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Effects of Standardized Ileal Digestible Lysine on Growth Performance and Economic Return of 108 to 178 lb Grow-Finish Pigs

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Effects of Standardized Ileal Digestible Lysine on Growth Performance and Economic Return of 108 to 178 lb Grow-Finish Pigs[1]

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Summary

A total of 2,124 barrows and gilts (PIC 1050 × DNA 600; initially 107.9 ± 1.31 lb) were used in a 32-d study to determine the optimal level of dietary standardized ileal digestibility (SID) Lys for 108 to 178 lb pigs in a commercial setting. Pigs were randomly allotted to 1 of 5 dietary treatments with 24 to 27 pigs per pen and 16 replications pen treatment. A similar number of barrows and gilts were placed in each pen. Diets were fed over 3 phases (108 to 129, 129 to 156, and 156 to 178 lb, respectively). Dietary treatments were corn-soybean meal-based and contained 10% (phase 1 and 2) or 5% (phase 3) DDGS. Diets were formulated to 85, 95, 103, 110, or 120% of the 2016 PIC[4] SID Lys gilt recommendations as follows: phase 1 SID Lys levels of 0.90, 1.01, 1.09, 1.17 and 1.27%; phase 2 levels of 0.79, 0.87, 0.94, 1.03, and 1.10%; and phase 3 levels of 0.71, 0.78, 0.85, 0.92, and 0.99%, respectively. Overall (d 0 to 32), increasing SID Lys increased (linear, $P < 0.001$) ADG, final body weight, Lys intake/d, and Lys intake/kg of gain with an improvement in F/G (quadratic, $P = 0.047$). Additionally, feed cost per pig, feed cost per lb of gain, total revenue per pig, and income over feed cost (IOFC) increased (linear, $P \leq 0.002$) as SID Lys increased. Projecting IOFC, broken line linear and quadratic polynomial models estimated the maximum IOFC at 105.8% and 113.7% SID Lys, respectively. In summary, while growth performance increased linearly up to 120% of the 2016 PIC[4] recommended Lys requirement, the optimal IOFC was 106% to 114%.

Introduction

Lysine is typically the first limiting amino acid in corn-soybean meal-based swine diets. Other essential amino acids are formulated as a percentage of standardized ileal

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[1] Appreciation is expressed to Pipestone Nutrition (Pipestone, MN) for providing the animals, research facility, and barn management.
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digestible (SID) Lys. Thus, it is critical to establish the SID Lys requirement in order to investigate next-limiting amino acid ratios. While genetic suppliers provide amino acid requirements for the various body weight ranges of their specific genetics, validating these levels is needed within production systems to achieve maximum lean growth and optimal feed cost. Along with standard statistical analysis procedures for growth performance, advanced dose-response models are helpful for estimating the pig's nutrient requirements and optimal economics more precisely.[5] Therefore, the objective of this study was to determine the optimum SID Lys requirement for growth performance and economic return of finishing pigs from 108 to 178 lb.

Materials and Methods

The Pipestone Institutional Animal Care and Use Committee approved the protocol used in this experiment. This study 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 self-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 2,124 barrows and gilts (PIC 1050 × DNA 600; initially 107.9 ± 1.31 lb) were used in a 32-d study to determine the optimal dietary SID Lys level for approximately 108 to 178 lb pigs in a commercial setting. Pens of pigs were blocked by location in the barn and randomly allotted to 1 of 5 dietary treatments with 24 to 27 pigs per pen and 16 replications per treatment. A similar number of barrows and gilts were placed in each pen. Diets were fed over 3 phases (108 to 129, 129 to 156, and 156 to 178 lb, respectively). Dietary treatments were corn-soybean meal-based and contained 10% (phase 1 and 2) or 5% (phase 3) DDGS. Diets were formulated to 85, 95, 103, 110, or 120% of the 2016 PIC[4] SID Lys recommendations for gilts as follows: phase 1 SID Lys levels of 0.90, 1.01, 1.09, 1.17 and 1.27%; phase 2 levels of 0.79, 0.87, 0.94, 1.03, and 1.10%; and phase 3 levels of 0.71, 0.78, 0.85, 0.92, and 0.99%, respectively (Tables 1 and 2). During the trial, pens of pigs were weighed, and feed disappearance was recorded on d 0, 10, 22, and 32 to determine ADG, ADFI, and F/G.

For the economic analysis, total feed cost per pig, feed cost per lb of gain, revenue, and income over feed cost (IOFC) were calculated. Diet costs were determined using the following ingredient costs: corn = \$3.36/bu (\$120/ton); soybean meal = \$300/ton; L-Lys HCl = \$0.65/lb; DL-methionine = \$1.04/lb; L-threonine = \$0.77/lb; and L-tryptophan = \$2.63/lb. Feed cost per pig was determined by total feed intake multiplied by diet cost (\$/lb). Feed cost per lb of gain was calculated by dividing the total feed cost per pig by the total lb gained overall. Revenue per pig 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 minus feed cost per pig.

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[5] Gonçalves, M., N. Bello, S. Dritz, M. Tokach, J. DeRouchey, R. Goodband, J. Woodworth. 2015. An update on modeling dose-response relationships: accounting for correlated data structures and heterogenous variance and non-linear mixed models. J. Anim. Sci. 94: 1940-1950. doi: 10.2527/jas.2015-0106.

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 the 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

In phase 1 (d 0 to 10), increasing SID Lys increased (linear, $P \leq 0.001$) ADG and F/G (Table 3). In phase 2 (d 10 to 22), there was a marginally significant improvement (linear, $P \leq 0.048$) in F/G as SID Lys increased in the diet. In phase 3 (d 22 to 32), increasing SID Lys increased ADG and improved F/G (quadratic, $P < 0.05$). There was no effect on ADFI throughout all three phases (Table 3).

For overall growth performance (d 0 to 32), increasing SID Lys increased (linear, $P < 0.001$) final body weight, ADG, Lys intake/d, and Lys intake/kg of gain (Table 3). For F/G there was an improvement (quadratic, $P = 0.047$) as dietary SID Lys increased. There was no effect on pig removals, mortality, or total pigs removed from pens.

For economic analysis, feed cost per pig, feed cost per lb of gain, total revenue per pig, and IOFC increased (linear, $P \leq 0.002$) as dietary SID Lys increased. When modeling IOFC, the BLL and QP models had a comparable fit (BIC = 307.7 and 307.9, BLL and QP, respectively; Figure 1). For the BLL, maximum IOFC was achieved with a minimum of 105.8% SID Lys (95% CI: 92.6, 119.0%). The QP model equation developed was: $\text{IOFC} = -1.6148 + 0.42\ (\text{SID Lys\%}) - 0.00189\ (\text{SID Lys\%})^2$ with 100% of maximum IOFC estimated at 113.7% SID Lys.

In summary, under these experimental conditions, growth performance increased linearly up to 120% of the 2016 PIC Lys recommendation, while the optimum IOFC was 105.8% to 113.7%.

Table 1. Composition of phase 1 and 2 diets (as-fed basis)

	Phase 1[1]					Phase 2[2]				
	Percentage of PIC SID Lys estimate[3]									
Item	**85**	**95**	**103**	**110**	**120**	**85**	**95**	**103**	**110**	**120**
Ingredient, %										
Corn	74.73	69.90	65.96	62.66	57.92	78.54	75.50	72.23	68.68	65.27
Soybean meal, 46.5% CP	11.95	16.35	19.95	22.95	27.25	8.25	11.00	13.95	17.20	20.30
DDGS	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Corn oil	0.78	1.23	1.58	1.88	2.33	0.80	1.08	1.38	1.70	2.03
Monocalcium P, 21% P	0.22	0.19	0.17	0.16	0.13	0.17	0.15	0.14	0.12	0.10
Limestone	0.98	0.95	0.93	0.93	0.90	0.95	0.93	0.93	0.90	0.88
Sodium chloride	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
L-Lys-HCl	0.49	0.49	0.49	0.49	0.49	0.46	0.48	0.48	0.49	0.49
DL-Met	0.05	0.07	0.10	0.11	0.14	0.02	0.04	0.06	0.08	0.10
L-Thr	0.13	0.14	0.14	0.15	0.16	0.12	0.13	0.14	0.15	0.16
L-Trp	0.04	0.04	0.04	0.03	0.03	0.04	0.04	0.04	0.04	0.04
Vitamin and trace mineral premix	0.10	0.10	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	0.03	0.03
Phytase[4]	0.04	0.04	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	100	100
Calculated analysis[5]										
Standardized ileal digestible (SID) amino acids, %										
Lys	0.90	1.01	1.09	1.17	1.27	0.79	0.87	0.94	1.03	1.10
Ile:Lys	55	57	58	58	59	55	55	56	57	58
Leu:Lys	143	138	134	132	128	152	145	141	137	134
Met:Lys	31	32	33	33	34	29	31	32	32	33
Met and Cys:Lys	58	58	58	58	58	58	58	58	58	58
Thr:Lys	63	63	63	63	63	64	64	64	64	64
Trp:Lys	19	19	19	19	19	19	19	19	19	19
Val:Lys	65	65	65	65	65	66	65	65	65	65
Total Lys, %	1.01	1.13	1.23	1.31	1.42	0.89	0.98	1.06	1.15	1.24
ME, kcal/lb	1,490	1,490	1,490	1,490	1,490	1,500	1,500	1,500	1,500	1,500
NE, kcal/lb	1,160	1,161	1,162	1,163	1,164	1,169	1,171	1,171	1,172	1,173
SID Lys:NE, g/Mcal	3.52	3.93	4.27	4.55	4.96	3.06	3.38	3.65	3.97	4.26
CP, %	14.72	16.42	17.82	18.98	20.65	13.26	15.48	15.48	16.73	17.94
Ca, %	0.58	0.58	0.58	0.58	0.58	0.55	0.55	0.55	0.55	0.55
Available P, %	0.29	0.29	0.29	0.29	0.29	0.28	0.28	0.28	0.28	0.28
STTD P, %	0.35	0.36	0.37	0.37	0.38	0.34	0.34	0.34	0.35	0.35

[1]Phase 1 treatment diets were fed from 108 to 129 lb.
[2]Phase 2 treatment diets were fed from 129 to 156 lb.
[3]Columns represent the percentage of the 2016 PIC SID Lys recommendations for gilts.
[4]Quantum Blue 5G (AB Vista, Marlborough, UK) provided an estimated release of 0.12% available P.
[5]Ingredient values and SID coefficients were derived from NRC (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. Composition of phase 3 diets (as-fed basis)[1]

	Percentage of PIC SID Lys estimate[2]				
Item	**85**	**95**	**103**	**110**	**120**
Ingredient, %					
Corn	83.98	80.81	77.70	74.50	71.27
Soybean meal	7.65	10.55	13.40	16.30	19.25
DDGS	5.00	5.00	5.00	5.00	5.00
Corn oil	1.10	1.40	1.68	1.98	2.28
Monocalcium P	0.20	0.19	0.17	0.15	0.14
Limestone	0.88	0.85	0.83	0.83	0.80
Sodium chloride	0.50	0.50	0.50	0.50	0.50
L-Lys-HCl	0.40	0.40	0.40	0.40	0.40
DL-Methionine	0.00	0.02	0.03	0.05	0.07
L-Threonine	0.10	0.10	0.11	0.12	0.12
L-Tryptophan	0.04	0.03	0.03	0.03	0.03
Vitamin and trace mineral premix	0.10	0.10	0.10	0.10	0.10
Tri-basic copper chloride	0.03	0.03	0.03	0.03	0.03
Phytase[3]	0.04	0.04	0.04	0.04	0.04
Total	100	100	100	100	100
Calculated analysis[4]					
Standardized ileal digestible (SID) amino acids					
Lys, %	0.71	0.78	0.85	0.92	0.99
Ile:Lys	56	57	58	58	58
Leu:Lys	154	148	144	140	137
Met:Lys	28	29	30	31	31
Met and Cys:Lys	58	58	58	58	58
Thr:Lys	64	64	64	64	64
Trp:Lys	19	19	19	19	19
Val:Lys	67	67	67	67	67
Total Lys, %	0.80	0.87	0.95	1.03	1.11
ME, kcal/lb	1,517	1,517	1,517	1,517	1,517
NE, kcal/lb	1,185	1,186	1,186	1,187	1,188
SID Lys:NE, g/Mcal	2.72	2.99	3.25	3.52	3.79
CP, %	12.04	13.16	14.26	15.39	16.53
Ca, %	0.52	0.52	0.52	0.52	0.52
Available P, %	0.26	0.26	0.26	0.26	0.26
STTD P, %	0.33	0.33	0.33	0.34	0.34

[1]Phase 3 treatment diets were fed from 156 to 178 lb.
[2]Columns represent the percentage of the 2016 PIC SID Lys recommendations for gilts.
[3]Quantum Blue 5G (AB Vista, Marlborough, UK) provided an estimated release of 0.12% available P.
[4]Ingredient values and SID coefficients were derived from NRC (National Research Council. 2012. Nutrient Requirements of Swine: Eleventh Revised Edition. Washington, DC: The National Academies Press. https://doi.org/10.17226/13298).

Table 3. Effects of increasing standardized ileal digestible lysine on grow-finish pig performance[1]

	Percentage of PIC SID Lys estimate[2]						P =	
Item	85	95	103	110	120	SEM	Linear	Quadratic
BW, lb								
d 0	108.1	108.1	108.0	107.7	107.6	1.31	0.744	0.926
d 10	127.8	127.1	130.5	130.6	130.4	1.43	0.059	0.728
d 22	154.3	154.3	157.4	157.4	158.5	1.56	0.010	0.927
d 32	174.2	176.3	179.3	180.5	180.9	1.87	<0.001	0.342
d 0 to 10 (phase 1)								
ADG, lb	1.97	1.90	2.25	2.27	2.28	0.053	<0.001	0.506
ADFI, lb	4.65	4.26	4.83	4.78	4.72	0.129	0.125	0.820
F/G	2.39	2.24	2.15	2.11	2.08	0.065	0.001	0.264
d 10 to 22 (phase 2)								
ADG, lb	2.21	2.27	2.24	2.24	2.34	0.057	0.102	0.473
ADFI, lb	5.42	5.50	5.47	5.40	5.42	0.094	0.638	0.429
F/G	2.46	2.44	2.46	2.42	2.32	0.047	0.048	0.222
d 22 to 32 (phase 3)								
ADG, lb	1.99	2.17	2.18	2.30	2.23	0.073	0.001	0.050
ADFI, lb	5.62	5.62	5.54	5.55	5.56	0.134	0.440	0.761
F/G	2.84	2.62	2.56	2.44	2.51	0.062	<0.001	0.028
d 0 to 32								
ADG, lb	2.07	2.12	2.22	2.27	2.29	0.038	<0.001	0.191
ADFI, lb	5.24	5.15	5.29	5.25	5.25	0.094	0.547	0.985
F/G	2.53	2.43	2.38	2.32	2.29	0.021	<0.001	0.047
Lys intake g/d	18.9	20.4	22.9	24.6	26.5	0.41	<0.001	0.923
Lys intake g/kg gain	20.1	21.2	22.8	23.9	25.5	0.28	<0.001	0.292
Removals, %	0.47	0.23	0.23	0.70	0.71	0.319	0.371	0.418
Mortality, %	0.48	0.48	0.94	0.46	0.48	0.381	0.995	0.566
Total removals, %	0.95	0.71	1.18	1.16	1.19	0.485	0.561	0.926
Economics, $[3]								
Feed cost/pig	13.44	13.86	14.89	15.35	16.04	0.259	<0.001	0.880
Feed cost/lb gain[4]	0.203	0.203	0.209	0.211	0.218	0.0018	<0.001	0.118
Total revenue/pig[5]	34.80	35.81	37.56	38.29	38.69	0.636	<0.001	0.196
IOFC[6]	21.36	21.96	22.64	22.94	22.68	0.427	0.002	0.116

[1]A total of 2,124 pigs (PIC 1050 × DNA 600; initially 107.9 ± 1.31 lb) were used with 24 to 27 pigs per pen and 16 replications per treatment in a 32-d study.
[2]Columns represent the percentage of the 2016 PIC SID Lys levels for gilts for the respective phases.
[3]Corn was valued at $3.36/bu ($120/ton), soybean meal at $300/ton, L-Lys at $0.65/lb, DL-methionine at $1.04/lb, L-threonine at $0.77/lb, and L-tryptophan at $2.63/lb.
[4]Feed cost/lb gain = (feed cost/pig) / total gain.
[5]Total revenue/pig = (total gain/pig × 0.75) × $0.70.
[6]Income over feed cost = total revenue/pig – feed cost/pig.

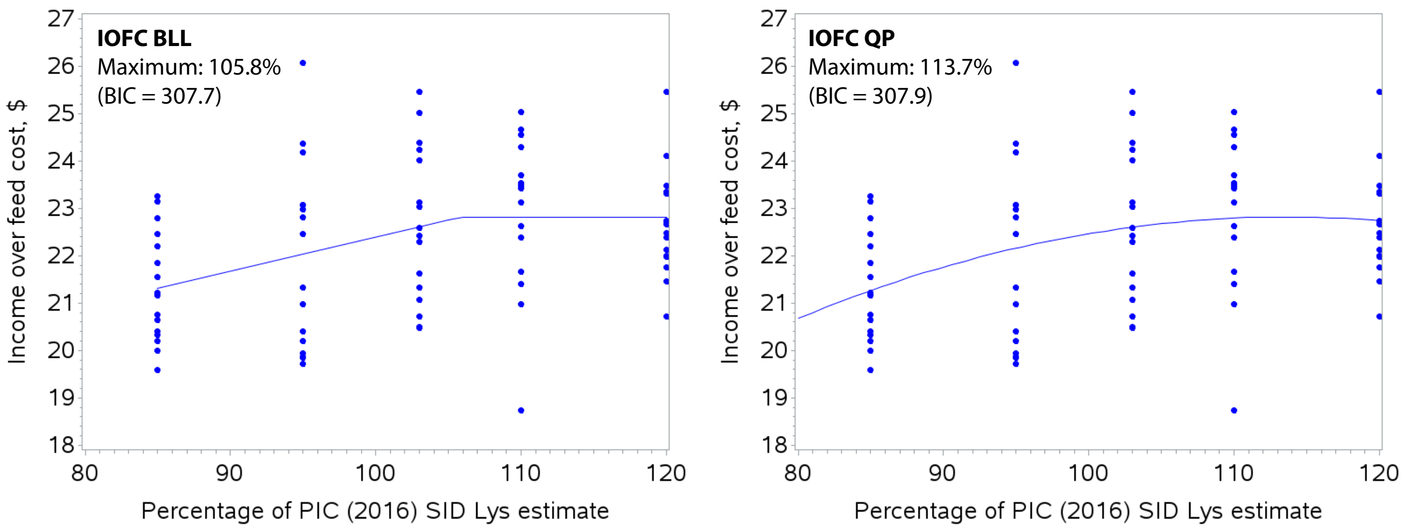

Figure 1. Estimation of standardized ileal digestible lysine requirement to maximize IOFC for 108 to 178 lb grow-finish pigs.
A total of 2,124 barrows and gilts (PIC 1050 × DNA 600; initially 107.9 ± 1.31 lb) were used in a 32-d growth trial with 24 to 27 pigs per pen and 16 replications per treatment. 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).