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Effects of Standardized Ileal Digestible Valine:Lysine Ratio on the Growth Performance and Economics of Finishing Pigs from 55 to 100 lb[1,2]

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Summary

The objective of these experiments was to determine the effects of SID Val:Lys ratio in low CP and low lysine diets on the growth performance and economics of finishing pigs from 55 to 100 lb. In Exp. 1, a total of 1,134 gilts (PIC 337 × 1050, initially 68.8 lb BW) were used in a 19-d growth trial with 27 pigs per pen and seven pens per treatment in a randomized complete block design with pens blocked by initial average BW. There was a total of six dietary treatments: 59.0, 62.5, 65.9, 69.6, 73.0, and 75.5% SID Val:Lys ratio. In Exp. 2, a total of 2,100 gilts (PIC 327 × 1050, initially 56.6 lb BW) were used in a 22-d growth trial with 25 pigs per pen and 12 pens per treatment in a randomized complete block design with pens blocked by initial average BW. There was a total of seven dietary treatments: 57.0, 60.6, 63.9, 67.5, 71.1, 74.4, and 78.0% SID Val:Lys ratio. In both experiments, the intermediate Val:Lys levels were obtained by blending different proportions of the low and high Val:Lys diets. Responses measured at the pen level were analyzed using general linear and non-linear mixed models. Competing statistical models were: a broken-line linear ascending (BLL) model, a broken-line quadratic ascending (BLQ) model, and a quadratic polynomial (QP). Competing models were compared using Bayesian information criteria (BIC). In Exp. 1, ADG increased linearly ($P = 0.009$) with increasing SID Val:Lys ratio whereas ADFI only marginally increased (linear, $P = 0.098$) with no evidence for differences on F/G. Feed cost per pig, feed cost per lb of gain, and total revenue per pig increased (linear, $P < 0.009$) with increasing SID Val:Lys ratio without evidence for differences in IOFC. In Exp. 2, ADG and ADFI increased ($P < 0.002$) with increasing SID Val:Lys ratio resulting in an improvement in F/G ($P < 0.001$). Similarly, increasing SID Val:Lys ratio increased feed cost per pig

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[4] Ajinomoto Heartland Inc., Chicago, IL.

(quadratic, $P < 0.001$), feed cost per lb of gain (linear, $P < 0.001$), total revenue (quadratic, $P < 0.001$), and IOFC (quadratic, $P < 0.001$). In conclusion, the SID Val:Lys ratio to optimize performance ranged from 71.0% for minimum F/G to 74.4% for maximum ADG. However, feed cost per lb of gain was minimized at less than 57% SID Val:Lys ratio and maximum income over feed cost was estimated at 62.3% SID Val:Lys ratio with a plateau thereafter. Therefore, 99% of the optimum ADG and F/G were estimated at approximately 69% and 65% SID Val:Lys ratio, respectively.

Key words: finishing pigs, growth, valine

Introduction

Valine is commonly considered to be the fifth limiting amino acid after tryptophan in corn-soybean meal–based diets for finishing pigs (Figueroa et al., 2003)[5]. Valine can become limiting in diets supplemented with feed-grade amino acids such as lysine, methionine, tryptophan, and threonine. There are many ways to express swine amino acid requirements, but the most common approach for diet formulation is the expression of the standardized ileal digestible (SID) Val requirement as a ratio to Lys (Val:Lys). The NRC (2012) estimated SID Val:Lys ratio requirement at 65.3% for early finishing pigs. However, even though NRC provides a single estimate for the AA requirements, the estimates to optimize ADG, F/G or especially economic criteria such as feed cost per lb of gain or income over feed cost (IOFC) can vary significantly. Therefore, the objective of these experiments was to determine the effects of SID Val:Lys ratio in low CP and lysine-limiting diets on the growth performance and economics of finishing pigs from 55 to 100 lb.

Procedures

The Kansas State University Institutional Animal Care and Use Committee (IACUC) approved the protocol used in this experiment. Two experiments were conducted at commercial research facilities located in Minnesota. Both barns were naturally ventilated and double-curtain-sided and pens also had completely slatted flooring and deep pits for manure storage. In Exp. 1, pens were equipped with a 4-hole stainless steel dry self-feeder (Thorp Equipment, Thorp, WI) and a cup waterer. In Exp. 2, each pen was equipped with a 3-hole stainless steel dry self-feeder (Thorp Equipment, Thorp, WI) and a cup waterer. Both facilities were equipped with a computerized feeding system (FeedPro; Feedlogic Corp., Willmar, MN) that delivered and recorded daily feed additions. During the experiments, pigs had ad libitum access to feed and water.

In Exp. 1, a total of 1,134 gilts (PIC 337 × 1050, initially 68.8 lb BW) were used in a 19-d growth trial with 27 pigs per pen and 7 pens per treatment. In Exp. 2, a total of 2,100 gilts (PIC 327 × 1050, initially 56.6 lb BW) were used in a 22-d growth trial with 25 pigs per pen and 12 pens per treatment. In both experiments, treatments were blocked by initial BW in a randomized complete block design. For Exp. 1 there was a total of six dietary treatments: 59.0, 62.5, 65.9, 69.6, 73.0, and 75.5% SID Val:Lys ratio. For Exp. 2 there was a total of seven dietary treatments: 57.0, 60.6, 63.9, 67.5,

[5] Figueroa, J. L., A. J. Lewis, P. S. Miller, R. L. Fischer, and R. M. Diedrichsen. 2003. Growth, carcass traits, and plasma amino acid concentrations of gilts fed low-protein diets supplemented with amino acids including histidine, isoleucine, and valine. J. Anim. Sci. 81:1529-1537.

71.1, 74.4, and 78.0% SID Val:Lys ratio. In both experiments, the intermediate Val:Lys ratios were obtained by blending different proportions of the low and high Val:Lys diets (Tables 1 and 2).

Diet samples were taken from 6 feeders per dietary treatment 3 d after the beginning and 3 d before the end of each experiment, then CP and total amino acid analysis was conducted on composite samples from each treatment (Ajinomoto Heartland, Inc.). Diet samples were also submitted for analysis of DM, crude fiber, ash, and ether extract (Ward Laboratories, Inc., Kearney, NE).

Pens of pigs were weighed and feed disappearance was measured at the beginning and at the end of each experiment to determine ADG, ADFI, and F/G. The total grams of SID Val intake based on formulated values were divided by total BW gain to calculate the g of SID Val intake per kilogram of gain.

For the economic evaluation, total feed cost per pig, cost per lb of gain, revenue, and income over feed cost (IOFC) were calculated. The total feed cost per pig was calculated by multiplying the ADFI by the cost per lb of feed and the number of days. Cost per lb of gain was calculated by dividing the total feed cost per pig by the amount of pounds gained overall. Revenue per pig was calculated by multiplying the ADG times the total days in the trial times a live price of $0.60/lb. To calculate IOFC, total feed cost per pig was subtracted from pig revenue. Corn was valued at $3.60/bu ($129/ton), DDGS at $180/ton, soybean meal at $340/ton, L-Lysine HCl at $0.71/lb, L-Tryptophan at $11.00/lb, and L-Valine at $7.00/lb. The cost per ton of feed was considered fixed for Val:Lys levels below 65%.

For the statistical analysis, initially, responses measured at the pen level were analyzed using a general linear mixed model. Within each experiment, linear and quadratic polynomial contrasts with coefficients adjusted for unequally spaced treatments were used to evaluate the dose response effect of increasing dietary SID Val:Lys ratio on ADG, ADFI, F/G, BW, grams of SID Val intake per day, grams of SID Val intake per kg of gain, feed cost/pig, feed cost/lb of gain, total revenue/pig, and IOFC. Heterogeneous residual variances as a function of the response variables were fitted as needed. Model assumptions were checked and considered to be appropriately met. The experimental data were analyzed using the GLIMMIX procedure of SAS (SAS Institute Inc., Cary, NC). Prior to fitting the requirement estimation models, a base model was fit to estimate and assess variance components of weight block, weight block nested within experiment, and treatment by experiment interaction for each of the response variables. Subsequently, initial BW was tested as a covariate for each of the response variables. Linear and non-linear regression models adapted from Robbins et al. (2006)[6] were expanded to accommodate random effects and were fitted to ADG, F/G, feed cost per lb of gain, and IOFC to further estimate SID Val:Lys ratio requirements using an inverse prediction strategy. Specifically, competing statistical models fitted to the data were: a broken-line linear ascending (BLL) model, a broken-line quadratic ascending (BLQ) model, and a quadratic polynomial (QP). Broken-line regression models were fitted using the NLMIXED procedures of SAS. The optimization technique used was the dual

[6] Robbins, K. R., A. M. Saxton, and L. L. Southern. 2006. Estimation of nutrient requirements using broken-line regression analysis. J. Anim. Sci. 84: E155–E165.

Quasi-Newton algorithm, as specified by default in the NLMIXED procedure. Competing statistical models were compared using maximum-likelihood-based fit criteria, specifically the Bayesian information criteria (BIC). Results were considered significant at $P \leq 0.05$.

Results and Discussion

The analyzed total amino acids, DM, CP, crude fiber, ether extract and ash contents of the experimental diets were reasonably consistent with formulated estimates (Tables 3 and 4).

In Exp. 1, ADG increased (linear, $P = 0.009$) with increasing SID Val:Lys ratio whereas ADFI only marginally increased (linear, $P = 0.098$) with no impact on F/G (Table 5). Final BW marginally increased (linear, $P = 0.064$) with increasing SID Val:Lys ratio. Grams of SID Val intake per day and grams of SID Val per kg of gain increased (linear, $P < 0.001$) with increasing SID Val:Lys ratio. Feed cost per pig, feed cost per lb of gain, and total revenue per pig increased (linear, $P < 0.009$) with increasing SID Val:Lys ratio with no evidence for differences in IOFC.

In Exp. 2, ADG and ADFI increased (quadratic, $P < 0.002$) with increasing SID Val:Lys ratio whereas F/G improved (linear, $P < 0.001$; Table 6). Final BW also increased (quadratic, $P = 0.010$) with increasing SID Val:Lys ratio. Increasing SID Val:Lys ratio increased grams of SID Val intake per day (quadratic, $P = 0.005$) and grams of SID Val per kg of gain (linear, $P < 0.001$). Increasing SID Val:Lys ratio increased feed cost per pig (quadratic, $P < 0.001$), feed cost per lb of gain (linear, $P < 0.001$), total revenue (quadratic, $P < 0.001$), and IOFC (quadratic, $P < 0.001$).

Overall, the best-fitting model for ADG in the 55 to 100 lb BW pigs was a QP (BIC: 1482.9) compared with BLL and BLQ models (BIC: 1491.0 and 1488.6, respectively). The estimated regression equation for the best-fitting QP model (Fig. 1) was:

$$\text{QP equation for ADG} = -2.54 + 9.10 \times (\text{SID Val:Lys}) - 6.12 \times (\text{SID Val:Lys})^2 + 0.012 \times (\text{Initial BW})$$

where the SID Val:Lys ratio explanatory variable is expressed as a proportion (i.e., 0.700) rather than a percentage (i.e., 70.0%). Based on the best-fitting QP model, the maximum mean ADG was estimated at a 74.4% (95% CI: [69.5, >78.0%]) SID Val:Lys ratio.

The overall best-fitting models for F/G were a QP (BIC: 1562.1) and a BLL (BIC: 1563.0) compared to BLQ model (1568.5). The estimated maximum response for ADG was 71.0% (95% CI: [69.4, 73.5%]) SID Val:Lys ratio for QP model. The estimated breakpoint for F/G was 66.0% (95% CI: [65.7, 66.4%]) SID Val:Lys ratio. The estimated regression equation for the best-fitting QP model (Fig. 2) was:

$$\text{QP equation for F/G} = 5.64 - 9.68 \times (\text{SID Val:Lys}) + 6.81 \times (\text{SID Val:Lys})^2$$

BLL equation for F/G: if SID Val:Lys < 66.0%, equation is $2.22 + 1.0 \times (0.66 - \text{Val:Lys})$, otherwise F/G is predicted at minimum for doses greater than 66.0%.

Based on the best-fitting QP model, the minimum mean F/G was estimated at 71.0% (95% CI: [69.4, 73.5%]) SID Val:Lys ratio.

For feed cost per lb of gain, the overall best-fitting model was a QP (BIC: 914.5) compared with BLL and BLQ models (BIC: 919.3 and 921.8, respectively). The estimated regression equation for the best-fitting QP model (Fig. 3) was:

$$\text{QP equation for feed cost per lb of gain} = 0.389 - 0.643 \times (\text{SID Val:Lys}) + 0.567 \times (\text{SID Val:Lys})^2 + 0.0005 \times (\text{Initial BW})$$

Based on the best-fitting QP model, the minimum mean feed cost per lb of gain was estimated at less than 57.0% SID Val:Lys ratio.

For IOFC, the overall best-fitting model was a BLL (BIC: 341.1) compared with QP and BLQ models (BIC: 345.1 and 347.0, respectively). The estimated regression equation for the best-fitting BLL model (Fig. 4) was:

$$\text{QP equation for IOFC} = 6.90 - 20.19 \times (0.623 - \text{SID Val:Lys}) + 0.085 \times (\text{Initial BW})$$

Based on the best-fitting BLL model, the maximum mean IOFC was estimated at 62.3% (95% CI: [58.5, 66.2]%) SID Val:Lys ratio.

Target performance levels based on the best fitting models for ADG and F/G are listed in Table 7. Note that at 97% of the optimum performance, the SID Val:Lys ratio for ADG and F/G is approximately 66 and 60%, respectively, whereas at 99% of the optimum performance, the SID Val:Lys ratio for ADG and F/G is approximately 69% and 64 to 65.5%, respectively.

In conclusion, the SID Val:Lys ratio to optimize performance ranged from 71.0% for minimum F/G to 74.4% for maximum ADG. However, feed cost per lb of gain was minimized at less than 57% SID Val:Lys and maximum income over feed cost was estimated at 62.3% SID Val:Lys with a plateau thereafter. Therefore, 99% of the optimum ADG and F/G were estimated at approximately 69% and 65% SID Val:Lys, respectively.

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

Item	Standardized ileal digestible Val:Lys ratio	
	59.0%	75.5%
Ingredient, %		
Corn	73.31	73.16
Soybean meal (46% CP)	8.20	8.21
Dried distillers grains with solubles	15.00	15.00
Corn oil	0.50	0.50
Limestone	1.20	1.20
Monocalcium phosphate (21.5% P)	0.30	0.30
Salt	0.35	0.35
Trace mineral premix	0.100	0.100
Vitamin premix	0.075	0.075
L-lysine HCl	0.540	0.540
DL-methionine	0.105	0.105
L-threonine	0.175	0.175
L-tryptophan	0.071	0.071
L-valine	---	0.142
L-isoleucine	0.043	0.043
Phytase[2]	0.025	0.025
Total	100	100
SID amino acids, %		
Lys	0.85	0.85
Ile:lys	55.0	55.0
Leu:lys	139	139
Met:lys	36	36
Met & cys:lys	60	60
Thr:lys	65	65
Trp:lys	20.1	20.1
Val:lys	59.0	75.5
ME, kcal/lb	1,521	1,523
NE, kcal/lb	1,158	1,159
SID Lys:NE, g/Mcal	3.33	3.33
CP, %	13.9	14.0
Ca, %	0.57	0.57
Available P, %	0.31	0.31
Stand. dig. P with phytase, %	0.33	0.33
Ca:P	1.41	1.41
Ca:P (STTD P with phytase)	1.74	1.74

[1] Diets were fed from 68.9 to 99.0 lb BW. Corn, dried distillers grains with solubles (DDGS), and soybean meal were analyzed for CP and total amino acid concentrations and NRC (2012) SID digestibility values were used in the diet formulation. These diets were blended to make the intermediate dietary treatments: 62.5, 65.9, 69.6, and 73.0, SID Val:Lys.

[2] OptiPhos 2000 (Huvepharma, Peachtree, GA) provided 227 phytase units (FTU) per lb of diet.

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

	Standardized ileal digestible Val:Lys ratio	
Item	57.0%	78.0%
Ingredient		
Corn	74.56	74.37
Soybean meal (46% CP)	6.77	6.78
Dried distillers grains with solubles	15.00	15.00
Choice white grease	0.50	0.50
Limestone	1.10	1.10
Dicalcium phosphate (18.5% P)	0.45	0.45
Salt	0.35	0.35
Vitamin-mineral premix	0.200	0.200
Phytase[2]	0.050	0.050
L-lysine HCl	0.591	0.591
DL-methionine	0.105	0.105
L-threonine	0.195	0.195
L-tryptophan	0.073	0.073
L-valine	---	0.181
L-isoleucine	0.062	0.062
Total	100	100
SID amino acids, %	0.89	0.89
Lys	0.85	0.85
Ile:lys	55.0	55.0
Leu:lys	139	139
Met:lys	36	36
Met & cys:lys	60	60
Thr:lys	65	65
Trp:lys	20.1	20.1
Val:lys	57.0	78.0
ME, kcal/lb	1,520	1,522
NE NRC, kcal/lb	1,160	1,161
SID lysine:NE, g/Mcal	3.32	3.32
CP, %	13.6	13.7
Ca, %	0.57	0.57
P, %	0.42	0.41
Available P, %	0.27	0.27
Stand. dig. P with phytase, %	0.29	0.29
Ca:P	1.38	1.38
Ca:P (STTD P with phytase)	2.00	2.00

[1] Diets were fed from 56.0 to 89.7 lb BW. Corn, dried distillers grains with solubles (DDGS), and soybean meal were analyzed for CP and total amino acid concentrations and NRC (2012) SID digestibility values were used in the diet formulation. These diets were blended to make the intermediate dietary treatments: 60.6, 63.9, 67.5, 71.1, and 74.4 SID Val:Lys.

[2] Axtra PHY (DuPont, Wilmington, DE) provided 150 phytase units (FTU) per lb of diet.

Table 3. Chemical analysis of the diets (as-fed-basis; Exp. 1)[1]

	SID Val:Lys, %					
Item	59.0	62.5	66.0	69.5	73.0	75.5
Proximate analysis, %						
DM	86.8 (87.01)[2]	86.87 (87.01)	87.18 (87.02)	86.91 (87.02)	87.02 (87.03)	87.22 (87.03)
CP	14.6 (13.9)	14.2 (13.9)	14.4 (13.9)	14.2 (14.0)	14.3 (14.0)	14.5 (14.0)
Crude fiber	2.2 (3.1)	2.2 (3.1)	2.3 (3.1)	2.2 (3.1)	2.1 (3.1)	2.4 (3.1)
Ether extract	3.2 (4.5)	3.1 (4.5)	3.2 (4.5)	3.1 (4.5)	3.1 (4.5)	2.9 (4.5)
Ash	2.8 (2.5)	3.1 (2.5)	3.4 (2.5)	3.3 (2.5)	3.4 (2.5)	3.1 (2.5)
Amino acids, %						
Lys	0.97 (0.97)	0.98 (0.97)	1.03 (0.97)	0.94 (0.97)	0.94 (0.97)	0.96 (0.97)
Ile	0.55 (0.53)	0.53 (0.53)	0.57 (0.53)	0.52 (0.53)	0.52 (0.53)	0.54 (0.53)
Leu	1.38 (1.34)	1.38 (1.34)	1.44 (1.34)	1.32 (1.34)	1.34 (1.34)	1.40 (1.34)
Met	0.33 (0.36)	0.33 (0.36)	0.34 (0.36)	0.32 (0.36)	0.31 (0.36)	0.32 (0.36)
Met & cys	0.60 (0.60)	0.59 (0.60)	0.62 (0.60)	0.56 (0.60)	0.56 (0.60)	0.57 (0.60)
Thr	0.65 (0.66)	0.67 (0.66)	0.68 (0.66)	0.63 (0.66)	0.63 (0.66)	0.64 (0.66)
Trp	0.18 (0.20)	0.18 (0.20)	0.18 (0.20)	0.18 (0.20)	0.18 (0.20)	0.19 (0.20)
Val	0.65 (0.59)	0.64 (0.62)	0.69 (0.65)	0.66 (0.68)	0.69 (0.71)	0.73 (0.73)

[1] Diet samples were taken from six feeders per dietary treatment 3 d after the beginning of the trial and 3 d prior to the end of the trial and stored at -20°C, then CP and amino acid analysis was conducted on composite samples by Ajinomoto Heartland, Inc. (Chicago, IL). Samples of the diets were also submitted to Ward Laboratories, Inc. (Kearney, NE) for analysis of DM, crude fiber, Ca, P, ash and crude fat.
[2] Values in parentheses indicate those calculated from diet formulation and are based on values from NRC (2012), with the exception of CP and total amino acid content from corn, soybean meal, and dried distillers grains with solubles; which were analyzed prior to diet formulation by Ajinomoto Heartland, Inc.

Table 4. Chemical analysis of the diets (as-fed-basis; Exp. 2)[1]

	Standardized ileal digestible Val:Lys ratio, %						
Item	57.0	60.6	63.9	67.5	71.1	74.4	78.0
Proximate analysis, %							
DM	87.91	87.79	86.9	87.01	87.38	87.64	87.50
	(86.71)[2]	(86.71)	(86.71)	(86.71)	(86.71)	(86.71)	(86.73)
CP	13.8	13.8	14.5	13.8	13.8	13.9	13.9
	(13.6)	(13.7)	(13.7)	(13.7)	(13.7)	(13.7)	(13.7)
Crude fiber	2.7	3.1	3.0	3.0	3.1	3.1	3.1
	(3.1)	(3.1)	(3.1)	(3.1)	(3.1)	(3.1)	(3.1)
Fat	3.7	3.7	3.5	3.4	3.6	3.9	3.8
	(4.5)	(4.5)	(4.5)	(4.5)	(4.5)	(4.5)	(4.5)
Ash	3.6	3.8	3.5	3.9	3.8	3.4	4.0
	(2.4)	(2.4)	(2.4)	(2.4)	(2.4)	(2.4)	(2.4)
Amino acids, %							
Lys	0.97	0.95	0.98	1.01	1.05	1.03	0.98
	(0.96)	(0.96)	(0.96)	(0.96)	(0.96)	(0.96)	(0.96)
Ile	0.54	0.54	0.57	0.54	0.55	0.55	0.55
	(0.52)	(0.52)	(0.52)	(0.52)	(0.52)	(0.52)	(0.52)
Leu	1.34	1.37	1.38	1.34	1.30	1.35	1.33
	(1.31)	(1.31)	(1.31)	(1.31)	(1.31)	(1.31)	(1.31)
Met	0.32	0.30	0.33	0.32	0.33	0.32	0.33
	(0.35)	(0.35)	(0.35)	(0.35)	(0.35)	(0.35)	(0.35)
Met & cys	0.57	0.55	0.57	0.56	0.57	0.58	0.57
	(0.59)	(0.59)	(0.59)	(0.59)	(0.59)	(0.59)	(0.59)
Thr	0.69	0.64	0.67	0.63	0.66	0.67	0.69
	(0.66)	(0.66)	(0.66)	(0.66)	(0.66)	(0.66)	(0.66)
Trp	0.17	0.17	0.17	0.17	0.17	0.17	0.17
	(0.19)	(0.19)	(0.19)	(0.19)	(0.19)	(0.19)	(0.19)
Val	0.63	0.64	0.68	0.66	0.72	0.73	0.75
	(0.56)	(0.59)	(0.62)	(0.65)	(0.68)	(0.71)	(0.74)

[1] Diet samples were taken from six feeders per dietary treatment 3 d after the beginning of the trial and 3 d prior to the end of the trial and stored at -20°C, then CP and amino acid analysis was conducted on composite samples by Ajinomoto Heartland, Inc. (Chicago, IL). Samples of the diets were also submitted to Ward Laboratories, Inc. (Kearney, NE) for analysis of DM, crude fiber, Ca, P, ash and crude fat.

[2] Values in parentheses indicate those calculated from diet formulation and are based on values from NRC (2012), with the exception of CP and total amino acid content from corn, soybean meal, and dried distillers grains with solubles, which were analyzed prior to diet formulation by Ajinomoto Heartland, Inc.

Table 5. Effects of standardized ileal digestible (SID) Val:Lys ratio on the growth performance and economics of finishing pigs from 70 to 100 lb, Exp. 1[1,2]

	SID Val:Lys ratio, %							
Item	59.0	62.5	66.0	69.5	73.0	75.5	Linear	Quadratic
d 0 to 19								
ADG, lb	1.50 ± 0.04	1.58 ± 0.04	1.58 ± 0.04	1.57 ± 0.04	1.64 ± 0.04	1.60 ± 0.04	0.009	0.305
ADFI, lb	3.22 ± 0.11	3.39 ± 0.11	3.35 ± 0.08	3.31 ± 0.11	3.42 ± 0.08	3.40 ± 0.11	0.098	0.578
F/G	2.14 ± 0.04	2.14 ± 0.02	2.12 ± 0.02	2.11 ± 0.04	2.08 ± 0.04	2.12 ± 0.04	0.370	0.648
BW, lb								
d 0	68.9 ± 1.7	68.9 ± 1.7	68.7 ± 1.7	68.9 ± 1.7	68.8 ± 1.7	68.7 ± 1.7	0.762	0.962
d 21	97.5 ± 2.2	99.2 ± 2.4	98.7 ± 2.2	99.1 ± 2.4	100.0 ± 2.2	99.2 ± 2.4	0.064	0.349
SID Val intake, g/d	7.33 ± 0.28	8.17 ± 0.28	8.53 ± 0.22	8.87 ± 0.28	9.63 ± 0.22	9.89 ± 0.28	0.001	0.716
SID Val, g/kg gain	10.7 ± 0.23	11.3 ± 0.10	11.9 ± 0.10	12.3 ± 0.23	12.9 ± 0.23	13.6 ± 0.23	0.001	0.490
Economics, $								
Feed cost/pig	6.52 ± 0.23	7.03 ± 0.23	7.12 ± 0.18	7.21 ± 0.23	7.62 ± 0.18	7.69 ± 0.23	0.001	0.641
Feed cost/lb gain[3]	0.228 ± 0.004	0.234 ± 0.002	0.237 ± 0.002	0.242 ± 0.004	0.244 ± 0.004	0.253 ± 0.004	0.001	0.653
Total revenue/pig[4]	17.16 ± 0.43	18.05 ± 0.43	18.02 ± 0.43	17.94 ± 0.43	18.73 ± 0.43	18.25 ± 0.43	0.009	0.305
IOFC[5]	10.63 ± 0.29	11.02 ± 0.29	10.90 ± 0.29	10.74 ± 0.29	11.11 ± 0.29	10.56 ± 0.29	0.968	0.295

[1] A total of 1,134 gilts (PIC 337 × 1050, initially 68.8 lb BW) were used in a 19-d growth trial with 27 pigs per pen and seven pens per treatment.
[2] Corn was valued at $3.60/bu ($129/ton), DDGS at $180/ton, soybean-meal at $340/ton, and L-Valine at $7.00/lb.
[3] Feed cost/lb gain = total feed cost divided by total gain per pig. Cost per ton used was not considering processing costs.
[4] One pound of live gain was considered to be worth $0.60. Total revenue/pig = total gain/pig × $0.60.
[5] Income over feed cost = total revenue/pig – feed cost/pig.

Table 6. Effects of standardized ileal digestible (SID) Val:Lys ratio on the growth performance and economics of finishing pigs from 55 to 90 lb, Exp. 2[1,2]

	SID Val:Lys ratio, %								Probability, $P <$	
Item	57.0	60.6	63.9	67.5	71.1	74.4	78.0	SEM[3]	Linear	Quadratic
d 0 to 22										
ADG, lb	1.37	1.46	1.58	1.56	1.56	1.60	1.58	0.036	0.001	0.002
ADFI, lb	3.28	3.46	3.60	3.62	3.60	3.64	3.61	0.061	0.001	0.001
F/G	2.41	2.38	2.29	2.33	2.31	2.27	2.28	0.024	0.001	0.132
BW, lb										
d 0	56.0	55.9	56.2	56.1	56.1	56.1	55.9	1.21	0.989	0.584
d 21	86.2	87.9	90.9	90.5	90.5	91.4	90.8	1.71	0.001	0.010
SID Val intake, g/d	7.6	8.5	9.3	9.9	10.3	11.0	11.4	0.17	0.001	0.005
SID Val, g/kg gain	10.5	11.1	11.2	12.0	12.6	13.0	13.6	0.12	0.001	0.368
Economics[4], $										
Feed cost/pig	7.70	8.27	8.78	9.00	9.11	9.38	9.45	0.15	0.001	0.001
Feed cost/lb gain[5]	0.256	0.258	0.254	0.262	0.266	0.266	0.272	0.003	0.001	0.159
Total revenue/pig[6]	18.06	19.22	20.80	20.62	20.62	21.18	20.90	0.43	0.001	0.001
IOFC[7]	10.36	10.96	12.01	11.63	11.51	11.80	11.45	0.32	0.002	0.001

[1] A total of 2,100 gilts (PIC 327 × 1050, initially 56.0 lb BW) were used in a 22-d growth trial with 25 pigs per pen and 12 pens per treatment.
[2] The NRC (2012) model was used to determine the Lys requirement of gilts at the end of the BW range and that value was reduced by 0.10 percentage point.
[3] Represents the greatest SEM.
[4] Corn was valued at $3.60/bu ($129/ton), DDGS at $180/ton, soybean meal at $340/ton, and L-Valine at $7.00/lb.
[5] Feed cost/lb gain = total feed cost divided by total gain per pig. Cost per ton used was not considering processing costs.
[6] One pound of live gain was considered to be worth $0.60. Total revenue/pig = total gain/pig × $0.60.
[7] Income over feed cost = total revenue/pig – feed cost/pig.

Table 7. Standardized ileal digestible (SID) Val:Lys ratio at different target performance levels of growing pigs

	Percent of optimum performance, %					
Item	95%	96%	97%	98%	99%	100%
ADG						
QP[1]	63.1	64.3	65.7	67.3	69.3	74.4
F/G						
QP[2]	58.0	59.4	61.0	63.0	65.5	71.0
BLL[3]	<57.0	<57.0	59.2	61.4	63.8	66.0

[1] QP equation for ADG = −2.54 + 9.10 × (SID Val:Lys ratio) − 6.12 × (SID Val:Lys ratio)^2 + 0.012 × (initial BW), estimated to 60-lb pigs.
[2] QP equation for F/G = 5.64 − 9.68 × (SID Val:Lys ratio) + 6.81 × (SID Val:Lys ratio)^2
[3] BLL equation for F/G: if SID Val:Lys ratio < 66.0%, equation is 2.22 + 1.0 × (0.66 − Val:Lys ratio).

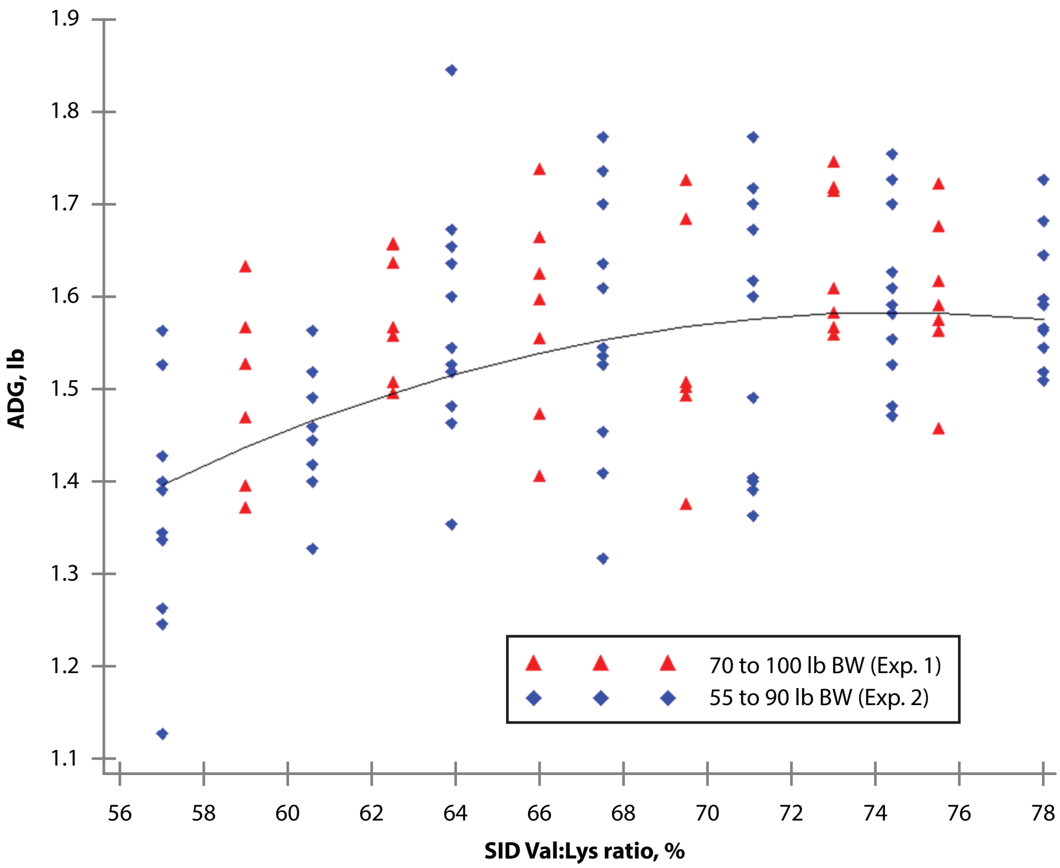

Figure 1. Fitted quadratic polynomial (QP) regression model with ADG as a function of increasing standardized ileal digestible (SID) Val:Lys ratio in 55 to 100 lb pigs. The maximum mean ADG was estimated at 74.4% (95% CI: [69.5, >78.0%]) SID Val:Lys ratio. Each point represents a pen of pigs.

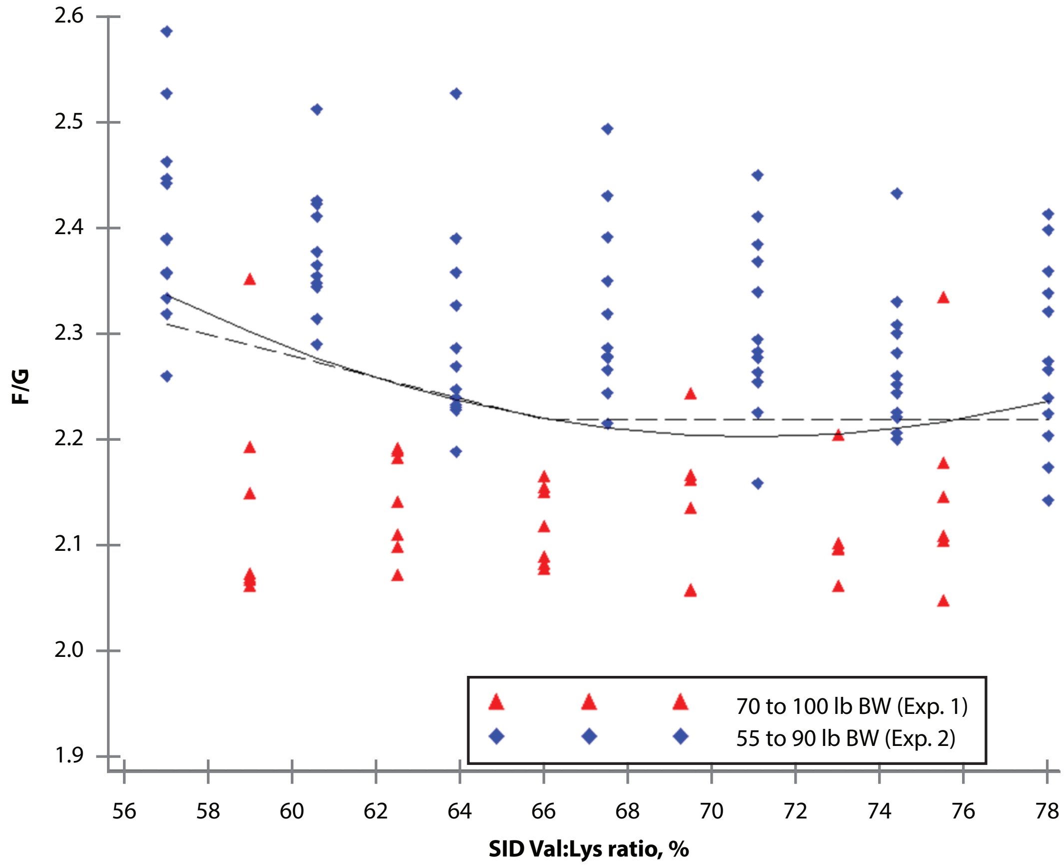

Figure 2. Fitted quadratic polynomial (QP; —) and broken-line linear ascending (BLL; ---) regression models with F/G as a function of increasing standardized ileal digestible (SID) Val:Lys ratio in 55 to 100 lb pigs. The minimum mean F/G was estimated at 71.0% (95% CI: [69.4, 73.5%]) and 66.0% (95% CI: [65.7, 66.4%]) SID Val:Lys ratio for the QP and BLL models, respectively. Each point represents a pen of pigs.

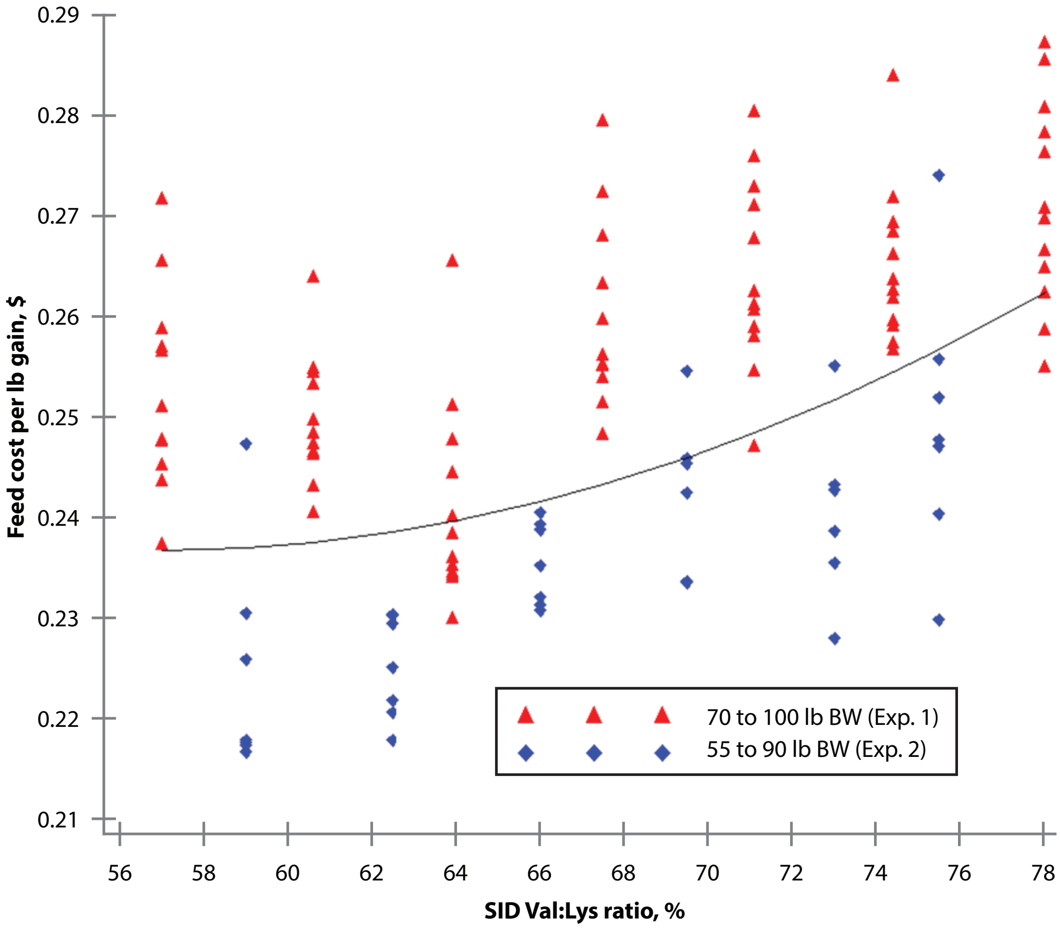

Figure 3. Fitted quadratic polynomial (QP) regression model with feed cost per lb of gain as a function of increasing standardized ileal digestible (SID) Val:Lys ratio in 55 to 100 lb pigs. The minimum mean feed cost per lb of gain was estimated at less than 57% SID Val:Lys ratio. Each point represents a pen of pigs.

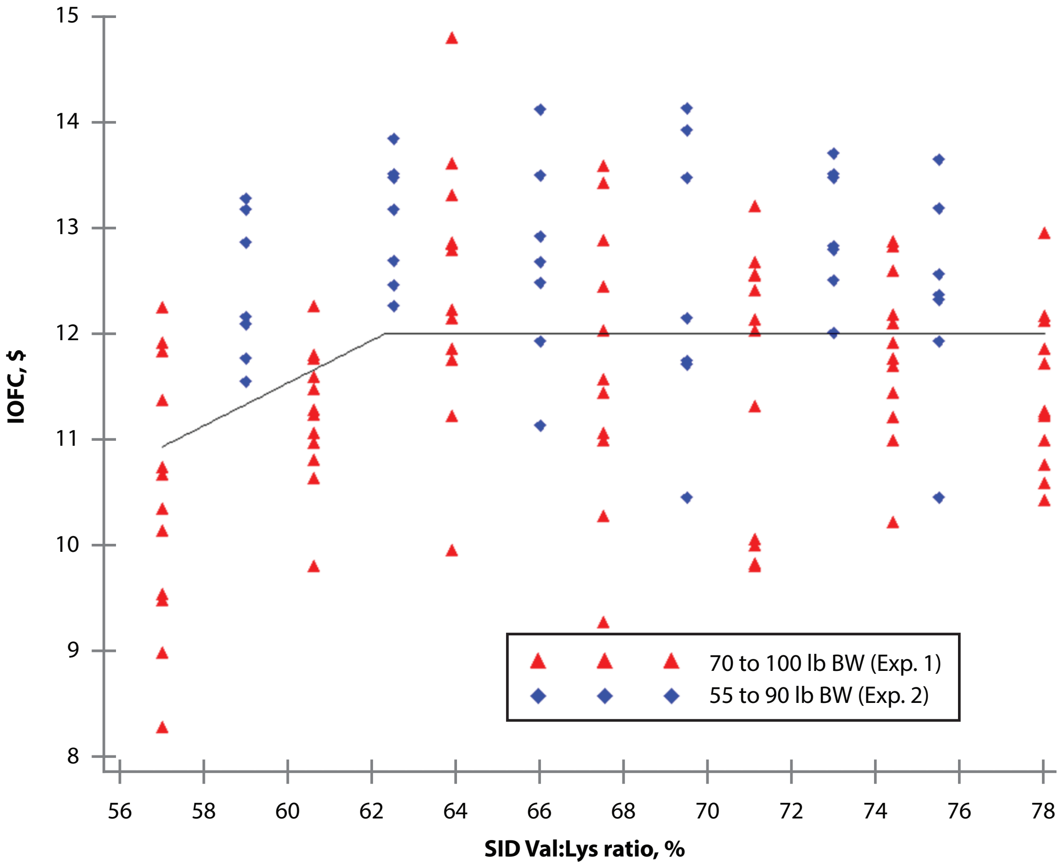

Figure 4. Fitted broken-line linear (BLL) regression model with income over feed cost (IOFC) as a function of increasing standardized ileal digestible (SID) Val:Lys ratio in 55 to 100 lb pigs. The maximum mean IOFC was estimated at 62.3% (95% CI: [58.5, 66.2]%) SID Val:Lys ratio. Each point represents a pen of pigs.