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Abstract

A total of 300 nursery pigs (PIC 327 × 1050, initially 14.8 lb BW) were used in a 28-d growth trial to evaluate the effects of increasing dietary standardized ileal digestible (SID) lysine (Lys) on nursery pig growth performance. Pigs were weaned at approximately 21 d of age and allotted to the pens according to BW and gender. A common starter diet was fed for 6 d, then pens were allotted to 1 of 6 dietary treatments in a completely randomized design. Experimental diets were fed for 14 d followed by a common diet for 14 d. The 6 dietary treatments were formulated to contain 1.10, 1.20, 1.30, 1.40, 1.50, and 1.60% SID Lys.

Increasing SID Lys resulted in improved (linear, $P < 0.001$) ADG and F/G during d 0 to 14 when experimental diets where fed, with no differences observed in ADFI. For ADG, broken line linear (BLL) and quadratic polynomial (QP) models demonstrated similar fits, with maximum ADG at 1.45% and above 1.60% for BLL and QP models, respectively. Similar estimates were found when modeling feed efficiency. In conclusion, this experiment determined that the SID Lys requirement for 15 to 24 lb nursery pigs was at least 1.45% SID Lys for both ADG and feed efficiency.

Keywords

lysine, growth, nursery pigs, swine

Authors

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K-STATE Research and Extension

Swine Day 2016

Effects of Increasing Dietary Standardized Ileal Digestible Lysine on 15 to 24 lb Nursery Pigs[1]

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Summary

A total of 300 nursery pigs (PIC 327 × 1050, initially 14.8 lb BW) were used in a 28-d growth trial to evaluate the effects of increasing dietary standardized ileal digestible (SID) lysine (Lys) on nursery pig growth performance. Pigs were weaned at approximately 21 d of age and allotted to the pens according to BW and gender. A common starter diet was fed for 6 d, then pens were allotted to 1 of 6 dietary treatments in a completely randomized design. Experimental diets were fed for 14 d followed by a common diet for 14 d. The 6 dietary treatments were formulated to contain 1.10, 1.20, 1.30, 1.40, 1.50, and 1.60% SID Lys.

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In conclusion, this experiment determined that the SID Lys requirement for 15 to 24 lb nursery pigs was at least 1.45% SID Lys for both ADG and feed efficiency.

Key words: lysine, growth, nursery pigs, swine

Introduction

Lysine is typically the first limiting amino acid in corn and soybean meal-based swine diets. Therefore, it is critical to establish the Lys requirement at each growth phase in order to allow the pig maximum growth potential and keep diets economical. Increasing crystalline amino acid usage to replace specialty protein sources and current statistical modeling capabilities has created a need for more research in amino acid requirements. Typically, essential amino acids are formulated in ratio to Lys. Thus, the Lys require-

[1] Appreciation is expressed to Ajinomoto Heartland, Inc., Chicago, IL, for partial financial support.
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[3] Ajinomoto Heartland, Inc. (Chicago, IL).

ment must first be established to properly investigate next-limiting amino acid ratios. Therefore, the objective of this study was to determine the standardized ileal digestible (SID) Lys requirement for nursery pigs weighing approximately 15 to 25 lb.

Procedures

The Kansas State University Institutional Animal Care and Use Committee approved the protocol used in this experiment. The trial was conducted at the Kansas State University Swine Teaching and Research Center in Manhattan, KS. All diets were manufactured at the Kansas State University O.H. Kruse Feed Technology Innovation Center, Manhattan, KS.

A total of 300 nursery pigs (PIC 327 × 1050) were used in the 28-d experiment. There were 10 replicate pens per treatment and 5 pigs per pen. Pigs were weaned at approximately 21 d of age (14.8 lb BW) and allotted to pens according to BW and gender. A common starter diet was fed for 6 d post-weaning. On d 6, pens were allotted to 1 of 6 dietary treatments in a completely randomized design. The six dietary treatments were formulated to contain 1.10, 1.20, 1.30, 1.40, 1.50, and 1.60% SID Lys and fed for 14 d followed by a common diet for 14 d. Both phases were fed in meal form. Diets were corn and soybean meal-based and contained 10% dried whey, with crystalline amino acids replacing corn. Extreme diets (1.10 and 1.60% SID Lys, Table 1) were manufactured first, then blended to create the intermediate treatments.

Pigs were weighed and feed disappearance was measured on d 0, 7, 14, 21, and 28. Each pen (5 × 5 ft) contained a 4-hole, dry, self-feeder and a nipple waterer to provide ad libitum access to feed and water. Samples of treatment diets were collected upon manufacturing at the feed mill and proximate analysis (Ward Laboratories, Inc., Kearney, NE) was conducted on composite samples. Additionally, experimental diet samples were submitted for amino acid analysis (Ajinomoto Heartland, Chicago, IL).

A base model where data were analyzed as a completely randomized design using PROC GLIMMIX in SAS (SAS Institute, Inc., Cary, NC) with pen as the experimental unit was initially evaluated. Results were considered significant at $P \leq 0.05$. The effect of SID Lys dose response on ADG and feed efficiency (modeled as gain to feed ratio; G:F) during the experimental period (d 0 to 14) were fit using PROC GLIMMIX and PROC NLMIXED according to procedures of Gonçalves et al. (2016).[4] Feed intake was not modeled, as there was no evidence of linear or quadratic effect of treatment. Dose response models evaluated were quadratic polynomial (QP), broken-line linear (BLL), and broken-line quadratic (BLQ) models. Heterogeneous variance was applied where appropriate. The Bayesian Information Criterion (BIC) was used to determine best fit, with a lower number indicating an improved fit. A decrease in BIC greater than 2 among models for a particular response criterion was considered a significant improvement in fit. Two outlier pens were removed from the data set, as they were greater than 2 standard deviations from the means.

[4] Gonçalves, M., N. Bello, S. Dritz, M. Tokach, J. DeRouchey, J. Woodworth, and R. Goodband. 2016. An update on modeling dose–response relationships: Accounting for correlated data structure and heterogeneous error variance in linear and nonlinear mixed models. Journal of Animal Science. 94(5): 1940-1950.

Results and Discussion

Diet analysis matched formulated values (Table 2). Amino acids showed a step-wise increase in total Lys level as treatments increased in formulated SID Lys value.

During the experimental period (d 0 to 14), ADG and F/G improved (linear, $P < 0.001$) as SID Lys increased, with no observed differences in ADFI (Table 3). There were no significant differences in ADG, ADFI, or F/G during the common period (d 14 to 28). During the overall period (d 0 to 28), ADG and F/G linearly improved ($P < 0.001$) as SID Lys increased. Similarly, BW was improved in a linear manner ($P < 0.001$) with increasing SID Lys on d 14 and 28.

Homogeneous variance was used for ADG models and heterogeneous variance was used for feed efficiency models. For ADG (Figure 1), the best fitting models were BLL and QP (BIC: 305.8 and 306.8, respectively). For the BLL, maximum ADG was achieved with a minimum of 1.45% SID Lys (95% CI: [1.31, 1.58%]). The QP [-0.403606 + 1.2932 × (SID Lys) – 0.3721 × (SID Lys)^2] resulted in a maximum ADG above 1.60% SID Lys and 95% of maximum performance was achieved with 1.43% SID Lys. Feed efficiency (Figure 2), modeled as G:F, also had similar fitting models for the BLL and QP (BIC: 627.7 and 629.6, respectively). For the BLL, maximum G:F was achieved with a minimum of 1.45% SID Lys (95% CI: [1.35, 1.54%]). The QP [-0.3041 + 1.2081×(SID Lys) – 0.3485 × (SID Lys)^2] reported maximum G:F above 1.60% SID Lys and 95% of maximum performance was achieved with 1.41% SID Lys.

In conclusion, this experiment demonstrated that the Lys requirement for 15 to 25 lb nursery pigs was 1.45% SID Lys as reported by BLL models for both ADG and feed efficiency. Using QP models, the maximum was above 1.60%, with 95% of maximum performance achieved with 1.43% and 1.41% SID Lys, for ADG, and QP, respectively. Therefore, formulating nursery diets for pigs of this weight range to 1.45% SID Lys would allow for maximum growth responses in ADG and feed efficiency. This experiment was the first step in establishing a Lys requirement for subsequent trials evaluating other essential amino acids.

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

	Formulated SID Lys, %		
Item	1.10	1.60	Common phase
Ingredient, %			
Corn	59.06	48.15	63.77
Soybean meal (48% CP)	26.89	27.05	32.86
Dried whey	10.00	10.00	--
Limestone	1.00	1.00	0.98
Monocalcium phosphate (22% P)	1.60	1.50	1.10
Sodium chloride	0.30	0.30	0.35
L-Lys-HCl	0.25	0.55	0.3
DL-Met	0.13	0.33	0.12
L-Thr	0.10	0.26	0.12
L-Trp	0.02	0.06	--
L-Val	0.01	0.15	--
Trace mineral premix	0.15	0.15	0.15
Vitamin premix	0.25	0.25	0.25
Zinc oxide	0.25	0.25	--
HP 300[2]	0.00	10.00	--
Total	100.00	100.00	100.00
Calculated analysis[3]			
Standardized ileal digestible (SID) amino acids, %			
Lys	1.10	1.60	1.22
Ile:Lys	64	57	63
Leu:Lys	133	109	129
Met:Lys	35	40	33
Met and Cys:Lys	60	59	57
Thr:Lys	65	65	63
Trp:lys	20.4	20.3	18.7
Val:Lys	70	70	69
Total Lys, %	1.23	1.77	1.37
ME, kcal/lb	1,477	1,498	1,484
NE, kcal/lb	1,101	1,092	1,092
SID Lys:ME, g/Mcal	3.38	4.84	3.73
SID Lys:NE, g/Mcal	4.57	7.44	5.16
CP, %	19.3	24.7	21.4
Ca, %	0.82	0.83	0.70
P, %	0.76	0.79	0.64
Available P, %	0.48	0.48	0.41

[1] Treatments 1.10% and 1.60% SID Lys were manufactured and blended at the feed mill to create the intermediate levels of 1.20%, 1.30%, 1.40%, and 1.50% SID Lys.
[2] Hamlet Protein, Findley, OH.
[3] NRC. 2012. Nutrient Requirements of Swine, 11th ed. Natl. Acad. Press, Washington DC.

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

	Formulated standardized ileal digestible (SID) Lys, %[2]					
Item	1.10	1.20	1.30	1.40	1.50	1.60
Proximate analysis, %[3]						
DM	88.77	88.24	88.81	87.35	89.18	89.22
CP	20.6	20.9	21.6	23.0	23.4	24.4
Crude fiber	1.8	1.7	2.1	1.9	1.9	2.2
Ether extract	2.5	2.2	2.4	2.4	2.3	2.4
Ash	5.05	5.58	5.31	5.60	5.81	5.52
Amino acid analysis, %[4]						
Lys	1.26	1.38	1.42	1.52	1.60	1.75
Ile	0.83	0.86	0.91	0.94	0.96	1.02
Leu	1.76	1.76	1.83	1.88	1.93	1.98
Met	0.40	0.47	0.48	0.51	0.54	0.65
Met + Cys	0.75	0.81	0.84	0.88	0.92	1.04
Thr	0.80	0.85	0.92	1.00	1.02	1.12
Trp	0.25	0.26	0.28	0.30	0.32	0.35
Val	0.91	0.95	1.03	1.08	1.12	1.22
His	0.49	0.52	0.52	0.56	0.58	0.60
Phe	0.95	0.98	1.03	1.06	1.11	1.15

[1] Diet samples were collected at the feed mill after manufacturing.
[2] Low (1.10% SID Lys) and high (1.60% SID Lys) diets were blended at the feed mill to create the intermediate treatments.
[3] Composite samples were submitted to Ward Laboratories (Kearney, NE) for proximate analysis.
[4] Composite samples were submitted to Ajinomoto Heartland Inc. (Chicago, IL) for amino acid analysis.

Table 3. Effects of standardized ileal digestible (SID) Lys on nursery pig growth performance[1, 2]

	Formulated standardized ileal digestible (SID) Lys, %[3]							Probability, $P <$	
Item	1.10	1.20	1.30	1.40	1.50	1.60	SEM	Linear	Quadratic
Phase 1 (d 0 to 14)									
ADG, lb	0.58	0.58	0.66	0.69	0.70	0.71	0.022	0.001	0.278
ADFI, lb	0.95	0.92	0.98	0.97	0.97	0.97	0.032	0.336	0.835
F/G	1.64	1.60	1.50	1.40	1.39	1.38	0.040	0.001	0.136
Phase 2 (d 14 to 28)									
ADG, lb	1.24	1.25	1.28	1.22	1.27	1.28	0.029	0.391	0.652
ADFI, lb	1.95	1.96	2.02	1.93	2.00	2.04	0.040	0.154	0.558
F/G	1.57	1.57	1.58	1.58	1.57	1.59	0.023	0.540	0.966
Overall (d 0 to 28)									
ADG, lb	0.91	0.92	0.97	0.96	0.99	0.99	0.022	0.001	0.797
ADFI, lb	1.45	1.44	1.50	1.45	1.49	1.51	0.033	0.180	0.799
F/G	1.59	1.61	1.55	1.52	1.51	1.52	0.021	0.001	0.336
BW, lb									
d 0	14.8	14.8	14.9	14.8	14.8	14.8	0.133	0.952	0.721
d 14	23.0	22.8	24.1	24.5	24.6	24.7	0.338	0.001	0.263
d 28	40.4	40.4	42.0	41.6	42.5	42.7	0.633	0.001	0.758

[1] A total of 300 nursery pigs (PIC 327 × 1050, initially 14.8 lb BW) were used in a 28-d growth trial with 5 pigs per pen and 10 pens per treatment. Pigs were weaned at approximately 21 d, fed a common starter diet for 6 d post-weaning, then placed on experimental diets.

[2] Experimental diets were fed from d 0 to 14 and a common diet was fed from d 14 to 28.

[3] Low (1.10% SID Lys) and high (1.60% SID Lys) diets were blended upon manufacturing at the feed mill to create the 1.20, 1.30, 1.40, and 1.50% SID Lys dietary treatments.

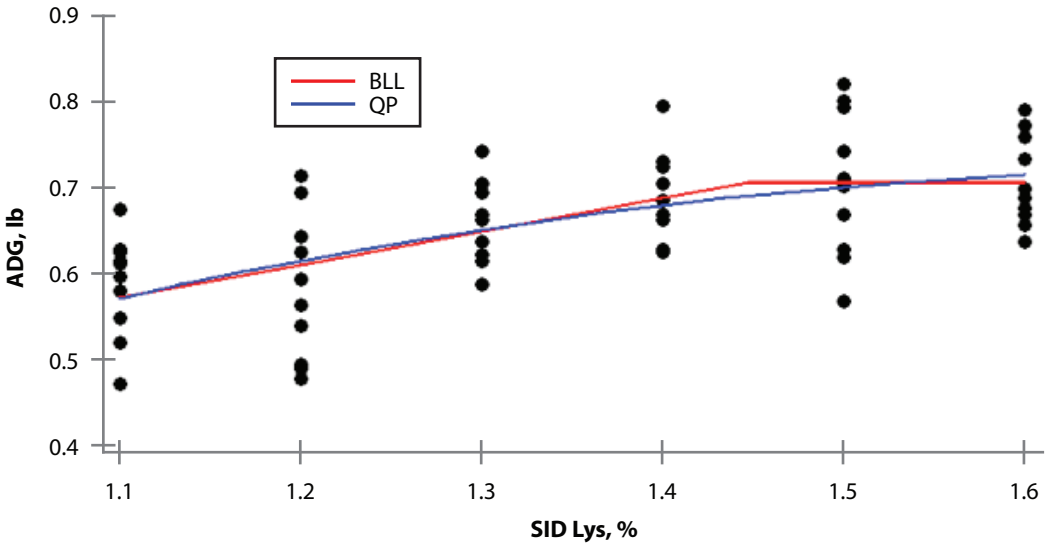

Figure 1. The standardized ileal digestible (SID) Lys dose response curve for ADG in nursery pigs.

ADG **BLL** 1.45% (95% CI: 1.31, 1.58)
(BIC =305.8)
QP Maximum: >1.60%
95% Maximum: 1.43%
$[-0.403606 + 1.2932\times(\text{SID Lys}) - 0.3721\times(\text{SID Lys})^2]$
(BIC = 306.8)

A total of 300 nursery pigs (PIC 327 × 1050, initially 14.8 lb BW) were used in a 28-d growth trial with 5 pigs per pen and 10 pens per treatment. Pigs were weaned at approximately 21 d, fed a common starter diet for 6 d post-weaning, then placed on experimental diets. Quadratic polynomial (QP), broken-line linear (BLL), and broken-line quadratic (BLQ) models were fit to characterize the SID Lys dose response curve. The BLL and QP models were the best fitting models based on Bayesian Information Criterion (BIC).

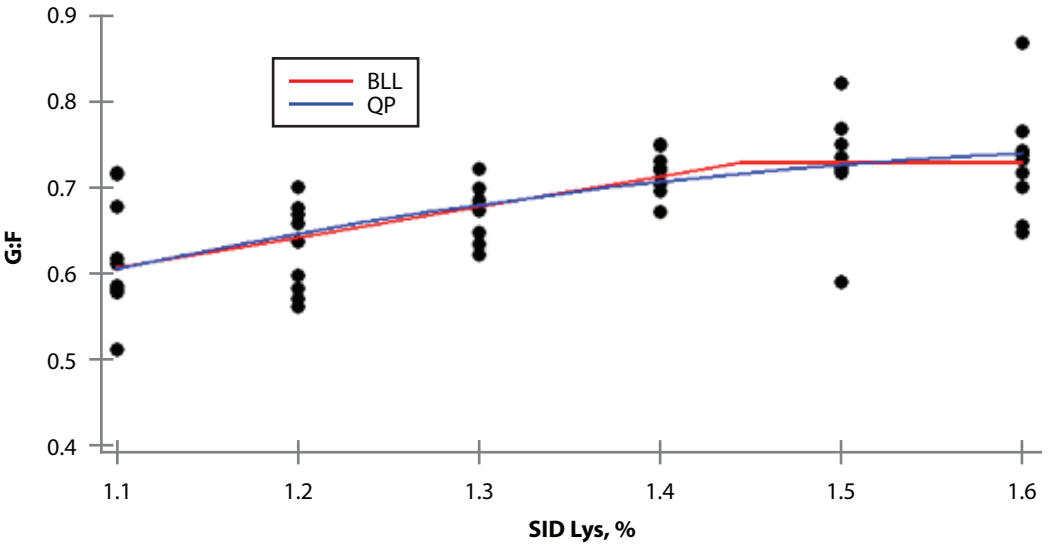

Figure 2. The standardized ileal digestible (SID) Lys dose response curve for feed efficiency (G:F) in nursery pigs.

G:F **QP** Maximum: >1.60%
95% Maximum: 1.41%
$[-0.3041 + 1.2081\times(\text{SID Lys}) - 0.3485\times(\text{SID Lys})^2]$
(BIC = 629.6)
BLL 1.45% (95% CI: 1.35, 1.54)
(BIC = 627.7)

A total of 300 nursery pigs (PIC 327 × 1050, initially 14.8 lb BW) were used in a 28-d growth trial with 5 pigs per pen and 10 pens per treatment. Pigs were weaned at approximately 21 d, fed a common starter diet for 6 d post-weaning, then placed on experimental diets. Quadratic polynomial (QP), broken-line linear (BLL), and broken-line quadratic (BLQ) models were fit to characterize the SID Lys dose response curve. The BLL and QP models were the best fitting models based on Bayesian Information Criterion (BIC).