96.6% SID Lys to maximize IOFC. In summary, the SID Lys requirement was 97% to 111% of the 2016 PIC recommended Lys requirement for phase 1 and 97% for phase 2 to maximize IOFC.

[1] Appreciation is expressed to Pipestone Nutrition (Pipestone, MN) for providing the animals, research facility, and barn management.

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Introduction

Providing optimum dietary Lys is crucial for maximizing lean growth and reducing feed cost in grow-finish pigs. There are several factors that impact optimal dietary concentration of dietary Lys including genetics, environment, sex, and weight of the pig.[5] The genetics of modern pigs continue to advance and have potentially altered nutrient requirements. As a result, dietary nutrient requirements need to be re-evaluated over time.[6] Therefore, the objective of this study was to determine the optimum standardized ileal digestible (SID) Lys requirement for growth performance and economic return of finishing pigs from 200 to 300 lb.

Materials and Methods

The Pipestone Institutional Animal Care and Use Committee approved the protocol used in this study. This experiment was conducted at a commercial wean-to-finish research facility located in southwest Minnesota (Pipestone Applied Research; Edgerton, MN). Each pen contained one nipple waterer and a 1-hole wet/dry feeder or a 4-hole dry self-feeder for *ad libitum* access to feed and water. Treatments were equally allotted and replicated across different feeder types. Diets were manufactured at the Spronk Brothers feed mill in Edgerton, MN. 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 2,099 barrows and gilts (PIC 1050 × DNA 600; initially 198.6 ± 3.72 lb) were used in a 57-d study to determine the optimal dietary SID Lys level of approximately 200 to 300 lb pigs in a commercial setting. Pens of pigs were blocked by location in the barn and randomly allotted to 1 of 4 dietary treatments with 24 to 27 pigs per pen and 20 replications per treatment. A similar number of barrows and gilts were placed in each pen. Diets were fed over 2 phases (199 to 233 and 233 to 299 lb, respectively). Dietary treatments were corn-soybean meal-based. Diets were formulated to 85, 93, 100, or 110% of the 2016 PIC (Hendersonville, TN) SID Lys recommendations for gilts, with phase 1 SID Lys levels of 0.65, 0.71, 0.77, 0.84%, and phase 2 levels of 0.60, 0.66, 0.71, 0.78%, respectively (Table 1). During the trial, pens of pigs were weighed, and feed disappearance was recorded on d 0, 16, 29, 44, and 57 to determine ADG, ADFI, and F/G (Table 2). Pigs were individually ear tagged with RFID ear tags prior to the start of this trial. On d 29 and 44, eight of the heaviest pigs per pen were weighed individually and transported to a commercial packing plant (WholeStone Farms, Fremont, NE) for processing and determination of carcass characteristics. The remaining pigs were marketed at the conclusion of this trial on d 57 and also transported to WholeStone Farms for carcass characteristic collection.

For the economic analysis, total feed cost per pig, cost per lb of gain, revenue, and income over feed cost (IOFC) were calculated. Feed cost per pig placed was determined by multiplying total feed intake by diet cost. Feed cost per lb of gain was calculated by dividing the total feed cost per pig by the total weight gained. Revenue per pig placed

[5] Shelton, N., M. Tokach, S. Dritz, R. Goodband, J. Nelssen, and J. DeRouchey. 2011. Effects of increasing dietary standardized ileal digestible Lys for gilts grown in a commercial finishing environment. J. Anim. Sci. 89:3587-3595. doi:10.2527/jas.2010-3030.

[6] O'Connell, M., P. Lynch, and J. O'Doherty. 2005. Determination of the optimum dietary Lys concentration for boars and gilts penned in pairs and in groups in the weight range 60 to 100 kg. Anim. Sci. 82:65-73.

was determined by total gain times the dressing percentage (0.75) and then multiplied by \$0.70 carcass price in order to convert to a live price. Income over feed cost was calculated using revenue per pig placed minus feed cost per pig placed. For all economic evaluations, the following ingredients costs were used: corn = \$3.94/bu (\$140.80/ton); soybean meal = \$320/ton; L-Lys HCl = \$0.65/lb; DL-methionine = \$1.12/lb; L-threonine = \$0.63/lb; and L-tryptophan = \$3.23/lb.

Data were analyzed using the GLIMMIX procedure of SAS OnDemand for Academics (SAS Institute, Inc., Cary, NC) in a randomized complete block design with pen as the experimental unit and location as the blocking factor. Treatments were considered a fixed effect and block as a random effect. Contrast coefficients were adjusted to account for unequal spacing of Lys treatments. Dose response curves were evaluated using linear (LM), quadratic polynomial (QP), broken-line linear (BLL), and broken-line quadratic (BLQ) models. For each response variable, the best-fitting model was selected using the Bayesian information criterion (BIC). Results were considered significant with $P \leq 0.05$ and were considered marginally significant with $P \leq 0.10$.

Results and Discussion

For phase 1 growth performance (d 0 to 16), increasing SID Lys improved (linear, $P < 0.001$) ADG and F/G (Table 2). We observed a marginally significant increase (quadratic, $P = 0.057$) in ADFI as SID Lys increased. For phase 2 (d 16 to 57), we observed increased (quadratic, $P = 0.045$) ADG as SID Lys was increased, but no effect on ADFI or F/G.

For overall growth performance (d 0 to 57), increasing SID Lys increased (linear, $P < 0.05$) the overall market weight, HCW, F/G, Lys intake/d, and Lys intake/kg of gain. Average daily gain increased (quadratic, $P = 0.020$) with the greatest response observed in pigs fed 100% of the 2016 PIC feeding level, with no improvement observed thereafter. For ADFI, a marginally significant increase (quadratic, $P = 0.092$) was observed as SID Lys was increased.

For economic analysis in phase 1 (d 0 to 16), we observed increased (linear, $P < 0.05$) revenue per pig placed, and IOFC as SID Lys increased (Table 3). For feed cost per pig placed we observed a marginal increase (quadratic, $P = 0.057$) as SID Lys increased. For phase 2, increasing SID Lys increased (linear, $P < 0.05$) the feed cost per pig placed. A quadratic response was observed for revenue per pig placed ($P = 0.048$) as SID Lys increased, where pigs fed 100% of the SID Lys requirement had the greatest revenue per pig placed with no improvement observed thereafter. A marginally significant increase (quadratic, $P = 0.061$) was observed for IOFC with the greatest response observed at 100% of the PIC 2016 SID Lys estimate. For overall economics (d 0 to 57), feed cost per lb of gain increased (linear, $P < 0.05$) with increasing SID Lys. Revenue per pig placed and IOFC increased (quadratic, $P < 0.05$) as SID Lys increased. Feed cost per pig placed tended to increase as the amount of SID Lys increased (quadratic, $P = 0.073$).

For modeling IOFC, data were analyzed separately for each phase. In phase 1, the QP and BLL models had a comparable fit (BIC = 279.6 and 279.8, QP and BLL, respectively) with the SID Lys requirement to achieve maximal performance being predicted at 110.9% with QP, and 96.9% for the BLL model (Figure 1). The QP model equation was: $IOFC = -6.435 + 0.284 \times (SID\ Lys\%) - 0.00128 \times (SID\ Lys\%)^2$. With this model, 99% of maximum IOFC could be achieved at 102.4% of the PIC 2016 SID Lys recommendation. For BLL, there was no further improvement in IOFC beyond the breakpoint of 96.9 % SID Lys (95% CI: 82.2, 111.7%). For phase 2, the QP model predicted maximal IOFC at 96.6% of the SID Lys requirement suggested by 2016 PIC feeding level. The QP model equation was: $\text{IOFC} = -39.7425 + 1.1047 \times (\text{SID Lys\%}) - 0.00572 \times (\text{SID Lys\%})^2$, with 99% of maximum IOFC achieved at 91.7% SID Lys.

In summary, the SID Lys requirement was determined to be 97% to 111% of the 2016 PIC feeding recommendations depending on the model used for phase 1, and 97% for phase 2 to maximize IOFC.

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

	Phase 1[2]				Phase 2[3]			
	Percentage of PIC SID Lys estimate[4]							
Item	85	93	100	110	85	93	100	110
Ingredient, %								
Corn	90.36	88.16	85.89	82.43	89.99	87.58	85.34	82.11
Soybean meal, 46.5% CP	6.85	8.85	10.90	14.05	7.05	9.25	11.30	14.25
Corn oil	0.65	0.85	1.05	1.38	0.93	1.18	1.38	1.68
Monocalcium P	0.21	0.20	0.19	0.18	0.21	0.20	0.19	0.17
Limestone	0.78	0.75	0.75	0.73	0.78	0.75	0.75	0.73
Sodium chloride	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
L-Lys-HCl	0.37	0.39	0.39	0.39	0.30	0.30	0.30	0.30
DL-Met	0.00	0.01	0.03	0.05	0.00	0.00	0.00	0.01
L-Thr	0.10	0.11	0.12	0.13	0.07	0.07	0.08	0.09
L-Trp	0.03	0.03	0.03	0.03	0.02	0.02	0.02	0.02
Vitamin and trace mineral premix	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Tri-basic copper chloride	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Phytase[5]	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Total	100	100	100	100	100	100	100	100
Calculated analysis[6]								
Standardized ileal digestible (SID) amino acids, %								
Lys	0.65	0.71	0.77	0.84	0.60	0.66	0.71	0.78
Ile:Lys	55	55	56	57	60	61	60	62
Leu:Lys	151	145	141	136	164	159	154	149
Met:Lys	27	28	29	30	30	29	29	27
Met and Cys:Lys	59	58	58	58	64	62	60	58
Thr:Lys	65	65	65	65	66	66	66	66
Trp:Lys	19	19	19	19	19	19	19	19
Val:Lys	66	65	65	65	73	72	71	71
Total Lys, %	0.72	0.79	0.85	0.93	0.65	0.73	0.79	0.86
ME, kcal/lb	1,520	1,520	1,520	1,520	1,525	1,525	1,525	1,525
NE, kcal/lb	1,184	1,184	1,185	1,186	1,189	1,191	1,191	1,192
SID Lys:NE, g/Mcal	2.50	2.73	2.94	3.22	2.30	2.50	2.69	2.96
CP, %	10.81	11.59	12.39	13.61	10.84	11.69	12.49	13.64
Ca, %	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48
Available P, %	0.24	0.24	0.24	0.24	0.25	0.25	0.25	0.25
STTD P, %	0.31	0.31	0.32	0.32	0.31	0.31	0.32	0.32

[1]Treatment diets were fed to 2,099 pigs (PIC 1050 × DNA 600; initially 198.6 ± 3.72 lb).
[2]Phase 1 treatment diets were fed from 199 to 233 lb.
[3]Phase 2 treatment diets were fed from 233 to 299 lb.
[4]Columns represent the percentage of the 2016 PIC (Hendersonville, TN) SID Lys recommendations for gilts.
[5]Quantum Blue 5G (AB Vista, Marlborough, UK) provided an estimated release of 0.12% available P.
[6]Ingredient values and SID coefficients were derived from NRC. 2012. (National Research Council. 2012. Nutrient Requirements of Swine: Eleventh Revised Edition. Washington, DC: The National Academies Press. https://doi.org/10.17226/13298.)

Table 2. Effects of increasing standardized ileal digestible (SID) lysine on grow-finish pig performance[1]

	Percentage of PIC 2016 SID Lys estimate[2]					*P* <	
Item	85	93	100	110	SEM	Linear	Quadratic
BW, lb							
d 0	198.2	198.5	198.5	198.9	3.72	0.766	0.961
d 16	231.2	233.3	233.9	235.2	2.69	0.107	0.759
d 57[3]	292.7	298.5	302.3	302.1	3.73	0.029	0.275
Market weights							
Cut 1[4] (d 29)	276.7	279.2	281.0	280.3	2.89	0.240	0.436
Cut 2[4] (d 44)	296.8	303.4	303.5	305.0	3.78	0.007	0.166
Overall market weight	289.2	294.3	294.9	295.7	3.41	0.039	0.267
d 0 to 16 (phase 1)							
ADG, lb	2.04	2.16	2.20	2.26	0.083	<0.001	0.250
ADFI, lb	6.25	6.47	6.43	6.35	0.080	0.509	0.057
F/G	3.08	3.01	2.93	2.82	0.130	<0.001	0.848
d 16 to 57 (phase 2)							
ADG, lb	2.04	2.12	2.18	2.12	0.036	0.087	0.045
ADFI, lb	7.08	7.20	7.18	7.07	0.115	0.842	0.224
F/G	3.64	3.60	3.51	3.55	0.064	0.236	0.494
d 0 to 57							
ADG, lb	2.04	2.13	2.19	2.17	0.033	0.001	0.020
ADFI, lb	6.78	6.94	6.91	6.81	0.077	0.883	0.092
F/G	3.49	3.44	3.35	3.34	0.049	0.016	0.587
Lys intake g/d	20.1	22.4	24.0	26.0	0.27	<0.001	0.112
Lys intake g/kg gain	21.7	23.2	24.3	26.5	0.26	<0.001	0.493
Total removals, %	2.46	3.05	1.72	2.65	0.800	0.845	0.634
Carcass performance							
HCW, lb	213.8	217.1	218.6	219.4	2.04	0.021	0.419
Yield, %	73.93	73.78	73.93	73.99	0.003	0.749	0.690

[1]A total of 2,099 pigs (initially 198.6 ± 3.72 lb) were used, with 27 to 24 pigs per pen and 20 replications per treatment.
[2]Columns represent the percentage of the 2016 PIC (Hendersonville, TN) gilt curve SID Lys level.
[3]Values represent weights at final marketing.
[4]Eight of the heaviest pigs were marketed from each pen.

Table 3. Effects of increasing standardized ileal digestible (SID) lysine on economic return of grow-finish pigs[1,2]

	Percentage of PIC SID Lys estimate[3]					*P* <	
Item	85	93	100	110	SEM	Linear	Quadratic
d 0 to 16 (phase 1)							
Feed cost/pig placed	8.61	9.20	9.41	9.63	0.114	<0.001	0.057
Feed cost/lb gain[4]	0.266	0.268	0.267	0.268	0.0120	0.827	0.996
Revenue/pig placed[5]	17.09	18.13	18.49	18.91	0.703	<0.001	0.181
IOFC[6]	8.49	8.94	9.09	9.29	0.739	0.018	0.534
d 16 to 57 (phase 2)							
Feed cost/pig placed	17.22	18.04	18.47	18.89	0.298	<0.001	0.284
Feed cost/lb gain[7]	0.300	0.304	0.302	0.317	0.0057	0.011	0.184
Revenue/pig placed[8]	30.13	31.32	32.27	31.43	0.545	0.096	0.048
IOFC[6]	12.92	13.28	13.79	12.53	0.482	0.632	0.061
d 0 to 57							
Feed cost/pig placed	25.65	27.17	27.82	28.40	0.334	<0.001	0.073
Feed cost/lb gain[9]	0.289	0.291	0.289	0.298	0.003	0.048	0.307
Revenue/pig placed[10]	46.92	49.33	50.66	50.16	0.819	0.001	0.011
IOFC[6]	21.26	22.16	22.83	21.77	0.603	0.391	0.038

[1]A total of 2,099 pigs (initially 198.6 ± 3.72 lb) were used with 27 to 24 pigs per pen and 20 replications per treatment.
[2]Corn was valued at $3.94/bu ($140.80/ton); soybean meal at $320/ton; L-Lys at $0.65/lb; DL-Met at $1.12; L-Thr at $0.63/lb; and L-Trp at $3.23/lb.
[3]Columns represent the percentage of the 2016 PIC (Hendersonville, TN) gilt curve SID Lys level.
[4]Feed cost/lb gain = (phase 1 feed cost/pig placed)/phase 1 gain.
[5]Revenue/pig placed = (phase 1 gain/pig placed × 0.75) × $0.70.
[6]Income over feed cost = revenue/pig placed – feed cost/pig placed.
[7]Feed cost/lb gain = (phase 2 feed cost/pig placed)/phase 2 gain.
[8]Revenue/pig placed = (phase 2 gain/pig placed × 0.75) × $0.70.
[9]Feed cost/lb gain = (total feed cost/pig placed)/total gain.
[10]Revenue/pig placed = (total gain/pig placed × 0.75) × $0.70.

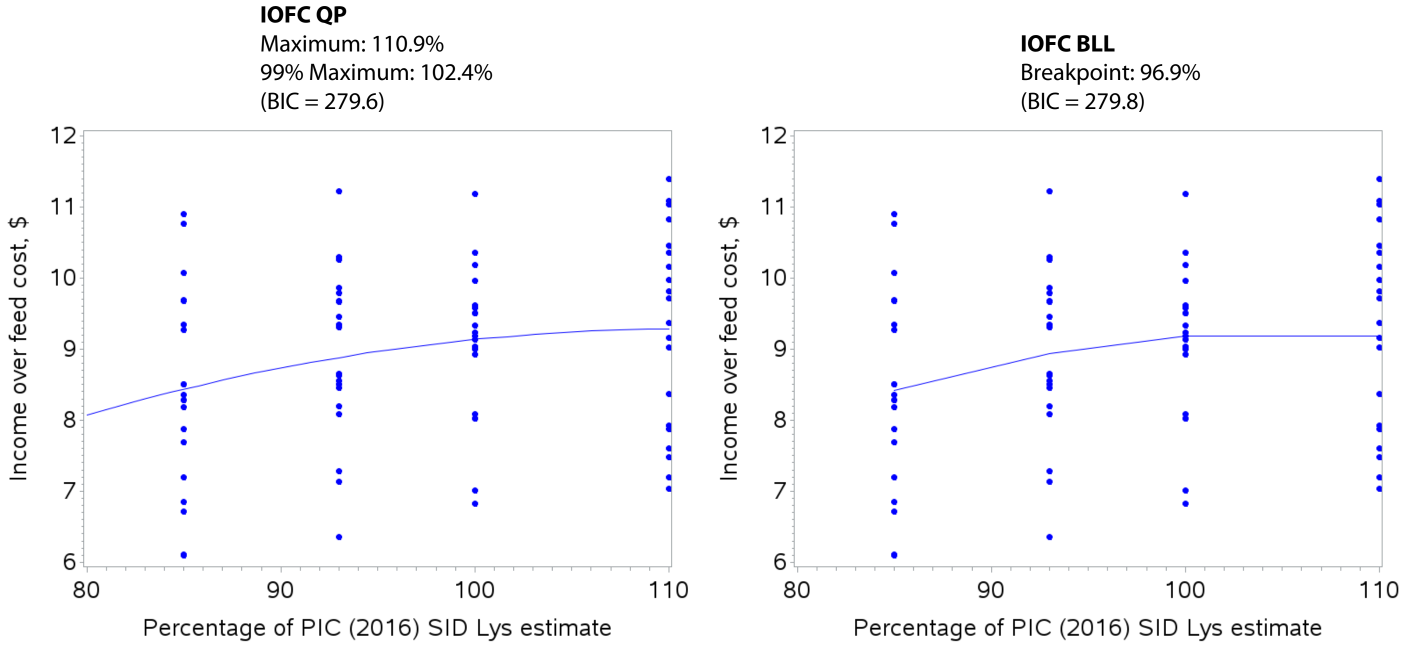

Figure 1. Estimation of standardized ileal digestible (SID) lysine requirement to maximize IOFC in phase 1 for 200 to 235 lb grow-finish pigs.
A total of 2,099 pigs (initially 198.6 ± 3.72 lb) were used in a 57-d trial with 27 to 24 pigs per pen and 20 replications per treatment. Dose response curves were evaluated using linear (LM), quadratic polynomial (QP), broken-line linear (BLL), and broken-line quadratic (BLQ) models were fit to estimate SID Lys level to achieve maximum IOFC. For each response variable, the best-fitting model was selected using the Bayesian information criterion (BIC). The QP model equation was: IOFC = -6.435 + 0.284 (SID Lys%) – 0.00128 $(\text{SID Lys\%})^2$.

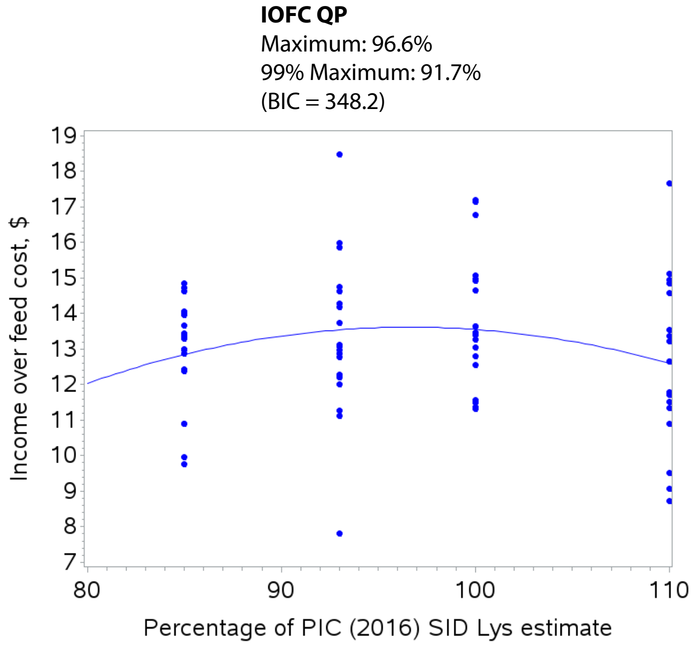

Figure 2. Estimation of standardized ileal digestible (SID) lysine requirement to maximize IOFC in phase 2 for 235 to 300 lb grow-finish pigs.
A total of 2,099 pigs (initially 198.6 ± 3.72 lb) were used in a 57-d trial with 27 to 24 pigs per pen and 20 replications per treatment. Dose response curves were evaluated using linear (LM), quadratic polynomial (QP), broken-line linear (BLL), and broken-line quadratic (BLQ) models were fit to estimate SID Lys level to achieve maximum IOFC. For each response variable, the best-fitting model was selected using the Bayesian information criterion (BIC). The QP model equation was: IOFC = -39.7425 + 1.1047 (SID Lys%) – 0.00572 (SID Lys%)^2.