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Effects of Dietary Standardized Ileal Digestible Lysine on Growth Performance, Carcass Characteristics, and Economics of Pigs from 230 to 285 lb[1]

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Summary

A total of 1,570 finishing pigs (337 × 1050, PIC; initially 228.4 ± 1.87 lb) were used in a 28-d trial to determine the effects of feeding increasing standardized ileal digestible (SID) Lys to pigs between 230 to 285 lb on growth performance, carcass characteristics, and economics. Prior to the beginning of the study, the three heaviest pigs per pen were removed and marketed, with all remaining pigs marketed 28-d later at the end of the study. Pigs were housed in mixed-sex pens, with 20 pigs per pen and 20 pens per treatment. The experiment was a randomized complete block design with four dietary treatments: 0.61, 0.68, 0.75, and 0.82% SID Lys. Diets were corn-soybean meal-based and fed in meal form. Dietary treatments were similar in NE and increasing SID Lys was achieved by increasing soybean meal and feed-grade amino acids. For the first 14 d from 230 to approximately 260 lb, as SID Lys increased, there was a tendency for increased (linear, $P = 0.074$) ADG, an improvement (linear, $P < 0.05$) in F/G, and increase (linear, $P < 0.001$) in SID Lys intake per kg of gain. For the second 14 d from 260 to 285 lb, SID Lys intake per kg of gain increased (linear, $P < 0.001$) as SID Lys increased; however, there was no evidence for difference ($P > 0.10$) for any growth performance traits. Overall, there was an improvement (linear, $P < 0.05$) in F/G and increase (linear, $P < 0.001$) in SID Lys intake per kg of gain as SID Lys increased. Increasing SID Lys also increased (linear, $P < 0.05$) percentage lean and decreased (linear, $P < 0.05$) backfat depth with no evidence for differences ($P > 0.10$) in other carcass criteria. For economics, feed cost and feed cost per lb of gain increased (linear, $P < 0.05$) as SID Lys increased in both low- and high-price scenarios. Income over feed cost decreased (linear, $P < 0.05$) as dietary SID Lys increased in a low-price scenario, but there was no difference ($P > 0.10$) between treatments in a high-price scenario. In conclusion, increasing dietary SID Lys in feed offered to pigs remaining in the pen after topping for the last 28-d of the finisher period linearly improved F/G and increased SID Lys intake per kg of gain without significantly influencing other growth performance traits. Feed

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cost per pound of gain was linearly increased for both low and high-price scenarios with a detriment for IOFC with increasing SID Lys in the low-price scenario.

Introduction

Lysine is the first limiting amino acid for lean tissue deposition in swine. It was reported[3] that for every hundred grams of protein deposition, 7.1 grams of Lys are needed. However, more recent publications showed that for 240 to 300 lb pigs, levels of Lys were at least 2 grams higher per each 100 grams of protein deposited compared to NRC-reported values based on measurements at the longissimus dorsi muscle.[4] In addition to Lys intake, pigs' growth curve can affect feed efficiency. Pigs with low feed intake and slow growth rates during the finisher period had improved feed efficiency when higher levels of SID amino acids were supplied compared to pigs with faster growth rates.[5]

Considerable research has been conducted[6] to determine the optimal SID Lys requirements at the end of the finisher. However, limited data reported the SID Lys requirements after the most efficient pigs were removed from the pens, which provided more space and feeder allowance per pig left in the pen. Therefore, the objective of this study was to determine the effects of dietary standardized ileal digestible Lys on growth performance, carcass characteristics, and economics of pigs from 230 to 285 lb after the heaviest pigs in each pen were marketed.

Material and Methods

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 barns were naturally ventilated and double-curtain-sided with totally slatted floors. Each pen was equipped with a five-hole stainless steel dry self-feeder and a bowl waterer for ad libitum access to feed and water. Daily feed additions to each pen were accomplished using a robotic feeding system (FeedPro; Feedlogic Corp., Wilmar, MN) able to record feed deliveries for individual pens.

Animals and diets

Two groups of pigs (total 1,570 pigs, 337 × 1050, PIC; initially 228.4 ± 1.87 lb) were used in a 28-d growth trial. Prior to the beginning of the study, the three heaviest pigs per pen were removed and marketed, with all remaining pigs marketed 28-d later at the end of the study. Pigs were housed in mixed-sex pens, with 20 pigs per pen and 20 pens per treatment. The experiment was a randomized complete block design with

[3] National Research Council. 2012. Nutrient Requirements of Swine: Eleventh Revised Edition. Washington, DC: The National Academies Press. https://doi.org/10.17226/1

[4] Remus, A., L. Hauschild, M.-P. Letourneau-Montminy, E. Corrent, C. Pomar. 2020. The ideal protein profile for late-finishing pigs precision feeding systems: Threonine. J Anim Feed Sci. doi:10.1016/j.anifeedsci.2020.114500

[5] Camp Montoro, J., D. Sola-Oriol, R. Muns, J. Gasa, N. Llanes, and E. Garcia Manzanilla. 2021. High levels of standardized ileal digestible amino acids improve feed efficiency in slow-growing pigs at late grower-finisher stage. J Anim Physiol Anim Nutr. doi: 10.1111/jpn.13610

[6] Soto, J. A., M. D. Tokach, S. S. Dritz, J. C. Woodworth, J. M. DeRouchey, R. D. Goodband, and F. Wu. 2019. Optimal dietary standardized ileal digestible lysine and crude protein concentration for growth and carcass performance in finishing pigs weighing greater than 100 kg. J. Anim. Sci. doi: 10.1093/jas/skz052

four dietary treatments: 0.61, 0.68, 0.75, and 0.82% SID Lys. Diets were corn-soybean meal-based and fed in meal form. Dietary treatments were similar in NE and increasing SID Lys was achieved by increasing soybean meal and feed-grade amino acids (Tables 1) with soybean assumed to have 78% of the NE of corn. All treatment diets were manufactured at the New Horizon Farms Feed Mill in Pipestone, MN, and fed during the experimental period.

Pens of pigs were weighed at the beginning, d 14, and d 28 to determine ADG, ADFI, and F/G. On the last day of the trial, pigs were tattooed with a pen identification number and transported to a U.S. Department of Agriculture-inspected packing plant (JBS Swift, Worthington, MN) for carcass data collection. Carcass measurements included HCW, loin depth, backfat, and percentage lean. Percentage lean was calculated from a plant proprietary equation. Carcass yield was calculated by dividing the pen average HCW by the pen average final live weight obtained at the farm. Feed cost per pig was calculated by diet feed cost times feed intake per phase divided by pigs placed. Feed cost per lb of gain was calculated by dividing total feed cost per pen by total gain per pen. Revenue per pig placed was calculated by multiplying total pen gain by carcass yield and carcass price. Income over feed cost (IOFC) was calculated by subtracting feed cost per pig from revenue.

Statistical analysis

Data were analyzed as a randomized complete block design for one-way ANOVA using the lmer function from the lme4 package in R (version 4.1.1 (2021-08-10), R Foundation for Statistical Computing, Vienna, Austria) with pen considered the experimental unit, treatment as fixed effect, and block as a random effect. Contrast coefficients were used to compare the effect of increasing levels of SID Lys. Hot carcass weight was used as a covariate for analysis of backfat, loin depth, and lean percentage. All results were considered significant at $P \leq 0.05$ and marginally significant between $P > 0.05$ and $P \leq 0.10$.

Results and Discussion

For the first 14 d from 230 lb to approximately 260 lb, as SID Lys increased there was a tendency for a linear increase ($P = 0.074$) in ADG, a linear improvement ($P < 0.05$) in F/G, and an increase ($P < 0.001$) in SID Lys intake per kg of gain. For the second 14 d from 260 to 285 lb, SID Lys intake per kg of gain increased ($P < 0.001$) as SID Lys increased; however, there was no evidence for difference ($P > 0.10$) for any growth performance traits. Overall, there was a linear improvement ($P < 0.05$) in F/G and increase ($P < 0.001$) in SID Lys intake per kg of gain as SID Lys increased. For carcass characteristics, increasing SID Lys linearly increased ($P < 0.05$) percentage lean and decreased ($P < 0.05$) backfat depth with no evidence for differences ($P > 0.10$) in other carcass criteria.

For economics, feed cost and feed cost per lb of gain linearly increased ($P < 0.05$) as SID Lys increased in both low and high-price scenarios. Income over feed cost linearly decreased ($P < 0.05$) as dietary SID Lys increased in a low-price scenario, but there was no difference between treatments in a high-price scenario ($P > 0.10$).

In conclusion, increasing dietary SID Lys in the last 28-d of the finisher period linearly improved F/G and SID Lys intake per kg of gain without significantly influencing other

growth performance traits. The responses observed were mainly driven by the results from the first 14 d of the study, where pigs fed 0.68% SID Lys or less, could not achieve the minimum SID Lys required based on NRC[3] (21 g/kg gain) for lean tissue deposition due to feed intake. In contrast, feed intake was high in the second period to reach the minimum needed even for pigs fed low SID Lys levels. Feed cost per lb of gain was linearly increased for both low- and high-price scenarios with a detriment for IOFC with increasing SID Lys in the low-price scenario.

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

	SID Lys, %			
Item	**0.61**	**0.68**	**0.75**	**0.82**
Ingredients, %				
Corn	86.20	85.35	84.61	81.85
Soybean meal, 46.5% CP[2]	11.94	12.68	13.20	15.97
Limestone	0.90	0.89	0.89	0.91
Monocalcium P, 21% P	0.09	0.07	0.07	0.02
Salt	0.40	0.40	0.40	0.40
Liquid-Lys-55%	0.25	0.34	0.44	0.44
DL-Met	---	--	0.04	0.06
L-Trp	---	0.01	0.02	0.02
Thr[3]	0.05	0.09	0.14	0.15
L-Val	---	---	0.02	0.02
Tribasic copper chloride	0.03	0.03	0.03	0.03
Vitamin-trace mineral premix	0.10	0.10	0.10	0.10
Phytase[4]	0.05	0.05	0.05	0.05
Total	100	100	100	100
Calculated analysis				
Standardized ileal digestible (SID) amino acids, %				
Lys	0.61	0.68	0.75	0.82
Ile:Lys	70	64	60	60
Leu:Lys	180	164	151	146
Met:Lys	33	30	32	33
Met and Cys:Lys	66	60	60	60
Thr:Lys	67	67	67	67
Trp:Lys	18.9	18.7	18.7	18.7
Val:Lys	82	75	72	72
His:Lys	51	46	43	43
Total Lys, %	0.71	0.78	0.85	0.92
NE, kcal/lb	1,161	1,159	1,158	1,152
SID Lys:NE, g/Mcal	2.39	2.66	2.93	3.21
CP, %[2]	13.0	13.4	13.7	14.8
Ca, %	0.40	0.39	0.39	0.40
STTD P, %	0.25	0.25	0.25	0.25

[1] Dietary treatments were fed for 28 d.
[2] CP = crude protein.
[3] Thr Pro; CJ America-Bio, Downers Grove, IL.
[4] Optiphos (Huvepharma, Sofia, Bulgaria) was included at 1,250 FTU/kg with an estimated release of 0.13% STTD P.

Table 2. Effects of dietary standardized ileal digestible lysine on growth performance, carcass characteristics, and economics of pigs from 230 to 285 lb[1]

	SID Lys, %					*P* =[2]	
Item	**0.61**	**0.68**	**0.75**	**0.82**	**SEM**	**Linear**	**Quadratic**
BW, lb							
d 0	228.4	228.3	228.2	228.3	1.87	0.660	0.679
d 14	259.3	260.1	260.2	261.4	2.62	0.078	0.780
d 28	282.2	283.5	282.7	284.7	4.00	0.149	0.716
Period 1 (d 0 to 14)							
ADG, lb	2.28	2.35	2.33	2.43	0.075	0.074	0.826
ADFI, lb	6.58	6.55	6.50	6.47	0.086	0.258	0.991
F/G	2.92	2.85	2.83	2.70	0.078	0.012	0.612
SID Lys, g/d	18.2	20.2	22.1	24.1	0.28	< 0.001	0.918
SID Lys, g/kg gain	17.8	19.4	21.2	22.2	0.56	< 0.001	0.419
Period 2 (d 14 to 28)							
ADG, lb	1.79	1.81	1.74	1.82	0.109	0.877	0.442
ADFI, lb	6.94	6.94	6.79	7.01	0.197	0.896	0.202
F/G	4.08	3.97	4.18	4.00	0.177	0.955	0.731
SID Lys, g/d	19.2	21.4	23.1	26.1	0.65	< 0.001	0.196
SID Lys, g/kg gain	24.9	27.0	31.4	32.8	1.27	< 0.001	0.630
Overall (d 0 to 28)							
ADG, lb	2.04	2.09	2.05	2.13	0.083	0.140	0.543
ADFI, lb	6.75	6.74	6.64	6.73	0.126	0.579	0.455
F/G	3.36	3.29	3.33	3.20	0.086	0.025	0.568
SID Lys, g/d	18.7	20.8	22.6	25.0	0.41	< 0.001	0.466
SID Lys, g/kg gain	20.5	22.4	25.0	26.3	0.62	< 0.001	0.359

continued

Table 2. Effects of dietary standardized ileal digestible lysine on growth performance, carcass characteristics, and economics of pigs from 230 to 285 lb[1]

	SID Lys, %					*P* =[2]	
Item	**0.61**	**0.68**	**0.75**	**0.82**	**SEM**	**Linear**	**Quadratic**
Carcass characteristics							
HCW, lb	208.5	210.9	210.2	210.0	2.34	0.415	0.205
Yield, %	73.8	73.5	73.8	73.4	0.24	0.472	0.634
Backfat, in.[3]	0.67	0.63	0.66	0.63	0.011	0.041	0.820
Loin depth, in.[3]	2.64	2.64	2.64	2.67	0.023	0.213	0.344
Lean, %[3]	56.6	57.1	56.7	57.2	0.16	0.036	0.980
Economics, $/pig placed							
Low-price scenario[4]							
Feed cost	13.19	13.69	14.09	14.82	0.381	< 0.001	0.425
Feed cost/lb gain[5]	0.251	0.254	0.270	0.269	0.0068	< 0.001	0.538
Revenue[6]	23.30	23.84	23.36	24.26	1.119	0.167	0.643
IOFC[7]	10.11	10.15	9.27	9.44	0.771	0.040	0.842
High-price scenario[8]							
Feed cost	22.40	22.92	23.26	24.13	0.633	< 0.001	0.469
Feed cost/lb gain[5]	0.426	0.426	0.446	0.438	0.0114	0.029	0.534
Revenue[6]	34.75	35.56	34.85	36.19	1.670	0.167	0.643
IOFC[7]	12.34	12.64	11.58	12.06	1.094	0.345	0.840

[1] A total of 1,570 pigs (initial BW of 228.4 lb ± 1.87 lb) were used in two groups with 20 pigs per pen and 20 replicates per treatment in a randomized complete block design.

[2] Contrast coefficients were used to compare the effect of increasing levels of SID Lys.

[3] Adjusted using HCW as covariate.

[4] Market price for the revenue calculation: Carcass price = $0.59/lb; Corn = $3.00/bushel ($107.14/ton); soybean meal = $300/ton; Liquid Lys 55% = $1.70/lb; DL-Met = $1.70/lb; ThreoPro = $0.80/lb; L-Trp = $3.00; L-Val = $2.50/lb; Optiphos Plus 2500 G = $1.60/lb; VTM = $1.50/lb.

[5] Feed cost/lb gain = total feed cost per pig divided by total gain per pig.

[6] Revenue = (total gain × carcass yield) × carcass price.

[7] Income over feed cost = revenue – feed cost.

[8] Market price for the revenue calculation: Carcass price = $0.88/lb; Corn = $6.00/bushel ($214.29/ton); soybean meal = $400/ton; Liquid Lys 55% = $1.70/lb; DL-Met = $2.50/lb; ThreoPro = $0.80/lb; L-Trp = $5.00; L-Val = $4.00/lb; Optiphos Plus 2500 G = $1.60/lb; VTM = $1.50/lb.