Kansas Agricultural Experiment Station Research Reports

Volume 7
Issue 11 *Swine Day*

Article 33

2021

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Rafe Q. Royall
Kansas State University, rroyall@ksu.edu

Robert D. Goodband
Kansas State University, goodband@ksu.edu

Mike D. Tokach
Kansas State University, mtokach@k-state.edu

See next page for additional authors

Recommended Citation

Royall, Rafe Q.; Goodband, Robert D.; Tokach, Mike D.; DeRouchey, Joel M.; Gebhardt, Jordan T.; and Woodworth, Jason C. (2021) "Effects of Standardized Ileal Digestible Lysine Level on Growth Performance of 80 to 120 lb DNA Grow-Finish Pigs," *Kansas Agricultural Experiment Station Research Reports*: Vol. 7: Iss. 11. https://doi.org/10.4148/2378-5977.8197

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Summary

The objective of this study was to estimate the SID Lys requirement for growth and feed efficiency of 80- to 120-lb DNA grow-finish pigs. A total of 608 barrows and gilts (600 × 241, DNA; initially 80.2 ± 2.0 lb) were used in two separate studies lasting 14 and 21 d, respectively. Pens of pigs were blocked by BW and randomly allotted to 1 of 6 dietary treatments with 7 to 9 pigs per pen and 12 replications per treatment in a randomized complete block design. Similar number of barrows and gilts were placed in each pen. Dietary treatments were corn-soybean meal-based and formulated to 0.80, 0.88, 0.96, 1.04, 1.12, and 1.20% SID Lys. Increasing SID Lys increased (linear, $P = 0.036$) the average daily gain (ADG), resulting in pigs fed 1.20% SID Lys having the greatest final body weight. The F/G improved, while lysine intake/d, and lysine intake/kg of gain increased (linear, $P < 0.001$) with increasing SID Lys. Feed cost per pig and feed cost/lb gain increased (linear, $P < 0.005$) with increasing SID Lys. Total revenue per pig tended to increase (linear, $P = 0.060$) with increasing SID Lys. At low ingredient and pig prices, income over feed cost (IOFC) tended to decrease (linear, $P = 0.099$) as SID Lys increased. At high ingredient prices, there were no differences in IOFC among dietary treatments. In summary, these results suggest that for 80- to 120-lb DNA growing-finishing pigs, the response to SID lysine was linear to at least 1.20% of the diet. However, based on current ingredient prices, the improved growth performance observed with increasing SID Lys did not offset the added diet costs, suggesting growth performance must be compared with IOFC when deciding optimal levels.

Introduction

As the swine industry continues to advance the genetics of modern pigs, we continue to see improvements in growth performance and protein accretion, potentially altering established dietary nutrient requirements.[2] As a result, it is critical to have an accurate estimation of nutrient requirements in order to optimize diet formulation and growth performance. In addition, it is vitally important to establish a pig's SID Lys requirement, as other essential AAs are generally formulated as a percentage of SID

[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.

Lys.[3] Therefore, the objective of this study was to determine the SID Lys requirement of DNA 600 × 241 pigs from 80- to 120-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 608 pigs (600 × 241, DNA; initially 80.2 ± 2.0 lb) were used in two separate studies lasting 14 and 21 d, respectively. There were 7 to 9 mixed gender pigs per pen at a floor space of 7.83 ft^2 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. 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 (0.80, 0.88, 0.96, 1.04, 1.12 and 1.20%), with 12 replications per 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 0.80% SID Lys was formulated containing 0.28% L-Lys HCl and other feed-grade AAs as necessary to maintain ratios relative to Lys. Then, a 1.20% SID Lys corn-soybean meal diet was formulated containing 0.33% L-Lys HCl and other feed-grade AAs as necessary to maintain ratios relative to Lys. Ratios of other AAs to Lys were maintained well above requirement estimates to ensure that Lys was the first-limiting AAs. The 0.80 and 1.20% SID Lys diets were blended via a robotic feeding system to create the 0.88, 0.96, 1.04, and 1.12% SID Lys diets (Table 1). Pigs were weighed and feed disappearance was recorded on d 0, 7, 14 (both studies), and 21 (study 2 only) to determine ADG, ADFI, and F/G.

Economic analysis

For the economic analysis, feed cost/pig, feed cost/lb gain, revenue per pig, and income over feed cost (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; DL-methionine = $2.500/lb; L-threonine = $1.200/lb; L-tryptophan = $5.000/lb; and L-valine = $4.000/lb. Diet costs were determined using the following ingredient costs for the low-priced diets: corn = $3.00/bushel ($100/ton); soybean meal = $300/ton; L-Lys HCl = $0.650/lb; DL-methionine = $1.700/lb; L-threonine = $0.850/lb; L-tryptophan = $3.000/lb; and L-valine = $2.500/lb. Feed cost/pig was determined by total

[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 Research Reports*: Vol. 1: Iss. 7. https://doi.org/10.4148/2378-5977.1114.

feed intake × 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 × $0.66/lb live gain, or total gain × $0.45/lb live gain, respectively. Income over feed cost (IOFC) 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, initial BW as blocking factor, and treatment as fixed effect. Our objective was to evaluate dose response curves for ADG, F/G, and IOFC at high and low prices, using various linear, quadratic polynomial, and broken-line models. However, due to linear instead of quadratic response being observed for each response criteria, the initial models predicted the maximum response to be outside the range of the tested Lys levels. As a result, these models were not considered. 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, $P = 0.036$) ADG, resulting in pigs fed 1.20% SID Lys having the highest growth rate (Table 2). Feed efficiency improved, while Lys intake/d, and Lys intake/kg of gain increased (linear, $P < 0.001$) with increasing SID Lys. Feed cost/pig and feed cost/lb gain increased (linear, $P < 0.005$) as SID Lys increased at both high and low ingredient prices. At high and low live pig prices, total revenue/pig tended to increase (linear, $P = 0.060$) as SID Lys increased. At low ingredient and pig prices, IOFC tended to decrease (linear, $P = 0.099$) as SID Lys increased, with pigs being fed the 0.88 or 0.96% SID Lys treatments having the highest numeric IOFC. At high ingredient and pig prices, we did not find a statistical difference for IOFC. However, the pigs fed the 0.88% SID lysine treatment had the highest IOFC.

These results suggest that for 80- to 120-lb DNA grow-finish pigs, there was a linear improvement in performance to increasing SID lysine, to at least 1.20% of the diet. However, with current ingredient and pig prices, this improvement in growth performance did not offset the additional feed cost. As a result, maximum growth performance should be compared with economic return to define the optimal dietary SID Lys level.

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

	SID Lys, %					
Item	**0.80**	**0.88**	**0.96**	**1.04**	**1.12**	**1.20**
Ingredient, %						
Corn	78.62	75.85	73.07	70.30	67.52	64.75
Soybean meal	16.62	19.52	22.43	25.33	28.23	31.13
Corn oil	1.65	1.52	1.39	1.26	1.13	1.00
Limestone	1.00	1.00	0.99	0.99	0.98	0.98
Monocalcium P, 21% P	0.90	0.86	0.82	0.78	0.74	0.70
Sodium chloride	0.50	0.50	0.50	0.50	0.50	0.50
L-Lys-HCl	0.28	0.29	0.30	0.31	0.32	0.33
DL-Met	0.03	0.05	0.07	0.09	0.11	0.13
L-Thr	0.08	0.08	0.09	0.10	0.11	0.12
L-Trp	0.02	0.01	0.01	0.01	0.01	0.01
L-Val	0.01	0.02	0.03	0.04	0.05	0.06
Vitamin premix	0.15	0.15	0.15	0.15	0.15	0.15
Trace mineral premix	0.15	0.15	0.15	0.15	0.15	0.15
Total	100	100	100	100	100	100
Calculated analysis[3]						
SID AA, %						
Lys, %	0.80	0.88	0.96	1.04	1.12	1.20
Ile:Lys	62	62	62	62	62	62
Leu:Lys	148	144	140	136	132	128
Met:Lys	31	31	32	33	34	34
Met and Cys:Lys	58	58	58	58	58	58
Thr:Lys	63	63	63	63	63	63
Trp:Lys	19	19	19	19	19	19
Val:Lys	72	72	72	72	72	72
His:Lys	44	43	42	42	41	41
ME, kcal/lb	1,528	1,525	1,522	1,519	1,516	1,512
NE, kcal/lb	1,224	1,224	1,224	1,224	1,224	1,224
SID Lys:NE, g/Mcal	2.96	3.26	3.56	3.85	4.15	4.45
CP, %	14.8	16.0	17.1	18.3	19.5	20.7
Ca, %	0.67	0.67	0.67	0.67	0.67	0.67
Available P, %	0.37	0.37	0.36	0.36	0.35	0.35
STTD P, %	0.40	0.40	0.40	0.40	0.40	0.40

[1]Treatment diets were fed to 608 pigs (600 × 241, DNA; initially 80.2 ± 2.0 lb).
[2]Treatment diets were fed from d 0 to 21.
[3] National 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 of DNA finishing pigs weighing 80-120 lb[1]

	SID Lys, %							*P* =	
Item	0.80	0.88	0.96	1.04	1.12	1.20	SEM	Linear	Quadratic
BW, lb									
Initial	80.1	80.3	80.1	80.2	80.3	79.9	2.00	0.826	0.634
Final	118.8	119.1	119.6	119.6	119.5	120.0	2.06	0.316	0.806
ADG, lb	2.18	2.19	2.23	2.24	2.23	2.28	0.042	0.036	0.952
ADFI, lb	4.46	4.32	4.36	4.43	4.30	4.37	0.071	0.308	0.399
F/G	2.06	1.98	1.96	1.98	1.93	1.92	0.043	<0.001	0.356
SID Lys g/d	16.2	17.2	19.0	20.9	21.8	23.8	0.34	<0.001	0.505
SID Lys g/kg gain	16.2	17.2	18.6	20.7	21.7	22.9	0.62	<0.001	0.963
Economic, $									
High ingredient prices[2]									
Feed cost/pig	11.03	10.92	11.27	11.56	11.67	11.99	0.646	<0.001	0.357
Feed cost/lb gain[3]	0.290	0.286	0.291	0.297	0.297	0.289	0.0064	0.002	0.424
Total revenue/pig[4]	25.52	25.67	26.04	26.05	26.15	26.47	1.858	0.060	0.949
IOFC[5]	14.49	14.74	14.77	14.50	14.48	14.48	1.235	0.662	0.622
Low ingredient prices[6]									
Feed cost/pig	6.73	6.75	7.01	7.32	7.42	7.71	0.406	<0.001	0.373
Feed cost/lb gain	0.177	0.176	0.181	0.188	0.189	0.194	0.0040	<0.001	0.464
Total revenue/pig[4]	17.40	17.50	17.75	17.76	17.82	18.05	1.267	0.060	0.949
IOFC	10.68	10.75	10.75	10.44	10.40	10.33	0.876	0.099	0.660

[1]A total of 608 pigs (600 × 241, DNA; initially 80.2 ± 2.0 lb BW) were used with 7 to 9 pigs per pen and 12 replications per treatment. A total of 285 pigs (initially 85.1 ± 1.8 lb BW) were fed trial diets for a 14-day period for group 1, and 323 pigs (initially 75.2 ± 2.1 lb BW) were fed trial diets for a 21-day period for group 2.

[2] For 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.

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

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

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

[6] For 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.