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Effects of Standardized Ileal Digestible Lysine Content in Low Crude Protein Diets on Finishing Pig Performance and Economics from 230 to 280 lb[1]

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Summary

The objective of this study was to estimate the nutritional requirement of standardized ileal digestible (SID) Lys on growth performance and economics of 230- to 280-lb finishing pigs housed in a commercial environment and fed diets not containing ractopamine HCl. A total of 1,101 gilts (PIC L327 × 1050, initially 233.4 lb BW) were used in a 28-d growth trial. Pens were blocked by BW and were randomly assigned to diets with 27 pigs per pen and 7 pens per treatment in a randomized complete block design. Diets were corn and soybean meal-based and fed in meal form, with dietary treatments consisting of: 0.52, 0.58, 0.64, 0.70, 0.76, or 0.82% SID lysine.

Increasing SID Lys increased (linear, $P < 0.05$) ADG and final BW, resulting in pigs fed 0.82% SID Lys having the greatest final BW. There was no difference in ADFI among pigs fed different SID Lys levels. Feed efficiency was improved (linear, $P < 0.05$) with increasing SID Lys. In addition, there was an improvement (linear, $P < 0.05$) in caloric efficiency on both a ME and NE basis with increasing SID Lys. Feed cost per pig increased (linear, $P < 0.05$) as SID lysine level increased. However, there was no difference in feed cost/lb gain. Total revenue per pig increased (linear, $P < 0.05$) while income over feed cost (IOFC) tended to increase (linear, $P < 0.07$) as SID lysine level increased.

Quadratic polynomial and broken-line linear models to maximize ADG resulted in similar fit and predicted the SID Lys level required to maximize ADG to be greater than 0.82 and at 0.685% SID Lys, QP vs. BLL, respectively. Using the QP model, 95% of the maximum growth was predicted to be at 0.675% SID Lys. The best F/G was achieved at greater than 0.82 and at 0.648% SID Lys for QP vs. BLL, respectively, with 95% of lowest F/G predicted at 0.638% SID Lys using the QP model. IOFC was maximized by the QP and BLL model at 0.754 and 0.640% SID Lys, respectively.

[1] Appreciation is expressed to New Horizon Farms (Pipestone, MN) for providing the animals and research facilities and to H. Houselog, M. Heintz, and C. Steck for technical assistance.

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In summary, the SID lysine requirement for optimal ADG, F/G, and IOFC of finishing pigs is at least 0.64% SID Lys.

Key words: amino acid, growth, lysine requirement, finishing pig

Introduction

Lysine is typically the first limiting amino acid in corn and soybean meal-based swine diets. Therefore, characterizing the requirement for optimum growth performance and efficiency is critical for diet formulation. Typically, the lysine requirement as a percentage of the diet decreases as pig body weight increases due to the increase in feed consumption as well as the decrease in lean tissue deposition rate compared to fat deposition. While the dietary percentage is expected to decrease, there are limited data reporting the lysine requirements at heavier market weights housed under commercial conditions. Additionally, the establishment of a pig's standard ileal digestible (SID) Lys requirement is essential because other essential amino acids are typically formulated as a percentage of SID Lys. Therefore, the objective of this study was to determine the SID Lys requirement of finishing gilts from 230 to 280 lb BW to optimize growth performance and economics.

Procedures

The Kansas State University Institutional Animal Care and Use Committee approved the protocol used in this experiment. The study was conducted at a commercial research-finishing site in southwest Minnesota. The barn was naturally ventilated and double-curtain-sided. Each pen (18 × 10 ft) was equipped with a 4-hole stainless steel feeder and cup waterer for ad libitum access to feed and water. Feed additions to each individual pen were made and recorded by a robotic feeding system (FeedPro; Feedlogic Corp., Wilmar, MN).

A total of 1,101 gilts (PIC L327 × 1050, initially 233.4 lb BW) were used in a 28-d growth trial. Pens were blocked by BW and were randomly assigned to diets with 27 pigs per pen and seven pens per treatment. Diets were corn and soybean meal-based and fed in meal form. Treatments consisted of diet formulated to achieve 0.52, 0.58, 0.64, 0.70, 0.76, or 0.82% SID Lys. To accomplish this treatment structure, two diets were prepared at a commercial feedmill (New Horizon Farms, Pipestone, MN); a high SID lysine diet (0.82% SID Lys); and a low SID Lys diet (0.52% SID Lys; Table 1). Intermediate SID Lys dietary treatments were created by blending the low and high SID Lys diets using the robotic feeding system. The percentage of low and high SID Lys blended to create the treatment diets were 100:0, 80:20, 60:40, 40:60, 20:80, and 0:100 to achieve 0.52, 0.58, 0.64, 0.70, 0.76, and 0.82% SID Lys, respectively.

Samples of the complete feed were taken from the feeder at the beginning and end of each phase, pooled, and proximate analysis conducted (Ward Laboratories, Inc., Kearney, NE) on each treatment diet (Table 2). Additionally, samples were submitted for amino acid analysis (Ajinomoto Heartland, Chicago, IL). Pens of pigs were weighed and feeder measurements were recorded on d 0, 14, and 28 to calculate ADG, ADFI, F/G, and caloric efficiency. On d 14, the three heaviest pigs in each pen were weighed and sold according to standard farm procedures. The remaining pigs were marketed at the conclusion of the trial on d 28. Carcass data were not available for this trial.

Caloric feed efficiencies were determined on both an ME and NE basis using values from the NRC (2012[3]). Efficiencies were calculated by multiplying total feed intake × energy content of the diet (kcal/lb) and dividing by total gain. Feed cost/pig, feed cost/lb gain, revenue per pig, and income over feed cost (IOFC) were calculated to determine economic implications. Diet costs were determined using the following ingredient costs (August 2015): corn = \$3.61/bushel (\$129/ton); soybean meal = \$340/ton; L-Lysine HCl = \$0.68/lb; DL-Methionine = \$2.60/lb; L-Threonine = \$1.50/lb; and L-Tryptophan = \$6.94/lb. Feed cost/pig was determined by total feed intake × diet cost (\$/lb). Feed cost/lb gain was calculated using feed cost/pig divided by total gain. Revenue per pig was determined by total gain × \$0.60/lb live gain, and income over feed cost (IOFC) was calculated using revenue/pig – feed cost/pig.

Data were analyzed as a randomized complete block design using PROC GLIMMIX in SAS (SAS Institute, Inc., Cary, NC) with pen as the experimental unit and block included in the model as a random effect. PROC GLIMMIX and PROC NLMIXED were used to predict the SID lysine dose response curves to optimize ADG, F/G, and IOFC. Dose response models evaluated were quadratic (QP), broken-line linear (BLL), and broken-line quadratic (BLQ) models. Best fit was determined using Bayesian Information Criterion (BIC), with a lower number being indicative of an improved fit. A decrease in BIC greater than 2.0 among models for a particular response criterion was considered an improved fit. Results were considered significant at $P \leq 0.05$ and a trend at $P \leq 0.10$.

Results and Discussion

Analysis of complete diets did not indicate any major deviations from formulated estimates (Table 2). Increasing SID Lys increased (linear, $P < 0.05$) in ADG and final BW, resulting in pigs fed 0.82% SID Lys having the greatest final BW (Table 3). There was no difference in ADFI among pigs fed the increasing SID Lys levels. Feed efficiency was improved (linear, $P < 0.05$) with increasing SID Lys. In addition, there was an improvement (linear, $P < 0.05$) in caloric efficiency on both a ME and NE basis with increasing SID Lys. Although linear, the greatest response in feed and caloric efficiency was when SID Lys was increased to 0.64% with little improvement thereafter. Feed cost/pig increased (linear, $P < 0.05$) as SID lysine increased. However, there was no difference in feed cost/lb gain among SID Lys levels. Total revenue/pig increased (linear, $P < 0.05$) while income over feed cost (IOFC) tended to increase (linear, $P < 0.07$) as SID lysine level increased.

The QP and BLL models had a similar and better fit than the BLQ for ADG, F/G, and IOFC (Figures 1 to 3). Quadratic models were used to predict the optimum level of SID Lys to maximize the given outcome based on the maximum value for the quadratic polynomial achieved by calculation of the point where the slope was equal to zero. Additionally, the quadratic polynomial function was used to determine the SID Lys level to achieve 95% of the maximum performance for each response criteria. Broken-line

[3] NRC. 2012. Nutrient Requirements of Swine, 11th ed. Natl. Acad. Press, Washington D.C.

linear models were used to predict the optimal level of SID Lys to optimize the given outcome based on the point at which increasing SID Lys no longer resulted in a linear increase in outcome and resulted in a plateau with no further improvement in response criteria. BLQ models were also fit; however, were not included due to poorer fit for all reported response criteria.

The QP and BLL models for ADG resulted in similar fit (BIC = 313.4 vs. 313.5, QP vs. BLL, respectively); with the QP model predicting maximum growth above 0.82% SID Lys, and BLL model predicting no further improvement in growth beyond 0.685% SID Lys. The QP model equation was: ADG = 0.4218 + 3.1845 × (% SID Lys) -1.7588 × $(\% \text{ SID Lys})^2$, with 95% of maximum growth estimated at 0.675% SID Lys. For maximization of F/G, the resulting QP and BLL models had a similar fit to the data (BIC = 340.2 vs. 339.6, QP vs. BLL, respectively), with the QP predicting lowest F/G beyond 0.82% SID Lys, and BLL model predicting no further improvement in F/G beyond 0.648% SID Lys. The QP model equation was: F/G = 5.9163 – 6.4606 × (% SID Lys) + 3.8125 × $(\% \text{ SID Lys})^2$, with 95% of lowest F/G estimated at 0.638% SID Lys. Economic implications of increasing SID Lys were calculated using IOFC to optimize profitability based on August 2015 ingredient prices. The QP and BLL models had a comparable fit (BIC = 155.2 vs. 153.7, QP vs. BLL, respectively), and predicted maximum IOFC to be 0.754% SID Lys using the QP model, and no further improvement in IOFC beyond the breakpoint of 0.640% SID Lys using the BLL model. The QP model equation was: IOFC = - 4.8871 + 38.2745 × (% SID Lys) - 25.3946 × $(\% \text{ SID Lys})^2$, with 95% of maximum IOFC estimated at 0.617% SID Lys.

In summary, for maximum growth, efficiency, and economic return, it is recommended that finishing swine should be fed diets containing no less than 0.64% SID Lys, with further improvement in select response criteria beyond 0.82% SID Lys.

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

	Formulated standardized ileal digestible (SID) Lys, %	
Item	0.52	0.82
Ingredient, %		
Corn	89.83	77.86
Soybean meal (46.5% CP)	7.20	19.27
Corn oil	0.50	0.50
Limestone	1.05	0.95
Monocalcium phosphate (21% P)	0.60	0.50
Salt	0.35	0.35
L-lysine HCl	0.23	0.23
DL-methionine	- - -	0.07
L-threonine	0.07	0.10
L-tryptophan	0.03	0.02
Phytase[2]	0.03	0.03
Trace mineral premix	0.06	0.06
Vitamin premix	0.06	0.06
Total	100	100
Calculated analysis[3]		
Standard ileal digestible (SID) amino acids, %		
Lys	0.52	0.82
Ile:lys	61	64
Leu:lys	168	142
Met:lys	29	34
Met & Cys:lys	60	60
Thr:lys	68	68
Trp:lys	20.1	20.1
Val:lys	73	70
Total lys, %	0.60	0.93
ME, kcal/lb	1,517	1,515
NE, kcal/lb	1,165	1,132
SID lys:ME, g/Mcal	1.56	2.46
SID lys:NE, g/Mcal	2.00	3.23
CP, %	10.0	14.9
Ca, %	0.55	0.53
P, %	0.41	0.45
Available P, %	0.31	0.30

[1] Treatment diets were fed to 1,101 gilts (PIC L327 × 1050, initially 233.4 lb BW) for 28 d. Diets were blended in the robotic feeding unit to achieve the 0.52, 0.58, 0.64, 0.70, 0.76, 0.82% SID Lys dietary treatments.
[2] Optiphos 2000 (Huvepharma, Sofia, Bulgaria) provided an estimated release of 0.13% available P.
[3] NRC. 2012. Nutrient Requirements of Swine, 11th ed. Natl. Acad. Press, Washington D.C.

Table 2. Chemical analysis of diets (as-fed basis)[1,2]

	Formulated standardized ileal digestible (SID) Lys, %[3]					
Item	0.52	0.58	0.64	0.70	0.76	0.82
Proximate analysis, %[4]						
DM	88.71	89.91	89.59	89.78	89.92	90.12
CP	11.4	12.8	15.4	14.3	14.9	17.7
Crude fiber	2.2	2.2	2.3	2.2	2.1	2.4
Ether extract	2.84	3.11	3.39	3.34	3.40	3.09
Ash	3.20	3.45	3.79	3.72	3.78	3.43
Amino acid analysis, %[5]						
Lys	0.61	0.72	0.78	0.82	0.82	0.89
Ile	0.37	0.43	0.46	0.50	0.51	0.57
Leu	1.01	1.09	1.15	1.20	1.22	1.29
Met	0.18	0.21	0.22	0.25	0.25	0.28
Met + Cys	0.37	0.42	0.43	0.48	0.48	0.53
Thr	0.42	0.50	0.51	0.59	0.65	0.65
Trp	0.11	0.13	0.13	0.15	0.16	0.18
Val	0.47	0.53	0.56	0.59	0.60	0.66
His	0.27	0.31	0.33	0.34	0.35	0.38
Phe	0.52	0.56	0.60	0.63	0.65	0.70

[1] A total of 1,101 gilts (PIC L327 × 1050, initially 233.4 lb BW) were used in a 28-d growth trial with 27 pigs per pen and seven pens per treatment.
[2] Diet samples were taken from 6 feeders per dietary treatment 3 d after the beginning of the trial and 3 d prior to the conclusion of the trial.
[3] Low (0.52% SID Lys) and high (0.82% SID Lys) diets were blended in the robotic feeding unit to achieve the 0.52, 0.58, 0.64, 0.70, 0.76, 0.82% SID Lys dietary treatments.
[4] Composite sample was submitted to Ward Laboratories (Kearney, NE) for proximate analysis.
[5] Composite sample was submitted to Ajinomoto Heartland Inc. (Chicago, IL) for amino acid analysis.

Table 3. Effects of standardized ileal digestible (SID) lysine content in low crude protein diets on growth performance and economics of finishing pigs from 230 to 280 lb[1]

	Formulated SID Lys, %[2]							Probability, $P <$	
Item	0.52	0.58	0.64	0.70	0.76	0.82	SEM	Linear	Quadratic
BW, lb									
d 0	233.3	233.2	233.3	233.3	233.4	233.6	2.53	0.635	0.771
d 28	275.5	276.5	279.7	281.8	279.5	282.3	2.45	0.004	0.400
d 0 to 28									
ADG, lb	1.60	1.67	1.76	1.82	1.75	1.89	0.050	0.001	0.456
ADFI, lb	5.72	5.79	5.71	5.98	5.76	5.89	0.108	0.264	0.790
F/G	3.60	3.48	3.25	3.29	3.29	3.13	0.070	0.001	0.223
Caloric efficiency[3,4]									
ME	5,465	5,279	4,925	4,985	4,982	4,740	106.2	0.001	0.222
NE	4,247	4,083	3,792	3,820	3,800	3,598	81.6	0.001	0.207
Economics, $[5]									
Feed cost/pig	18.80	19.49	19.69	21.12	20.80	21.76	0.371	0.001	0.818
Feed cost/lb gain[6]	0.423	0.419	0.400	0.415	0.424	0.413	0.0087	0.801	0.317
Total revenue/pig[7]	26.83	28.01	29.56	30.62	29.47	31.69	0.845	0.001	0.456
IOFC[8]	8.02	8.52	9.87	9.50	8.67	9.93	0.642	0.070	0.379

[1] A total of 1,101 gilts (PIC L327 × 1050, initially 233.4 lb BW) were used in a 28-d growth trial with 27 pigs per pen and seven pens per treatment.
[2] Low (0.52% SID Lys) and high (0.82% SID Lys) diets were blended in the robotic feeding unit to achieve the 0.52, 0.58, 0.64, 0.70, 0.76, 0.82% SID Lys dietary treatments.
[3] Caloric efficiency is expressed as kcal/lb of gain.
[4] NRC. 2012. Nutrient Requirements of Swine, 11th ed. Natl. Acad. Press, Washington D.C.
[5] Corn was valued at $3.61/bu ($129/ton), soybean meal at $340/ton, L-Lys at $0.68/lb, DL-Met at $2.60/lb, L-Thr at $1.50/lb, and L-Trp at $6.94/lb.
[6] Feed cost/lb gain = (feed cost/pig)/total gain.
[7] Total revenue/pig = total gain/pig × $0.60.
[8] Income over feed cost = total revenue/pig – feed cost/pig.

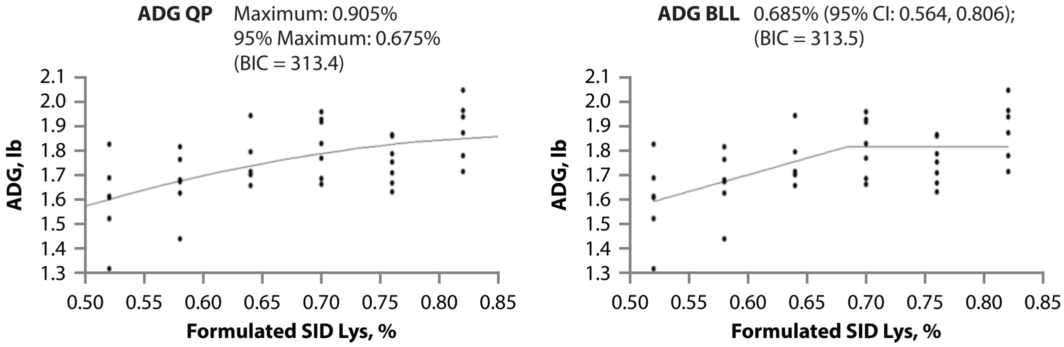

Figure 1. Estimation of standardized ileal digestible (SID) lysine requirement to maximize ADG for 230 to 280 lb finishing pigs

A total of 1,101 gilts (PIC L327 × 1050, initially 233.4 lb BW) were used in a 28-d growth trial with 27 pigs per pen and seven pens per treatment. Quadratic polynomial (QP), broken-line linear (BLL), and broken-line quadratic (BLQ) models were fit to estimate SID Lys level to maximize ADG, as well as SID Lys level to achieve 95% of maximum ADG using the QP model. BLQ models were not reported due to poorer fit than QP and BLL models. Bayesian Information Criterion (BIC) was used to determine which model best fits the data, with a lower number being indicative of an improved fit.

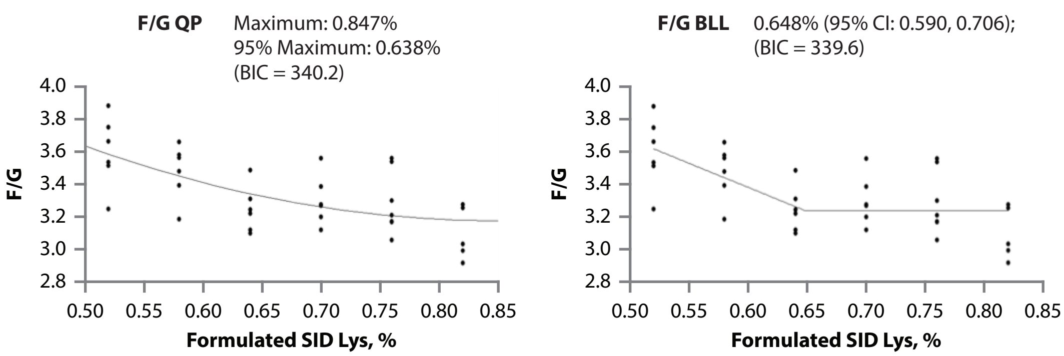

Figure 2. Estimation of standardized ileal digestible (SID) lysine requirement to maximize F/G for 230 to 280 lb finishing pigs

A total of 1,101 gilts (PIC L327 × 1050, initially 233.4 lb BW) were used in a 28-d growth trial with 27 pigs per pen and seven pens per treatment. Quadratic polynomial (QP), broken-line linear (BLL), and broken-line quadratic (BLQ) models were fit to estimate SID Lys level to maximize F/G, as well as SID Lys level to achieve 95% of maximum F/G using the QP model. BLQ models were not reported due to poorer fit than QP and BLL models. Bayesian Information Criterion (BIC) was used to determine which model best fits the data, with a lower number being indicative of an improved fit.

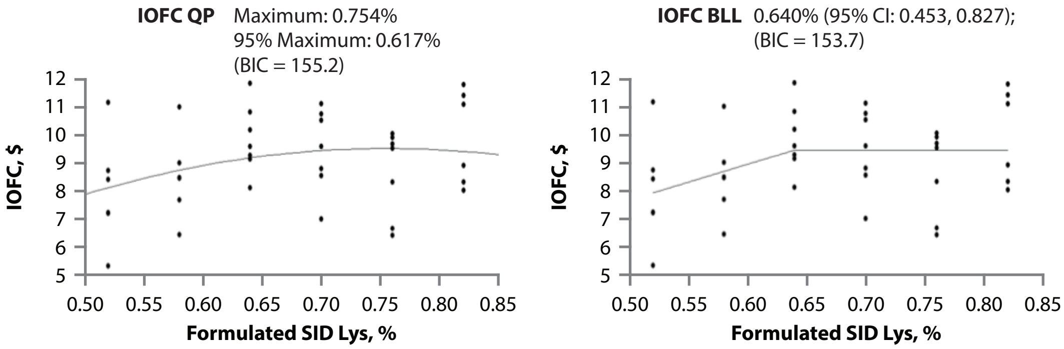

Figure 3. Estimation of SID lysine requirement to maximize IOFC for 230 to 280 lb finishing pigs

A total of 1,101 gilts (PIC L327 × 1050, initially 233.4 lb BW) were used in a 28-d growth trial with 27 pigs per pen and seven pens per treatment. Quadratic polynomial (QP), broken-line linear (BLL), and broken-line quadratic (BLQ) models were fit to estimate SID Lys level to maximize IOFC, as well as SID Lys level to achieve 95% of maximum IOFC using the QP model. BLQ models were not reported due to poorer fit than QP and BLL models. Bayesian Information Criterion (BIC) was used to determine which model best fits the data, with a lower number being indicative of an improved fit.