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Summary

The objective of this study was to estimate the SID Lys requirement for growth and feed efficiency of 230- to 285-lb DNA finishing pigs. A total of 679 barrows and gilts (600 × 241, DNA; initial BW of 228.8 ± 2.9 lb) were used in two separate studies lasting 21- and 28-d, respectively. Pens of pigs were blocked by BW and randomly allotted to 1 of 6 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 0.43, 0.50, 0.57, 0.64, 0.71, and 0.79% SID Lys, with 12 replications for the 0.43, 0.50, 0.57, 0.71, and 0.79% SID Lys treatments, and 11 replications for the 0.64% SID Lys treatment. Increasing SID Lys increased (linear, $P = 0.043$) ADG, and improved (quadratic, $P = 0.020$) feed efficiency, resulting in pigs fed the diet containing 0.71% SID Lys having the greatest final BW and most optimum F/G. At high and low ingredient and pig prices, increasing SID Lys increased (quadratic, $P = 0.004$) IOFC.

The broken-line linear model to maximize ADG predicted that there was no further improvement past 0.64% SID Lys. For F/G, the broken-line linear model predicted that there was no further improvement past 0.59% SID Lys. At high ingredient and pig prices, the quadratic polynomial model for IOFC predicted maximum economic return at 0.64% SID Lys. Additionally, at low ingredient and pig prices, the quadratic polynomial model for IOFC predicted maximum economic return at 0.62% SID Lys. In summary, the optimal SID Lys level for DNA finishing pigs from 230- to 285-lb depends upon the response criteria, with growth performance maximized between 0.59 to 0.64% SID Lys. Economic responses were maximized between 0.62% SID Lys and 0.64% SID Lys.

Introduction

With advancements in modern swine genetics, coupled with increasing industry pressure for Duroc-sired genetics in the marketplace, it is important to continuously analyze and potentially alter the established dietary nutrient requirements.² This analysis is a

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

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

critical component toward having an accurate estimation of nutrient requirement in order to optimize diet formulation and growth performance. Additionally, establishing a pig's SID Lys requirement is vital, as other essential AAs are typically formulated as a percentage of SID Lys.³ This study is a portion of an overarching project with the objective of predicting the SID Lys requirement of DNA 600 sired pigs from approximately 50 to 285 lb. Therefore, the objective of this study was to determine the SID Lys requirement of 600 × 241 pigs from 230- to 285-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 679 pigs (600 × 241, DNA; initial BW of 228.8 ± 2.9 lb) were used in two separate studies, lasting 21- and 28-d, respectively. There were 8 to 10 mixed gender pigs per pen at a floor space of 7.83 ft² 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. Pens of pigs were allotted by BW and randomly assigned to 1 of 6 dietary treatments in a complete randomized block design. The dietary treatments included 6 SID Lys concentrations (0.43, 0.50, 0.57, 0.64, 0.71, and 0.79%), with 12 replications for the 0.43, 0.50, 0.57, 0.71, and 0.79% SID Lys treatments, and 11 replications for the 0.64% SID Lys treatment. Pigs were provided *ad libitum* access to water and to feed in meal form.

To formulate the experimental diets, a corn-soybean meal diet with 0.43% SID Lys was formulated containing no added feed-grade AAs. Then a 0.79% SID Lys corn-soybean meal diet was formulated containing 0.30% 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 the first-limiting AA. The 0.43 and 0.79% SID Lys diets were blended via a robotic feeding system to create the 0.50, 0.57, 0.64, and 0.79% SID Lys diets (Table 1). Pigs were weighed and feed disappearance was recorded weekly in 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 = \$0.800/lb;

³ Gebhardt, J., M. Gonçalves, M. Tokach, J DeRouchey, R. Goodband, J. Woodworth, S. Dritz 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.

DL-Met = \$2.500/lb; L-Thr = \$1.200/lb; L-Trp = \$5.000/lb; and L-Val = \$4.000/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 = \$0.650/lb; DL-Met = \$1.700/lb; L-Thr = \$0.850/lb; L-Trp = \$3.000/lb; and L-Val = \$2.500/lb. Feed cost/pig was determined by total feed intake $\times$ 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 $\times$ \$0.66/lb live gain, or total gain $\times$ \$0.45/lb live gain, respectively. Income over feed cost was calculated using revenue/pig – feed cost/pig.

Statistical analysis

Data were analyzed as a randomized complete block design for one 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, pen average 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, $P = 0.043$) ADG and improved (quadratic, $P = 0.020$) feed efficiency, resulting in pigs fed the diet containing 0.71% SID Lys having the greatest final BW and most optimum F/G (Table 2). Lysine intake/d and Lys intake/kg of gain increased (linear, $P < 0.001$) with increasing SID Lys. At high ingredient prices, there was no significant difference between treatments for feed cost/pig. However, increasing SID Lys decreased (quadratic, $P = 0.032$) feed cost/lb of gain, with pigs fed 0.57% SID Lys having the lowest feed cost/lb of gain. At high ingredient and pig prices increasing SID Lys increased (linear, $P = 0.020$) total revenue/pig and (quadratic, $P = 0.001$) IOFC with pigs fed 0.71% SID Lys having the greatest total revenue/pig and IOFC. Additionally, increasing SID Lys at low prices increased (linear, $P < 0.05$) feed cost/pig, feed cost/lb of gain, and revenue/pig. As a result, increasing SID Lys increased ($P = 0.004$) IOFC at low prices, with pigs fed 0.71% SID Lys having the greatest numeric IOFC.

The best fitting model to predict maximum ADG was the BLL model, which predicted no further improvement to growth performance beyond 0.64% SID Lys (Figure 1). For optimization of F/G, the BLL model had the best fit, with this model predicting no further improvement past 0.59% SID Lys (Figure 2). At high ingredient and pig prices the QP model had the best fit to predict maximum IOFC, which predicted maximum profitability at 0.64% SID Lys. The QP model equation was: $\text{IOFC} = -41.7426 \times (\text{SID Lys, \%})^2 + 53.7384 \times (\text{SID Lys, \%}) - 4.0629$, with 95% of the greatest IOFC at 0.52 and 0.77% SID Lys (Figure 3). At low ingredient and pig prices the QP model had the best fit to predict maximum IOFC, which predicted maximum profitability at 0.62% SID Lys. The QP model equation was: $\text{IOFC} = -25.9989 \times (\text{SID Lys, \%})^2 + 32.4951 \times (\text{SID Lys, \%}) + 0.9228$, with 95% of the greatest IOFC at 0.48 and 0.77% SID Lys (Figure 3).

In summary, for maximum growth and optimum feed efficiency, it is recommended that 230- to 285-lb finishing pigs should be fed diets containing no less than 0.59% SID Lys, with further improvements in selected response criteria to 0.71% SID Lys. Additionally, growth performance and feed efficiency were optimized at 21.3 g of SID Lys per kg of gain. Economic responses are a result of set ingredient and market pig prices, and as such expected returns should always be compared to maximum growth potential in order to determine an optimal dietary SID Lys level.

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

Item	SID Lys, %					
	0.43	0.50	0.57	0.64	0.71	0.79
Ingredient, %						
Corn	87.36	86.23	85.10	83.97	82.84	81.71
Soybean meal	10.19	11.13	12.07	13.01	13.95	14.90
Corn oil	0.40	0.50	0.60	0.70	0.80	0.90
Limestone	0.80	0.80	0.80	0.80	0.80	0.80
Monocalcium P, 21% P	0.55	0.54	0.53	0.52	0.51	0.50
Sodium chloride	0.50	0.50	0.50	0.50	0.50	0.50
L-Lys-HCl	---	0.06	0.12	0.18	0.24	0.30
DL-Met	---	0.01	0.02	0.03	0.04	0.05
L-Thr	---	0.02	0.04	0.06	0.08	0.11
L-Trp	---	---	0.01	0.01	0.02	0.02
L-Val	---	---	0.01	0.01	0.02	0.02
Vitamin premix with phytase ²	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
Total	100	100	100	100	100	100
Calculated analysis ³						
SID AA, %						
Lys, %	0.43	0.50	0.57	0.64	0.71	0.79
Ile:Lys	92	86	79	73	67	60
Leu:Lys	245	226	206	187	168	148
Met:Lys	44	42	40	38	36	33
Met and Cys:Lys	89	83	78	72	66	60
Thr:Lys	81	78	75	72	69	66
Trp:Lys	24.0	22.4	21.3	20.3	19.6	19.0
Val:Lys	109	98	89	82	77	72
His:Lys	68	60	54	50	46	43
ME, kcal/lb	1,513	1,516	1,518	1,521	1,523	1,526
NE, kcal/lb	1,169	1,169	1,169	1,170	1,170	1,170
SID Lys:NE, g/Mcal	1.67	1.94	2.21	2.48	2.75	3.02
CP, %	12.1	12.5	12.9	13.4	13.8	14.3
Ca, %	0.50	0.50	0.50	0.50	0.50	0.50
Available P, %	0.27	0.27	0.27	0.27	0.27	0.26
STTD P, %	0.31	0.31	0.31	0.31	0.31	0.31

¹Treatment diets were fed to 679 pigs (600 × 241, DNA; initial BW of 228.8 ± 2.9 lb). Treatment diets were fed from d 0 to 21.

²HiPhos 2700 (DSM Nutritional Products, Parsippany, NJ) provided 227 FTU/lb, for an estimated release of 0.09% STTD P.

³National 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 lysine on growth performance in DNA finishing pigs 230-285 lb¹

Item	SID Lys, %						SEM	P =	
	0.43	0.50	0.57	0.64	0.71	0.79		Linear	Quadratic
BW, lb									
Initial	228.8	228.8	229.1	228.4	228.9	228.9	2.91	0.980	0.966
Final	277.5	280.6	279.9	281.3	283.0	280.6	2.52	0.025	0.102
ADG, lb	1.99	2.09	2.08	2.15	2.20	2.10	0.057	0.043	0.108
ADFI, lb	6.63	6.64	6.40	6.54	6.57	6.36	0.108	0.102	0.956
F/G	3.36	3.18	3.08	3.05	3.01	3.03	0.063	< 0.001	0.020
SID Lys, g/d	12.90	15.03	16.52	18.93	21.12	22.60	0.279	< 0.001	0.408
SID Lys, g/kg gain	14.43	15.87	17.54	19.48	21.30	23.75	0.376	< 0.001	0.178
Economic, \$									
High ingredient and pig prices ²									
Feed cost/pig	20.37	20.86	20.37	21.46	21.89	21.90	0.920	0.115	0.915
Feed cost/lb gain ³	0.420	0.407	0.401	0.406	0.406	0.418	0.0082	0.929	0.032
Total revenue/pig ⁴	31.64	33.45	33.16	34.54	35.20	34.14	0.989	0.020	0.205
IOFC ⁵	11.27	12.59	12.79	13.10	13.32	12.24	0.450	0.027	0.001
Low ingredient and pig prices ⁶									
Feed cost/pig	11.73	12.06	12.07	12.75	13.13	13.17	0.544	0.014	0.957
Feed cost/lb gain	0.242	0.235	0.237	0.241	0.244	0.252	0.0049	0.044	0.077
Total revenue/pig	21.75	22.99	22.80	23.76	24.20	23.47	0.724	0.028	0.229
IOFC	10.01	10.94	10.73	11.03	11.07	10.30	0.325	0.392	0.004

¹A total of 679 pigs (600 × 241, DNA; initial BW of 228.8 ± 2.9 lb) were used with 8 to 10 pigs per pen and 12 replications per treatment for the 0.43, 0.50, 0.57, 0.71 and 0.79% SID Lys treatments, 11 replications for the 0.64% SID Lys treatment, and were fed trial diets for a 21- or 28-d period in two groups.

²For 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.

³Feed cost/lb gain = (feed cost/pig) / total gain.

⁴Total revenue/pig = total gain/pig × gain value (\$0.66/lb at high prices; \$0.45/lb at low prices).

⁵Income over feed cost = total revenue/pig – feed cost/pig.

⁶For 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.

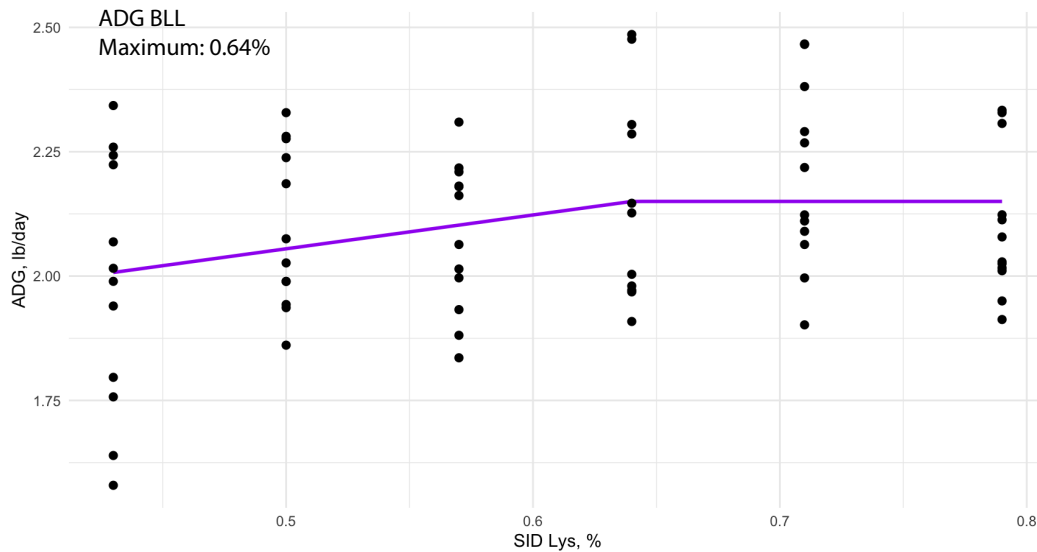


Figure 1. Estimation of SID Lys requirement to maximize ADG for 230 to 285 lb DNA finishing pigs.

A total of 679 pigs (600×241 , DNA; initial BW of 228.8 ± 2.91 lb) were used in two separate studies, lasting 21- or 28-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 model resulted in the best fit based on Bayesian Information Criterion (BIC), with a lower number being indicative of an improved fit. The BLL model predicted no further improvement past 0.64% SID Lys.

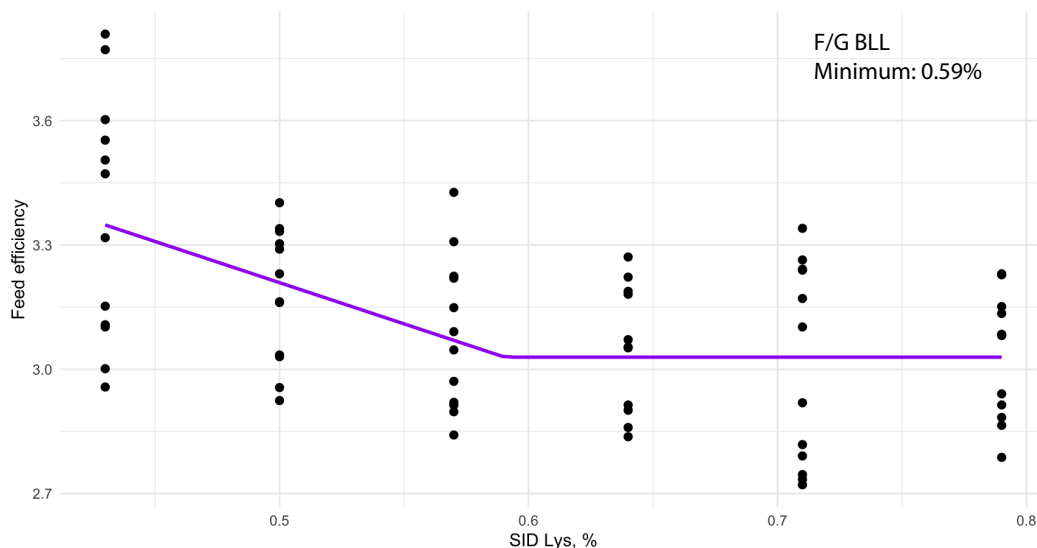


Figure 2. Estimation of SID Lys requirement to optimize F/G for 230 to 285 lb DNA finishing pigs.

A total of 679 pigs (600×241 , DNA; initial BW of 228.8 ± 2.91 lb) were used in two separate studies, lasting 21- or 28-d each. Linear (LM), quadratic polynomial (QP), and broken-line linear (BLL) models were fit to estimate SID Lys level to maximize F/G. The BLL model resulted in the best fit, based on Bayesian Information Criterion (BIC), with a lower number being indicative of an improved fit. The BLL model predicted no further improvement past 0.59% SID Lys.

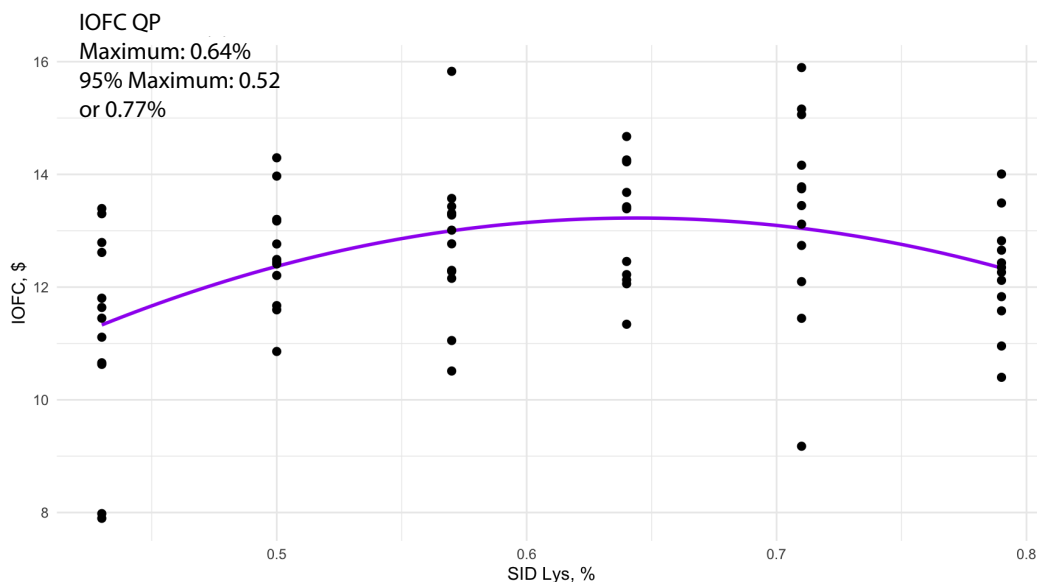


Figure 3. Estimation of SID Lys requirement to maximize IOFC at high ingredient and pig prices for 230 to 285 lb DNA finishing pigs.

A total of 679 pigs (600×241 , DNA; initial BW of 228.8 ± 2.91 lb) were used in two separate studies, lasting 21- or 28-d each. Linear (LM), quadratic polynomial (QP), and broken-line linear (BLL) models were fit to estimate SID Lys level to maximize F/G. The QP model resulted in the best fit, based on Bayesian Information Criterion (BIC), with a lower number being indicative of an improved fit. The QP model predicted 95 and 100% of maximum IOFC at 0.52, or 0.77, and 0.64% SID Lys, respectively. The QP model equation was: $\text{IOFC} = -41.7426 \times (\text{SID Lys, \%})^2 + 53.7384 \times (\text{SID Lys, \%}) - 4.0629$.

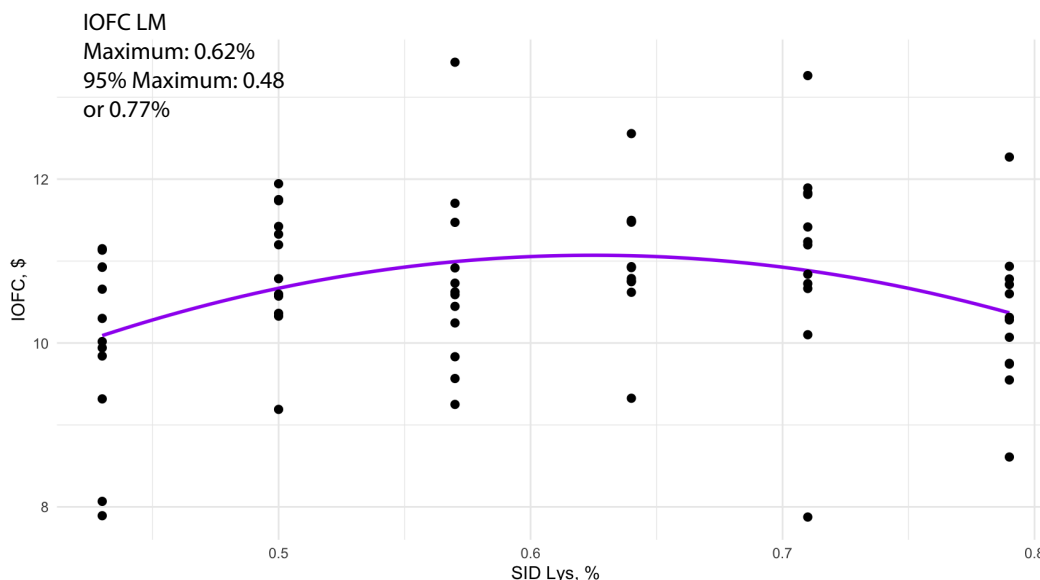


Figure 4. Estimation of SID Lys requirement to maximize IOFC at low ingredient and pig prices for 230 to 285 lb DNA finishing pigs.

A total of 679 pigs (600×241 , DNA; initial BW of 228.8 ± 2.91 lb) were used in two separate studies, lasting 21- or 28-d each. Linear (LM), quadratic polynomial (QP), and broken-line linear (BLL) models were fit to estimate SID Lys level to maximize F/G. The QP model resulted in the best fit, based on Bayesian Information Criterion (BIC), with a lower number being indicative of an improved fit. The QP model predicted 95 and 100% of maximum IOFC at 0.48, or 0.77, and 0.62% SID Lys, respectively. The QP model equation was: $\text{IOFC} = -25.9989 \times (\text{SID Lys, \%})^2 + 32.4951 \times (\text{SID Lys, \%}) + 0.9228$.