Effects of Standardized Ileal Digestible Lysine Level on Growth Performance in 170 to 220 lb DNA Finishing Pigs

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Summary

The objective of this study was to estimate the SID Lys requirement for growth and feed efficiency of 170- to 220-lb finishing pigs. A total of 616 barrows and gilts (600 × 241, DNA; initially 168.3 ± 2.7 lb BW) were used in two separate studies each lasting 21 d. Pens of pigs were blocked by BW and randomly allotted to 1 of 7 dietary treatments with 8 to 10 pigs per pen in a randomized complete block design. A similar number of barrows and gilts were placed in each pen. Dietary treatments were corn-soybean meal-based and formulated to 0.58, 0.65, 0.72, 0.79, 0.86, 0.92, and 1.00% SID Lys. There were 11 replications per treatment for levels of 0.65, 0.72, 0.79, 0.86, and 0.92% SID Lys; 6 replications for the 0.58% SID Lys treatment; and 5 replications for the 1.00% SID Lys treatment. Increasing SID Lys increased (linear, $P = 0.022$) ADG. Feed efficiency (quadratic, $P = 0.034$) improved, while Lys intake/d, and Lys intake/kg of gain increased (linear, $P < 0.001$) with increasing SID Lys. At both high and low ingredient and pig prices, feed cost per pig (linear, $P < 0.001$) and feed cost/lb gain increased (quadratic, $P < 0.05$), and total revenue per pig tended to increase (linear, $P = 0.051$) as SID Lys increased. However, at both high and low ingredient and pig prices, there were no differences in income over feed cost (IOFC) among dietary treatments.

The broken-line linear model to maximize ADG predicted that there was no further improvement to ADG past 0.83% and for F/G, the quadratic polynomial model predicted a requirement of 0.90% SID Lys. However, similar fitting linear models predicted maximum ADG and F/G greater than 1.00% SID Lys. Income over feed cost at high ingredient and pig prices was predicted by the QP model to be maximized at 0.78% SID Lys. Meanwhile, at low ingredient and pig prices, the BLL model predicted maximum IOFC at 0.76% SID Lys, or lower. In summary, the optimal SID Lys level for finishing pigs from 170 to 220 lb depends upon the response criteria, with growth performance maximized between 0.83 to 0.90% SID Lys. Income over feed cost was maximized at 0.78% SID Lys or lower.

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Introduction

It is critical for proper diet formulation to have an accurate estimation of dietary nutrient requirements to optimize growth performance and efficiency. Additionally, advancements in dose-response models have made it possible to set better requirement estimations.[2] These trials are a portion of an overarching project to predict the SID Lys requirement of DNA 600 sired pigs from approximately 50 to 285 lb. The objective of this study was to determine the SID Lys requirement of 600 × 241 pigs from 170 to 220 lb BW to optimize growth performance and economic return.

Materials and Methods

The Kansas State University Institutional Animal Care and Use Committee approved the protocol used in this experiment. This study was conducted at the Kansas State University Swine Teaching and Research Center in Manhattan, KS. The facility was totally enclosed and environmentally regulated, containing 36 pens. Each pen was equipped with a 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., Wimar, MN) was used to deliver and record daily feed additions to each individual pen.

Animals and diets

A total of 616 pigs (600 × 241, DNA; initially 168.3 ± 2.7 lb BW) were used in two separate studies, each lasting 21 d. There were 8 to 10 mixed gender pigs per pen with similar numbers of barrows and gilts placed in each pen. Pens were equipped with adjustable gates to allow space allowances of 7.83 ft^2 per pig to be maintained if a pig died or was removed from a pen during the experiment. Pens of pigs were allotted by BW and randomly assigned to 1 of 7 dietary treatments in a randomized complete block design. The dietary treatments included 7 SID Lys concentrations (0.58, 0.65, 0.72, 0.79, 0.86, 0.92, and 1.00%), with 11 replications for the 0.65, 0.72, 0.79, 0.86, and 0.92% SID Lys treatments; 6 replications for the 0.58% SID Lys treatment; and 5 replications for the 1.00% SID Lys treatment. Pigs were provided *ad libitum* access to water and to feed in meal form.

In the first study, to formulate the experimental diets, a corn-soybean meal diet with 0.65% SID Lys was formulated containing 0.19% L-Lys HCl and other feed-grade AAs as necessary to maintain appropriate ratios relative to Lys. Then, a 1.00% SID Lys corn-soybean meal diet was formulated containing 0.28% L-Lys HCl and other feed-grade AAs as necessary to maintain appropriate ratios relative to Lys. Ratios were maintained well above requirement estimates to ensure that Lys was first-limiting. The 0.65 and 1.00% SID Lys diets were blended via a robotic feeding system to create the 0.72, 0.79, 0.86, and 0.93% SID Lys diets (Table 1). In the second study, to formulate the experimental diets, a corn-soybean meal diet with 0.58% SID Lys was formulated containing 0.17% L-Lys HCl and other feed-grade AAs as necessary to maintain ratios relative to Lys. Then, a 0.93% SID Lys corn-soybean meal diet was formulated containing 0.27% L-Lys HCl and other feed-grade AAs as necessary to maintain ratios relative to Lys. Ratios were maintained well above requirement estimates to ensure that

[2] Gonçalves, M., N. Bello, S. Dritz, M. Tokach, J. DeRouchey, J. Woodworth, R. 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.

Lys was first-limiting. The 0.58 and 0.93% SID Lys diets were blended via a robotic feeding system to create the 0.65, 0.72, 0.79, and 0.86% SID Lys diets (Table 1). Pigs were weighed and feed disappearance was recorded on d 0, 7, 14, and 21 of each trial, to determine ADG, ADFI, and F/G.

Economic analysis

For the economic analysis, feed cost/pig, feed cost/lb gain, revenue per pig, and IOFC were calculated for high- and low-priced diets. Diet costs were determined using the following ingredient costs for the high-priced diets: corn = \$6.00/bushel (\$214/ton); soybean meal = \$400/ton; L-Lys HCl = \$0.80/lb; DL-methionine = \$2.50/lb; L-threonine = \$1.20/lb; L-tryptophan = \$5.00/lb; and L-valine = \$4.00/lb. Diet costs were determined using the following ingredient costs for the low-priced diets: corn = \$3.00/bushel (\$107.14/ton); soybean meal = \$300/ton; L-Lys HCl = \$0.65/lb; DL-methionine = \$1.70/lb; L-threonine = \$0.85/lb; L-tryptophan = \$3.00/lb; and L-valine = \$2.50/lb. Feed cost/pig was determined by total feed intake × diet cost (\$/lb). Feed cost/lb of gain was calculated using feed cost/pig divided by total gain. Revenue per pig was determined for both a high price and a low price by total gain × \$0.66/lb live gain, or total gain × \$0.45/lb live gain, respectively. The IOFC was calculated using revenue/pig – feed cost/pig.

Statistical analysis

Data were analyzed as a randomized complete block design for one-way ANOVA using the lmer function from the lme4 package in R Studio (Version 3.5.2, R Core Team; Vienna, Austria) with pen serving as the experimental unit, initial BW as blocking factor, and treatment as fixed effect. Dose response curves were evaluated using linear (LM), quadratic polynomial (QP), and broken-line linear (BLL) models. For each response variable, the best-fitting model was selected using the Bayesian Information Criterion (BIC). A decrease in BIC greater than 2.0 among models for a particular response criterion was considered an improved fit. Results were considered significant with $P \leq 0.05$ and were considered marginally significant with $P \leq 0.10$.

Results and Discussion

For overall growth performance, increasing SID Lys increased (linear, $P = 0.022$) ADG, resulting in pigs fed 0.86% SID Lys having numerically the highest BW (Table 2). Feed efficiency improved (quadratic $P = 0.034$) with increasing SID Lys. Lysine intake/d and Lys intake/kg of gain increased (linear, $P < 0.001$) with increasing SID Lys. Feed cost/pig (linear, $P < 0.001$) and feed cost/lb gain increased (quadratic, $P < 0.05$) as SID Lys increased at both high and low ingredient prices. At high and low live pig prices, total revenue/pig tended to increase (linear, $P = 0.051$) as SID Lys increased. At high and low ingredient and pig prices, we did not find a statistical difference for IOFC. However, numerically the pigs fed the 0.65, or 0.72% SID Lys treatment had the greatest IOFC.

The BLL and LM models for ADG resulted in similar fit (BIC = -75.0 vs. -74.7, BLL vs. LM, respectively); with the BLL model predicting no further growth beyond 0.83% SID Lys, while the LM model predicted maximum growth greater than 1.00% SID Lys (Figure 1). For optimization of F/G, the resulting QP and LM models had a similar fit (BIC = -77.2 vs. -76.2, QP vs. LM, respectively); with the QP predicting the lowest F/G response at 0.90% SID Lys, and the LM model predicting the lowest F/G beyond

1.00% SID Lys (Figure 2). The QP model equation was: F/G = 1.9241 × (SID Lys, %)^2 – 3.4772 × (SID Lys, %) + 4.1975; with 95% of the lowest F/G estimated at 0.64% SID Lys. Economic impacts of increasing SID Lys were calculated using IOFC at high and low ingredient and pig prices to optimize profitability. The best fitting model for IOFC at high prices was the QP model, which estimated maximum profitability at 0.78% SID Lys (Figure 3). The QP model equation was: IOFC = -17.2900 × (SID Lys, %)^2 + 26.9625 × (SID Lys, %) + 4.0925. Additionally, for IOFC at low prices the BLL and LM models resulted in a similar fit (BIC = 202.8 vs. 202.9, BLL vs. LM, respectively). The BLL model predicted a reduction in profitability past 0.76% SID Lys, while the LM model predicted maximum profitability at the lowest SID Lys concentrations (Figure 4).

In summary, for maximum growth and lowest feed efficiency, it is recommended that 170- to 220-lb finishing pigs should be fed diets containing no less than 0.83% SID Lys, with further improvements in selected response criteria beyond 1.00% SID Lys. It appears that growth performance and feed efficiency were optimized at 22.5 g of SID Lys per kg of gain. Meanwhile, IOFC was maximized at 0.78%, or lower, SID Lys concentrations.

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

	SID Lys, %						
Item	**0.58**	**0.65**	**0.72**	**0.79**	**0.86**	**0.93**	**1.00**
Ingredient, %							
Corn	85.26	83.12	80.98	78.63	76.49	74.35	71.87
Soybean meal	10.94	13.15	15.36	17.74	19.95	22.15	24.69
Corn oil	1.50	1.40	1.30	1.25	1.15	1.05	1.00
Limestone	0.80	0.80	0.79	0.79	0.78	0.78	0.78
Monocalcium P, 21% P	0.60	0.58	0.55	0.53	0.50	0.48	0.43
Sodium chloride	0.50	0.50	0.50	0.50	0.50	0.50	0.50
L-Lys-HCl	0.17	0.19	0.21	0.23	0.25	0.27	0.28
DL-Met	0.00	0.02	0.03	0.05	0.07	0.08	0.10
L-Thr	0.03	0.04	0.06	0.08	0.09	0.11	0.11
L-Trp	0.00	0.01	0.01	0.01	0.01	0.01	0.01
L-Val	0.00	0.01	0.02	0.02	0.03	0.04	0.05
Vitamin premix with phytase[2]	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Trace mineral premix	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Total	100	100	100	100	100	100	100
Calculated analysis[3]							
SID AA, %							
Lys, %	0.58	0.65	0.72	0.79	0.86	0.93	1.00
Ile:Lys	70	68	66	66	65	64	64
Leu:Lys	183	171	162	155	148	143	139
Met:Lys	33	33	34	34	35	35	35
Met and Cys:Lys	67	65	63	63	62	61	61
Thr:Lys	66	66	66	66	66	66	65
Trp:Lys	18	19	19	19	19	19	19
Val:Lys	82	80	78	77	76	75	75
His:Lys	51	49	47	46	44	43	43
ME, kcal/lb	1,536	1,533	1,531	1,529	1,527	1,525	1,524
NE, kcal/lb	1,224	1,224	1,225	1,225	1,225	1,225	1,226
SID Lys:NE, g/Mcal	2.15	2.41	2.67	2.93	3.18	3.44	3.70
CP, %	12.4	13.4	14.3	15.2	16.2	17.1	18.1
Ca, %	0.51	0.51	0.51	0.51	0.51	0.51	0.51
Available P, %	0.28	0.28	0.28	0.27	0.27	0.27	0.26
STTD P, %	0.32	0.32	0.32	0.32	0.32	0.32	0.32

[1]Treatment diets were fed to 616 pigs (600 × 241, DNA; initially 80.2 lb). Treatment diets were fed from d 0 to 21.
[2] HiPhos 2700 (DSM Nutritional Products, Parsippany, NJ) provided 227 FTU/lb, for an estimated release of 0.09% STTD P.
[3] 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 Lys on growth performance in DNA finishing pigs 170-220 lb[1]

	SID Lys, %								*P* =	
Item	**0.58**	**0.65**	**0.72**	**0.79**	**0.86**	**0.92**	**1.00**	**SEM**	**Linear**	**Quadratic**
BW, lb										
d 0	168.7	168.6	168.0	168.6	168.4	168.1	167.9	2.73	0.499	0.936
d 21	216.9	218.3	217.6	218.9	219.2	218.9	218.8	3.02	0.290	0.538
d 0 to 21										
ADG, lb	2.29	2.35	2.37	2.39	2.41	2.42	2.43	0.058	0.022	0.488
ADFI, lb	6.49	6.43	6.37	6.36	6.31	6.38	6.35	0.149	0.357	0.423
F/G	2.84	2.74	2.70	2.65	2.62	2.64	2.64	0.057	< 0.001	0.034
SID Lys g/d	16.9	19.0	20.8	22.8	24.6	26.9	28.7	0.53	< 0.001	0.874
SID Lys g/kg gain	16.3	17.8	19.4	21.0	22.5	24.5	26.2	0.47	< 0.001	0.398
Economics, $										
High ingredient and pig prices[2]										
Feed cost/pig	17.91	18.29	18.53	18.69	18.94	19.42	19.91	0.470	< 0.001	0.527
Feed cost/lb gain[3]	0.374	0.367	0.370	0.371	0.374	0.383	0.392	0.0081	0.008	0.038
Total revenue/pig[4]	31.68	32.87	33.17	33.17	33.40	33.54	33.73	0.833	0.051	0.405
IOFC[5]	13.53	14.58	14.58	14.55	14.46	14.11	14.09	0.673	0.831	0.150
Low ingredient and pig prices[6]										
Feed cost/pig	10.03	10.51	10.68	10.95	11.26	11.66	12.15	0.274	< 0.001	0.486
Feed cost/lb gain	0.209	0.211	0.213	0.218	0.223	0.230	0.239	0.0048	< 0.001	0.041
Total revenue/pig	21.60	22.41	22.62	22.62	22.77	22.87	22.99	0.568	0.051	0.405
IOFC	11.38	11.90	11.89	11.71	11.52	11.21	11.08	0.464	0.212	0.173

[1]A total of 616 pigs (600 × 241, DNA; initially 168.3 ± 2.7 lb BW) were used with 8 to 10 pigs per pen and 6 replications for the 0.58% SID Lys treatment; 11 replications for the 0.65, 0.72, 0.79, 0.86, and 0.92% SID Lys treatments; and 5 replications for the 1.00% SID Lys treatment.
[2] For high priced diets, corn was valued at $6.00/bu ($214/ton), soybean meal at $400/ton, L-Lys at $0.80/lb, DL-Met at $2.50/lb, L-Thr at $1.20/lb, L-Trp at $5.00/lb, and L-Val at $4.00/lb.
[3] Feed cost/lb gain = (feed cost/pig) / total gain.
[4] Total revenue/pig = total gain/pig × gain value ($0.66/lb at high prices; $0.45/lb at low prices).
[5] IOFC = total revenue/pig – feed cost/pig.
[6] For low priced diets, corn was valued at $3.00/bu ($107.14/ton), soybean meal at $300/ton, L-Lys at $0.65/lb, DL-Met at $1.70/lb, L-Thr at $0.85/lb, L-Trp at $3.00/lb, and L-Val at $2.50/lb.

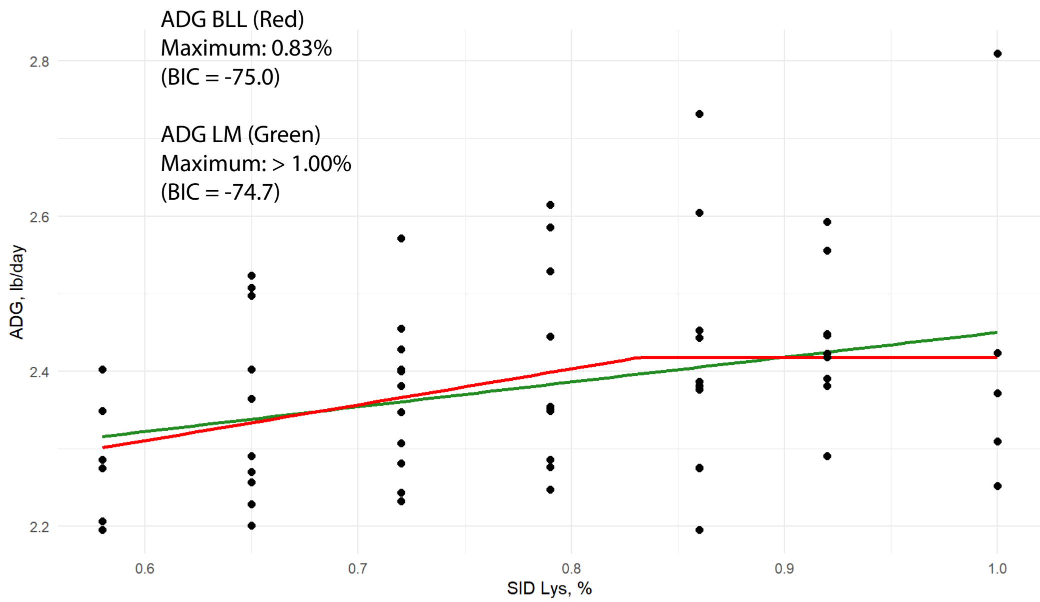

Figure 1. Estimation of SID Lys requirement to maximize ADG for 170 to 220 lb DNA finishing pigs.

A total of 616 barrows and gilts (600 × 241, DNA; initially 168.3 ± 2.7 lb) were used in two separate studies lasting 21 d each. Linear (LM), quadratic polynomial (QP), and broken-line linear (BLL) models were fit to estimate SID Lys level to maximize ADG. The BLL and LM models resulted in the best fit, based on Bayseian Information Criterion (BIC), with a lower number being indicative of an improved fit. The BLL model predicted no further improvement in ADG past 0.83% SID Lys, whereas the linear model predicted an increase in ADG through the highest SID Lys tested of 1.00%.

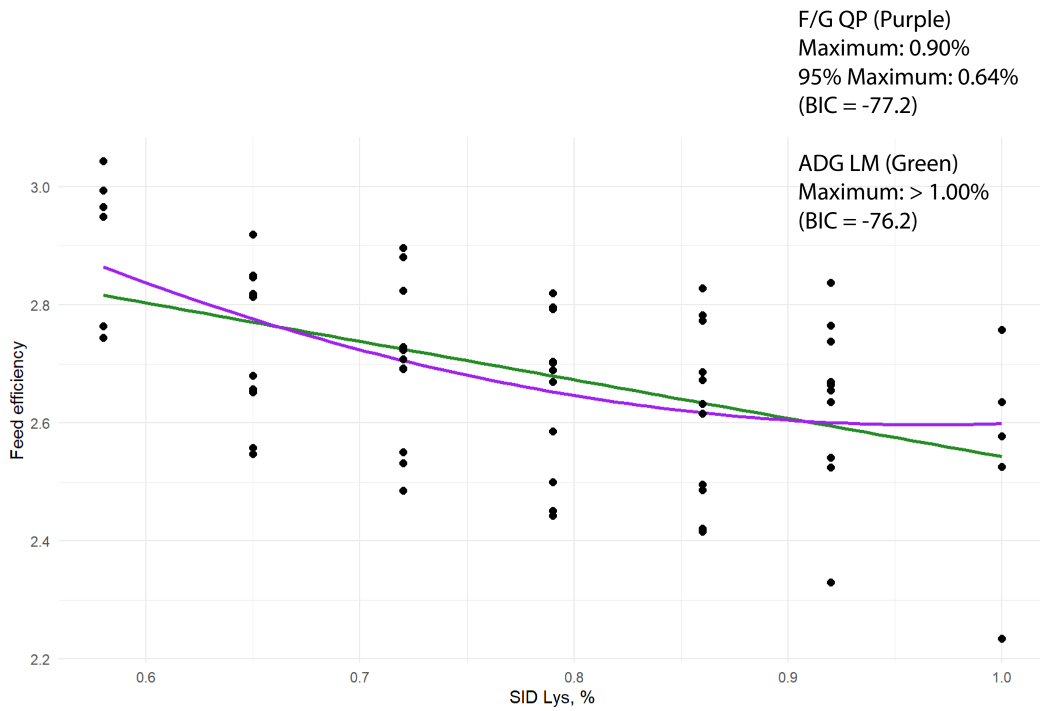

Figure 2. Estimation of SID Lys requirement to optimize F/G for 170 to 220 lb DNA finishing pigs.
A total of 616 barrows and gilts (600 × 241, DNA; initially 168.3 ± 2.7 lb) were used in two separate studies lasting 21 d each. Linear (LM), quadratic polynomial (QP), and broken-line linear (BLL) models were fit to estimate SID Lys level to optimize F/G. The QP and LM models resulted in the best fit, based on Bayseian Information Criterion (BIC), with a lower number being indicative of an improved fit. The QP model predicted 95 and 100% of optimum feed efficiency at 0.64 and 0.90% SID Lys, respectively. The QP equation model was: F/G = 1.9241 × (SID Lys, %)^2 – 3.4772 × (SID Lys, %) + 4.1975.

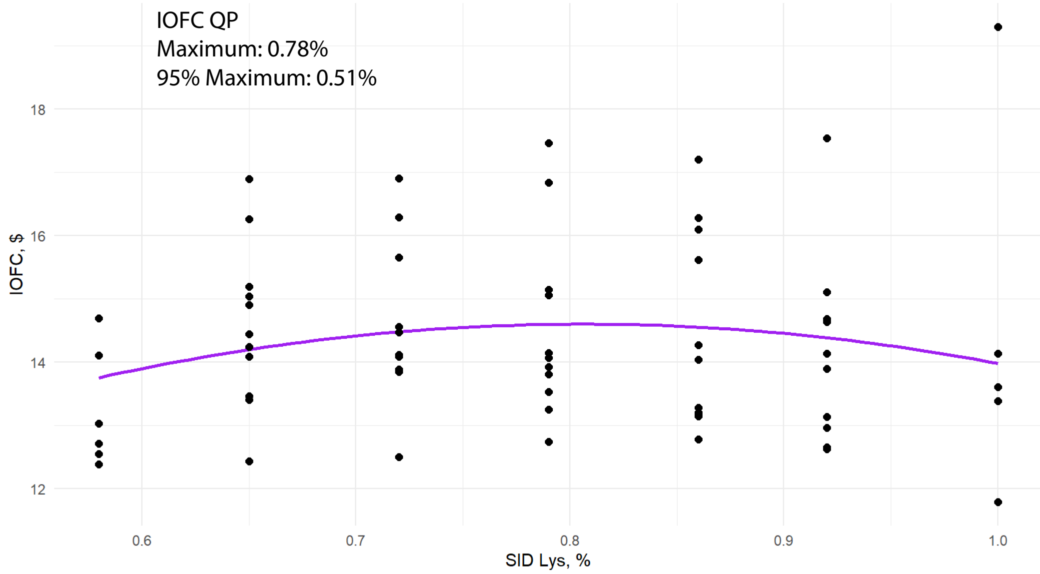

Figure 3. Estimation of SID Lys requirement to maximize IOFC at high ingredient and pig prices for 170 to 220 lb DNA finishing pigs.
A total of 616 barrows and gilts (600 × 241, DNA; initially 168.3 ± 2.7 lb) were used in two separate studies lasting 21 d each. Linear (LM), quadratic polynomial (QP), and broken-line linear (BLL) models were fit to estimate SID Lys level to maximize IOFC. The QP model resulted in the best fit, based on Bayseian Information Criterion (BIC), with a lower number being indicative of an improved fit. The QP model predicted 95 and 100% of maximum IOFC at 0.51 and 0.78% SID Lys, respectively. The QP model equation was: IOFC = -17.2900 × (SID Lys, %)^2 + 26.9625 × (SID Lys, %) + 4.0925.

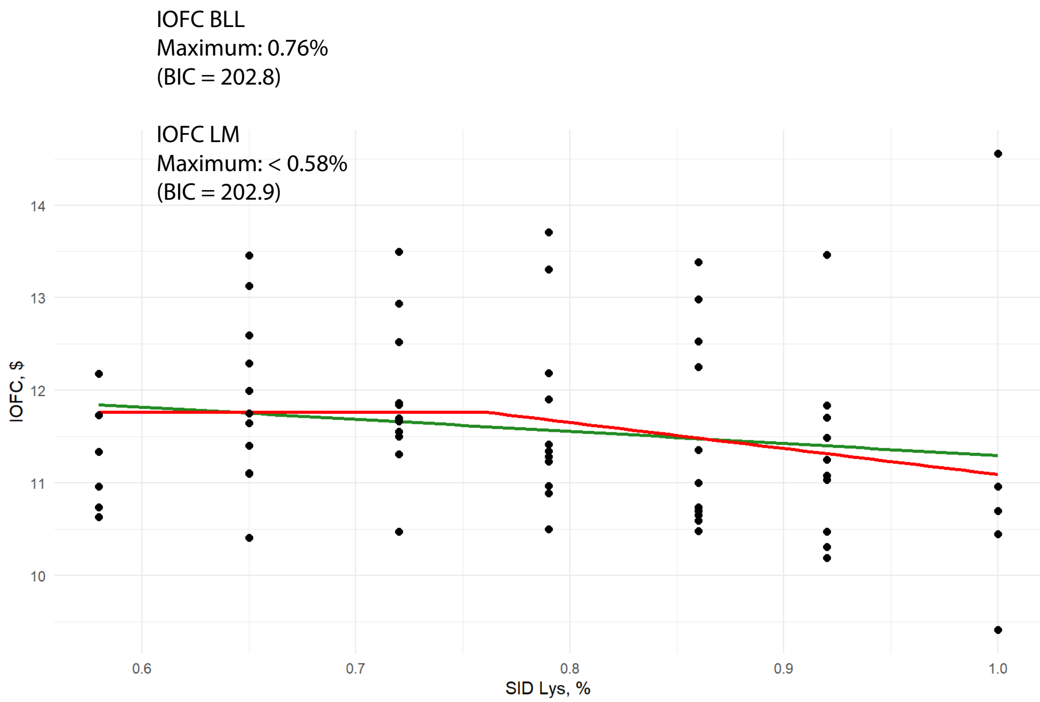

Figure 4. Estimation of SID Lys requirement to maximize IOFC at low ingredient and pig prices for 170 to 220 lb DNA finishing pigs.
A total of 616 barrows and gilts (600 × 241, DNA; initially 168.3 ± 2.7 lb) were used in two separate studies lasting 21 d each. Linear (LM), quadratic polynomial (QP), and broken-line linear (BLL) models were fit to estimate SID Lys level to maximize IOFC. The BLL and QP models resulted in the best fit, based on Bayseian Information Criterion (BIC), with a lower number being indicative of an improved fit. The BLL model predicted a reduction in IOFC when SID Lys increased past 0.76%.