Effects of Standardized Ileal Digestible Threonine to Lysine Ratio on Finishing Pig Growth Performance

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Summary

The objective of these experiments was to evaluate the effect of varying SID Thr:Lys ratios on growth performance of growing and finishing pigs. In each experiment, pens of pigs were blocked by BW and barn, and randomly assigned to one of six dietary treatments in a randomized complete block design with nine or 10 pigs per pen and 11 or 12 replications per treatment. A similar number of barrows and gilts were placed in each pen. In exp. 1, 684 pigs (DNA 600 × 241: initially 82.5 ± 2.99 lb) were used in two separate studies, lasting 35 and 28 d, respectively. In exp. 2, 662 pigs (600 × 241, DNA; initially 212.1 ± 2.29 lb) were used in two separate 28-d studies. Dietary treatments were corn-soybean meal-based and formulated with increasing SID Thr:Lys ratios of 53, 58, 63, 68, 73, and 78%. Diets with the lowest and highest Thr:Lys ratios were blended to achieve the target SID Thr:Lys treatments. The same set of pigs was used for the early and late trials and between experiments, all pens of pigs were fed a common diet for 28 d. In exp. 1, ADG and final BW increased (quadratic, $P \le 0.025$) with increasing SID Thr:Lys ratio with little improvement beyond the 63% SID Thr:Lys. Increasing Thr:Lys ratio improved (quadratic, $P = 0.041$) F/G ratio, appearing to have little improvement beyond 58% SID Thr:Lys. The quadratic polynomial (QP) model suggested that ADG was maximized at 69.0% SID Thr:Lys, while a similar fitting broken-line linear (BLL) model predicted no further improvement beyond 60.9%. For F/G, the QP model suggested minimum F/G was achieved at 74.3% SID Thr:Lys, while similar fitting BLL and BLQ models predicted no further improvement to F/G beyond 55.3 and 63.9%, respectively. In exp. 2, final BW tended to increase (quadratic, $P = 0.061$) with increasing SID Thr:Lys ratio and ADG increased (linear, $P = 0.035$; quadratic, $P = 0.063$), with the greatest numeric response between 63 and 68% SID Thr:Lys. Increasing SID Thr:Lys ratio improved (quadratic, $P = 0.048$) F/G up to 58 to 68% SID Thr:Lys ratio. Additionally, serum urea N decreased (linear, $P = 0.016$) with increasing SID Thr:Lys ratio. The QP model suggested that ADG was maximized at 70.3% SID Thr:Lys, while a similar fitting BLL model predicted no further improvement to ADG beyond 61.2%. For F/G, the QP model suggested minimum F/G was achieved at 68.7% SID Thr:Lys, while a similar fitting BLL model predicted no further improvement to F/G beyond 57%, respectively. In conclusion, the statistical models

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predict a wide range of SID Thr:Lys ratios to establish a requirement estimate for the different response criteria. However, for 82 to 154 lb pigs, there was little improvement in growth performance beyond a Thr:Lys ratio of 63%. For 212 to 265 lb pigs, the requirement estimate appeared to be between 63 and 68% Thr:Lys ratio. These results would suggest a similar requirement compared to our previous work in a commercial setting, based on SID Thr intake/d and SID Thr intake/kg of gain (Royall et al., 2023).

Introduction

Threonine is an essential amino acid for pigs, which has been categorized as the first limiting amino acid for maintenance and development of intestinal tissue.[2] An increase in the Thr requirement potentially occurs as pigs grow due to increased growth of intestinal tissue coupled with increased production of Thr-rich proteins (i.e., mucin).[3] With improvements in modern swine genetics, it is critical to continuously re-evaluate the established nutrient requirements to optimize genetic potential for growth performance. Recent research observed that SID Thr:Lys requirement estimates range from 61 to > 68% in PIC 337 × 1050 pigs under field conditions.[4] However, the wide range of requirement estimates coupled with the high degree of variation observed in these studies led us to develop a series of experiments to further refine the SID Thr:Lys requirement. Therefore, the objective of these studies was to determine the effect of various SID Thr:Lys ratios on growth performance of finishing pigs from 82- to 153-lb and 212- to 265-lb BW.

Materials and Methods

The Kansas State University Animal Care and Use Committee approved the protocol used in this experiment. The experiment was conducted at the Kansas State University Swine Teaching and Research Center. 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

In exp. 1, 684 pigs (DNA 600 × 241; initially 82.5 ± 2.99 lb) were used in two sequential groups with nine or 10 mixed-gender pigs per pen at a floor space of 7.83 ft^2 per pig. In exp. 2, 662 of the pigs from exp. 1 (initially 212.1 ± 2.29 lb) were used in a 28-d study in two sequential groups. There were between eight and 10 pigs per pen. In each experiment, 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 one of six dietary treatments

[2] Tolosa A. F., M. D. Tokach, R. D. Goodband, J. C. Woodworth, J. M. DeRouchey, and J. T. Gebhardt. 2022. Evaluation of increasing digestible threonine to lysine in corn-soybean meal diets without and with distillers dried grains with solubles on growth performance of growing-finishing pigs. Transl. Anim. Sci. 6:1-6. doi:10.1093/tas/txac058.

[3] National Research Council. 2012. Nutrient Requirements of Swine: Eleventh Revised Edition. Washington, DC: The National Academies Press. doi:10.17226/13298.

[4] Royall, R. Q., M. D. Tokach, J. C. Woodworth, J. M. DeRouchey, J. T. Gebhardt, C. M. Vier, M. Spindler, U. Orlando, L. Zaragoza, N. Lu, W. Cast, D. F. Wilson-Wells, J. P. Holen, and A. M. Betlach. 2023. Effects of standardized ileal digestible threonine to lysine ratio on growth performance of PIC line 337 × 1050 pigs. Kansas Agricultural Experiment Station Research Reports. Vol. 9:Iss.7

with 11 or 12 replications per treatment in a complete randomized block design. Pigs were provided ad libitum access to water and to feed in meal form.

Dietary treatments were corn-soybean meal-based and formulated to contain 0.84% and 0.58% SID Lys and SID Thr:Lys ratios of 53, 58, 63, 68, 73, and 78%. Diets containing low and high SID Thr:Lys ratios were blended to achieve the intermediate SID Thr:Lys treatments (Table 1). Threonine was the first-limiting AA, with Lys formulated to be approximately 10% below the expected requirement, while all other AA ratios were maintained above requirement estimates. Pens of pigs were weighed, and feed disappearance was recorded at the beginning and end of each study to determine ADG, ADFI, and F/G. Ten mL of blood was collected from the jugular vein of three pigs per pen (two barrows and one gilt) after a 12-h fasting period on d 14 in exp 1, and on d 13 and 14, in group 1 and 2 of exp 2. Serum was analyzed for urea N concentration using a Urea Nitrogen Colorimetric Detection Kit (Arbor Assays, Ann Arbor, MI).

Statistical analysis

Data were analyzed as a randomized complete block design for a one-way ANOVA using the GLIMMIX procedure of SAS (v. 9.4, SAS Institute, Inc., Cary, NC). Pen was considered the experimental unit, initial bodyweight and barn served as a blocking factor, and treatment served as the fixed effect in the statistical model. Results were considered significant with $P \leq 0.05$ and marginally significant with $P \leq 0.10$. Dose response curves were evaluated using quadratic polynomial (QP), broken-line linear (BLL), and broken-line quadratic (BLQ) models. The best-fitting model was selected using the Bayesian Information Criterion (BIC) with improved model fits accepted when BIC decreased at least 2.0.

Results and Discussion

Experiment 1

In 82- to 154-lb pigs, ADG and final BW increased (quadratic, $P \leq 0.025$) with increasing SID Thr:Lys ratio; however, ADFI was not affected (Table 2). Average daily gain and final BW increased up to 63% Thr:lys ratio, with little improvement thereafter. As a result, increasing Thr:Lys ratio improved (quadratic, $P = 0.041$) F/G. Threonine intake/d and Thr intake/kg of gain increased (linear, $P < 0.001$) with increasing Thr:Lys ratio, while Lys intake/kg of gain decreased (quadratic, $P = 0.039$). Serum urea N tended (quadratic, $P = 0.093$) to decrease, then increase with increasing Thr:Lys ratio, such that pigs fed the diet containing 68% SID Thr:Lys had the lowest numeric serum urea N.

The QP model suggested that ADG was maximized at 69.0% SID Thr:Lys, while a similar fitting BLL model predicted no further improvement beyond 60.9% (Figure 1). For F/G, the QP model suggested minimum F/G was achieved at 74.3% SID Thr:Lys, while similar fitting BLL and BLQ models predicted no further improvement to F/G beyond 55.3 and 63.9%, respectively (Figure 2).

Experiment 2

In 212- to 265-lb pigs, final BW tended to increase (quadratic, $P = 0.061$) with increasing SID Thr:Lys ratio and ADG increased (linear, $P = 0.035$; quadratic

P = 0.063), with the greatest numeric response between 63 and 68% SID Thr:Lys ratio (Table 3). Increasing SID Thr:Lys ratio improved (quadratic, *P* = 0.048) F/G. Threonine intake/d and Thr intake/kg of gain increased (linear, *P* < 0.001) with increasing Thr:Lys ratio, while Lys intake/kg of gain decreased (quadratic, *P* = 0.048). Additionally, serum urea N decreased (linear, *P* = 0.016; quadratic, *P* = 0.059) with increasing SID Thr:Lys ratio.

The QP model suggested that ADG was maximized at 70.3% SID Thr:Lys, while a similar fitting BLL and model predicted no further improvement to ADG beyond 61.2% (Figure 3). For F/G, a QP model suggested minimum F/G was achieved at 68.7% SID Thr:Lys, while similar fitting BLL and BLQ models predicted no further improvement to F/G beyond 57 and 59.8%, respectively (Figure 4).

In conclusion, the statistical models predict a wide range of SID Thr:Lys ratios to establish a requirement estimate for the different response criteria. However, for 82- to 154-lb pigs, there was little improvement in growth performance beyond a Thr:Lys ratio of 63%. For 212- to 265-lb pigs, the requirement estimate appeared to be between 63 and 68% Thr:Lys ratio. These results would suggest a slightly lower requirement compared to our previous work in a commercial setting (Royall et al., 2023).

Table 1. Diet composition (as-fed basis)[1,2]

	Exp. 1		Exp. 2	
SID Thr:Lys, %:	53	78	53	78
Ingredient, %				
Corn	79.56	79.33	90.08	89.77
Soybean meal	17.18	17.19	7.32	7.49
Monocalcium P, 21% P	1.30	1.30	0.80	0.80
Limestone	0.75	0.75	0.83	0.83
Sodium chloride	0.50	0.50	0.50	0.50
L-Lys-HCl	0.31	0.31	0.28	0.28
DL-Met	0.07	0.07	---	---
L-Thr	---	0.22	---	0.14
L-Trp	0.03	0.03	0.03	0.03
L-Val	0.02	0.02	---	---
Vitamin premix	0.15	0.15	0.10	0.10
Trace mineral premix	0.15	0.15	0.08	0.08
Total	100	100	100	100
Calculated analysis[1]				
SID AA, %				
Lys, %	0.84	0.84	0.58	0.58
Ile:Lys	61	61	60	60
Leu:Lys	144	144	170	170
Met and Cys:Lys	60	60	62	62
Thr:Lys	53	78	53	78
Trp:Lys	19.7	19.7	19.3	19.4
Val:Lys	71	71	73	73
His:Lys	42	42	45	46
NE, kcal/lb	1,134	1,134	1,166	1,166
SID Lys:NE, g/Mcal	3.36	3.36	2.26	2.26
CP, %	15.1	15.3	11.2	11.4
Ca, %	0.66	0.66	0.54	0.54
STTD P, %	0.44	0.44	0.26	0.26

[1]Calculated analysis based on nutrient profiles for ingredients listed in the 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.)

[2]53 and 78% SID Thr:Lys diets were blended to create treatment diets at 58, 63, 68, and 73% SID Thr:Lys.

Table 2. Effects of increasing SID Thr:Lys ratio on growth performance of 82 to 154 lb pigs (Exp. 1)[1,2]

	SID Thr:Lys, %							P =	
Item	53	58	63	68	73	78	SEM	Linear	Quadratic
BW, lb									
Initial	82.5	82.5	82.4	82.5	82.5	82.5	2.99	0.990	0.884
Final	149.2	151.8	153.0	153.4	152.5	152.5	1.94	0.030	0.025
Growth Performance									
ADG, lb	2.12	2.19	2.24	2.25	2.22	2.22	0.027	0.004	0.005
ADFI, lb	4.90	4.89	4.94	4.93	4.91	4.81	0.079	0.530	0.256
F/G	2.31	2.22	2.20	2.19	2.21	2.16	0.020	< 0.001	0.041
SID Thr intake, g/d	9.89	10.80	11.86	12.78	13.65	14.30	0.191	< 0.001	0.196
SID Thr intake, g/kg gain	10.30	10.83	11.66	12.52	13.54	14.17	0.110	< 0.001	0.192
SID Lys intake, g/d	18.66	18.61	18.82	18.80	18.70	18.34	0.300	0.544	0.252
SID Lys intake, g/kg gain	19.44	18.68	18.51	18.40	18.55	18.17	0.170	< 0.001	0.039
Serum urea nitrogen concentration, mg/dL[3]	7.26	7.17	7.13	6.88	7.08	7.14	0.204	0.215	0.093

[1]A total of 684 (initial BW = 82.5 ± 2.99 lb) pigs were used two growth performance studies with nine or 10 pigs per pen and 12 replicates per treatment.
[2]ADG = average daily gain; ADFI = average daily feed intake; F/G = feed-to-gain ratio.
[3]Blood samples were taken on d 14 from three pigs per pen (two barrows and one gilt) to measure serum urea N.

Table 3. Effects of increasing SID Thr:Lys ratio on growth performance of 212 to 265 lb pigs (Exp. 2)[1,2]

	SID Thr:Lys, %							P =	
Item	53	58	63	68	73	78	SEM	Linear	Quadratic
BW, lb									
Initial	212.1	212.3	212.1	212.1	212.1	212.2	2.29	0.962	0.985
Final	261.8	263.5	264.6	265.4	264.0	264.0	2.35	0.136	0.061
Growth Performance									
ADG, lb	1.77	1.83	1.87	1.90	1.85	1.87	0.043	0.035	0.063
ADFI, lb	6.21	6.21	6.27	6.38	6.41	6.28	0.084	0.114	0.301
F/G	3.53	3.40	3.35	3.36	3.48	3.37	0.061	0.099	0.048
SID Thr intake, g/d	8.67	9.47	10.39	11.41	12.32	12.89	0.144	< 0.001	0.321
SID Thr intake, g/kg gain	10.85	11.44	12.25	13.26	14.74	15.23	0.234	< 0.001	0.132
SID Lys intake, g/d	16.35	16.33	16.50	16.78	16.87	16.52	0.221	0.114	0.298
SID Lys intake, g/kg gain	20.47	19.73	19.43	19.50	20.20	19.52	0.355	0.100	0.048
Serum urea nitrogen concentration, mg/dL[3]	6.67	6.52	6.39	6.34	6.42	6.40	0.150	0.016	0.059

[1]A total of 662 (initial BW = 212.1 ± 2.29 lb) pigs were used in two 28-d growth performance studies with eight to 10 pigs per pen and 11 or 12 replicates per treatment.
[2]ADG = average daily gain; ADFI = average daily feed intake; F/G = feed-to-gain ratio.
[3]Blood samples were taken on d 13 and 14, group 1 and 2, respectively, from three pigs per pen (two barrows and one gilt) to measure serum urea N.

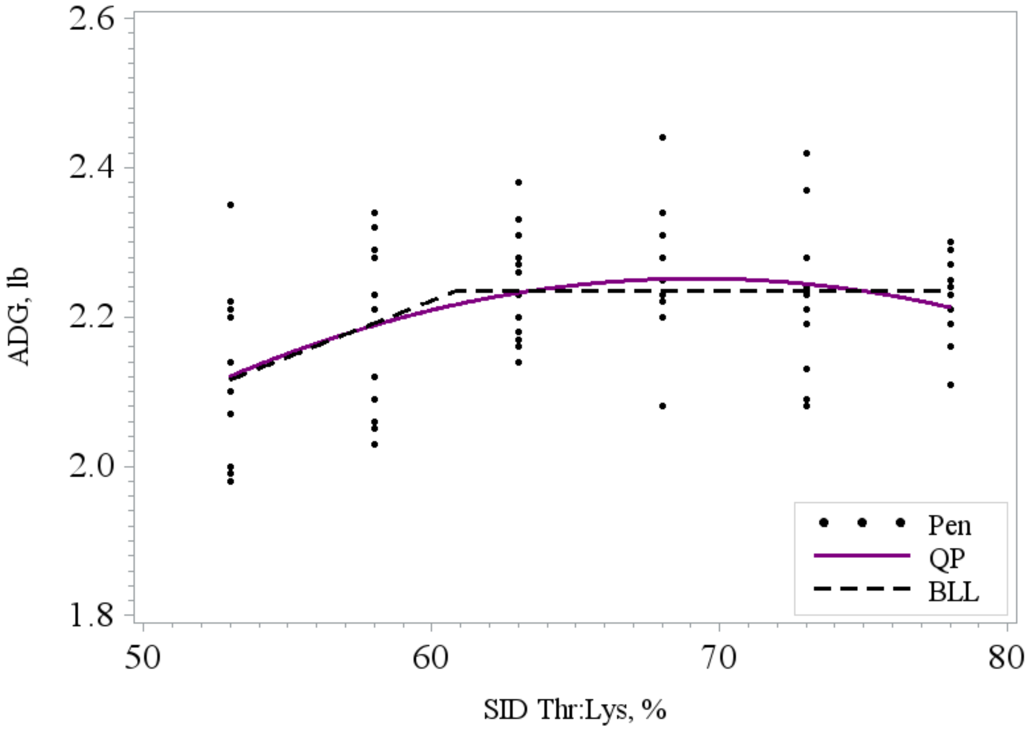

Figure 1. Estimation of SID Thr:Lys requirements to maximize ADG for 82- to 154-lb pigs, Exp. 1. Quadratic polynomial (QP), broken-line linear (BLL), and broken-line quadratic (BLQ) models were fit to estimate SID Thr:Lys ratio required to maximize ADG. The QP and BLL models resulted in the best fit, based on Bayesian Information Criterion (BIC), with a lower number being indicative of a better fit (BIC = -130.1 vs. -130.3, QP vs. BLL). The QP model predicted 95 and 100% of maximum ADG at 54.0 and 69.0% SID Thr:Lys, respectively. The QP model equation for ADG was: ADG = -0.00050 × (SID Thr:Lys, %)^2 + 0.6895 × (SID Thr:Lys, %) – 0.1342. The BLL model predicted no further improvement beyond 60.9% SID Thr:Lys.

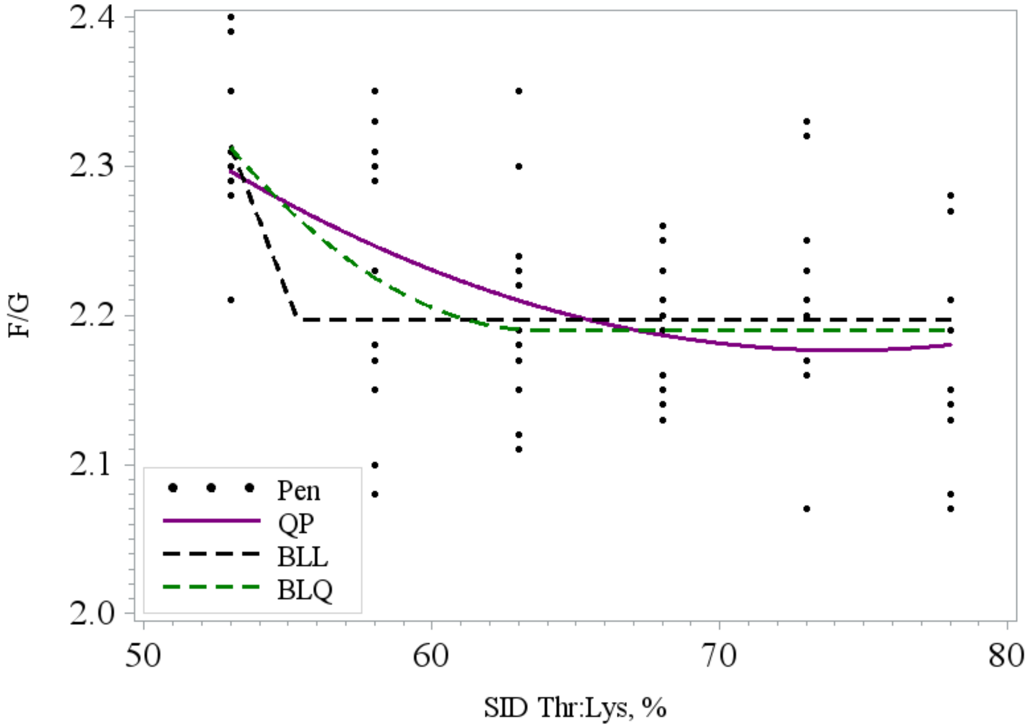

Figure 2. Estimation of SID Thr:Lys requirements to minimize F/G for 82- to 154-lb pigs, Exp. 1. Quadratic polynomial (QP), broken-line linear (BLL), and broken-line quadratic (BLQ) models were fit to estimate SID Thr:Lys level required to minimize F/G. All models resulted in a similar fit, based on Bayesian Information Criterion (BIC), with a lower number being indicative of a better fit. The QP model predicted 95 and 100% of minimum F/G at 54.0 and 74.3% SID Thr:Lys, respectively. The developed QP model equation for F/G was: F/G = 0.000266 × (SID Thr:Lys, %)^2 – 0.03951 × (SID Thr:Lys, %) + 3.6431. The BLL model predicted no further improvement beyond 55.3 % SID Thr:Lys. The BLQ model predicted no further improvement beyond 63.9% SID Thr:Lys.

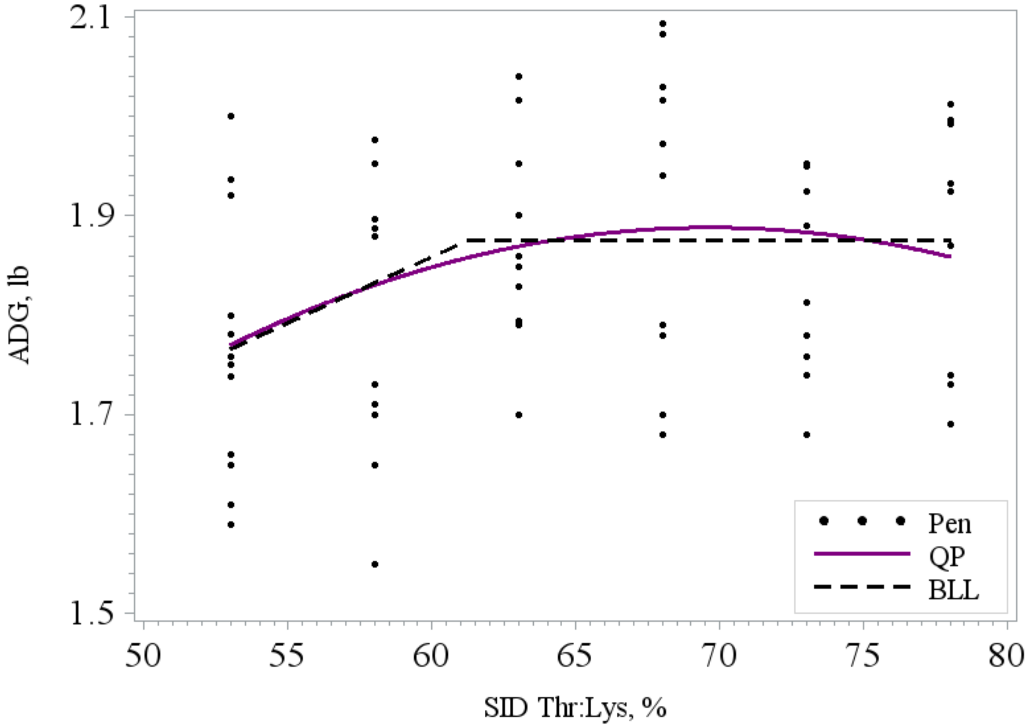

Figure 3. Estimation of SID Thr:Lys requirements to maximize ADG for 212- to 265-lb pigs, Exp. 2. Quadratic polynomial (QP), broken-line linear (BLL), and broken-line quadratic (BLQ) models were fit to estimate SID Thr:Lys ratio required to maximize ADG. All three models resulted in a similar fit, based on Bayesian Information Criterion (BIC), with a lower number being indicative of a better fit. The QP model predicted 95 and 100% of maximum ADG at 55.3 and 70.3% SID Thr:Lys ratio, respectively. The developed QP model equation for ADG was: ADG = -0.00042 × (SID Thr:Lys, %)^2 + 0.05909 × (SID Thr:Lys, %) – 0.17000. The BLL model predicted no further improvement beyond 61.2% SID Thr:Lys ratio.

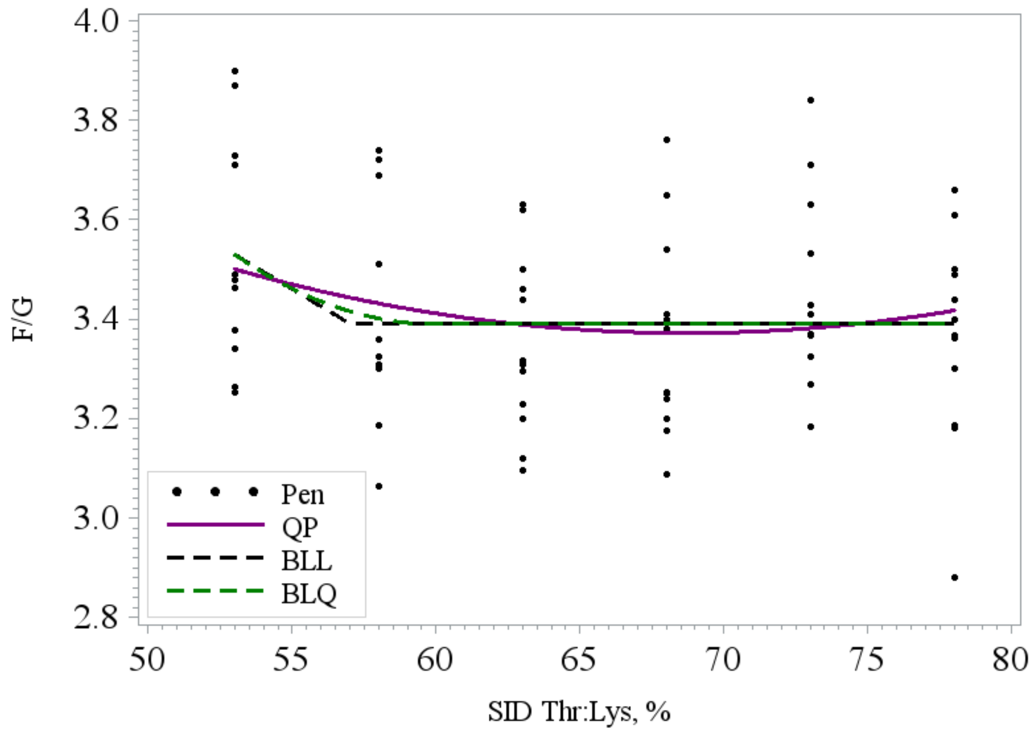

Figure 4. Estimation of SID Thr:Lys requirements to minimize F/G for 212- to 265-lb pigs, Exp. 2. Quadratic polynomial (QP), broken-line linear (BLL), and broken-line quadratic (BLQ) models were fit to estimate SID Thr:Lys ratio required to minimize F/G. All models resulted in a similar fit, based on Bayesian Information Criterion (BIC), with a lower number being indicative of a better fit. The QP model predicted 95 and 100% of minimum F/G at 50.7 and 68.7% SID Thr:Lys, respectively. The developed QP model equation for F/G was: F/G = 0.000523 × (SID Thr:Lys, %)^2 – 0.07182 × (SID Thr:Lys, %) + 5.83880. The BLL model predicted no further improvement beyond 57.0% SID Thr:Lys. The BLQ model predicted no further improvement beyond 59.8% SID Thr:Lys ratio.