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Summary
A total of 1,080 finishing pigs (327 × 1050, PIC; initially 71.3 ± 1.91 lb) were used in a 119-d growth trial to evaluate the effects of reducing the dietary SID Lys and SID Trp:Lys ratio on growth performance to find strategies to reduce growth rate of pigs during the grow-finish period. Pigs were allotted by initial BW and randomly assigned to 1 of 4 dietary treatments in a completely randomized block design with 27 pigs per pen and 10 pens per treatment. Dietary treatments were corn-soybean meal-based diets with DDGS. Three dietary regimes were formulated to contain either 100, 90, or 80% of the estimated SID Lys requirement for pigs in this facility, and these diets had a SID Trp:Lys ratio of 19%, with the exception of the last dietary phase formulated to 17% SID Trp:Lys. A fourth regime was formulated to 80% SID Lys with a SID Trp:Lys ratio of 16% (80–16% SID Trp:Lys) throughout all phases.

Overall, from d 0 to 119, ADG and final BW decreased (linear, $P < 0.001$) and F/G tended to worsen (linear, $P = 0.087$) as SID Lys decreased from 100 to 80% of the requirement. Pigs fed the diet with 80–16% SID Trp:Lys also had decreased ADG and poorer F/G compared with pigs fed 80% of the SID Lys requirement with high a Trp:Lys ratio.

In conclusion, reducing SID Lys decreased growth performance and final BW of pigs during the grow-finish period. A further reduction in Trp:Lys ratio also decreased ADG and tended to worsen feed efficiency. This resulted in a 25 lb difference in final BW between pigs fed Lys and Trp at the requirement (100%) compared with pigs fed the 80% SID Lys and 16% Trp:Lys ratio. This study provides alternatives to producers to reduce growth rate of finishing pigs.

Introduction
During the COVID-19 outbreak in 2020, the swine industry was forced to find dietary strategies to decrease growth rate of pigs due to plant closures and slowdowns. Lysine

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is the first limiting amino acid in corn soybean-meal-based diets. Decreasing the level of Lys in the diet will decrease protein deposition of the pig and, consequently, reduce overall growth rate. The second limiting amino acid in diets high in corn protein is Trp. Previous research has shown that reducing Trp in the diet from 19 to 16% of Lys will reduce feed intake, weight gain, and worsen feed efficiency (F/G).[4] Therefore, reducing Lys along with Trp could be a potential approach to further slowdown growth rate of pigs to increase the amount of time needed to reach market weights.

The objective of this study was to determine the effects of reducing Lys and Trp on growth performance of grow-finish pigs. The hypotheses were: 1) reducing the level of Lys in diets will impair growth performance, and 2) reducing Lys in diets with a further reduction in the Trp:Lys ratio will decrease weight gain and slowdown growth of pigs in the grow-finish period.

Materials and Methods

The Kansas State University Institutional Animal Care and Use Committee (IACUC) approved the protocol used in this experiment. The experiment was conducted at a commercial research facility in southwest Minnesota. The barn was naturally ventilated and double-curtain-sided and pens had completely slatted flooring and deep pits for manure storage. Each pen was equipped with a 3-hole stainless steel dry self-feeder (Thorp Equipment, Thorp, WI) and a cup waterer for *ad libitum* intake of feed and water. The facility was equipped with a computerized feeding system (FeedPro; Feedlogic Corp., Willmar, MN) that delivered and recorded daily feed additions.

Animals and diets

A total of 1,080 pigs (327 × 1050, PIC; initially 71.3 ± 1.91 lb) were used in a 119-d growth trial arranged in a randomized complete block design with 27 pigs per pen and 10 pens per treatment. Dietary treatments were fed in 7 phases and consisted of a control regimen (100% of the estimated SID Lys requirement for pigs in this facility) formulated to contain 1.10, 1.01, 0.91, 0.83, 0.79, 0.71, or 0.67% SID Lys from 70 to 90, 90 to 112, 112 to 159, 159 to 187, 187 to 216, 216 to 246, and 246 to 286 lb, respectively. Two additional regimens contained 90 or 80% of the SID Lys estimate. These 3 regimes were formulated to a SID Trp:Lys ratio of 19% except for the last dietary phase that contained 17% SID Trp:Lys ratio. The fourth regimen contained 80% of the SID Lys estimate with 16% SID Trp:Lys in all phases.

Pens of pigs were weighed, and feed disappearance measured approximately every 2 weeks throughout the experiment to determine ADG, ADFI, and F/G. Two weeks before the end of the experiment, 2 pigs per pen were removed and marketed. Consequently, the remaining pigs in the pen were weighed and marketed on October, 2020, final weights were obtained, and no carcass data were collected because of the ongoing outbreak of COVID-19.

[4] Gonçalves, M. A. D., M. D. Tokach, S. S. Dritz, K. J. Touchette, N. M. Bello, J. M. DeRouchey, J. C. Woodworth, and R. D. Goodband. 2014. Effects of standardized ileal digestible tryptophan:lysine ratio on growth performance and economics of finishing pigs. Proc Kansas State University Swine Day, SRP1110. *Agricultural Experiment Station and Cooperative Extension Service. Manhattan, KS*. pp. 109-122.

Statistical analysis

Pen was the experimental unit for all data. Response variables were analyzed using a general linear mixed model. Linear and quadratic contrasts were used to evaluate the effect of SID Lys reduction (treatments 100, 90, and 80) and pairwise comparisons were used to compare the 80% SID Lys treatment with the 80–16% SID Trp:Lys treatment. 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 lme4 package in R program (version 3.5.2, R Foundation for Statistical Computing, Vienna, Austria). Results were considered significant at $P \leq 0.05$ and a tendency at $P \leq 0.10$.

Results and Discussion

For the overall period, ADG decreased (linear, $P < 0.001$) and a tendency ($P = 0.087$) for poorer F/G was observed with decreasing SID Lys in the diet. There were no treatment differences ($P = 0.176$) observed in ADFI. Within the 80% SID Lys treatments, ADG was decreased ($P < 0.05$) and F/G tended ($P < 0.10$) to worsen when a further reduction of the SID Trp:Lys ratio was applied.

In conclusion, as expected, decreasing SID Lys decreased ADG and worsened F/G. Pigs fed 90 and 80% of the estimated Lys requirement for these pigs were approximately 9.5 and 18.9 lb lighter than pigs fed at their estimated requirement. When pigs were fed 80% of the Lys requirement and were also restricted in the Trp:Lys ratio, a further reduction in growth performance and final BW was observed. These pigs were 25.8 lb lighter in final BW compared with those fed 100% of the Lys requirement estimate. This study presents useful information for producers regarding dietary changes to slow-down growth of pigs during the grow-finish period.

Table 1. Composition of phase 1 and 2 experimental diets (as-fed basis)[1]

	Phase 1				Phase 2			
Ingredient, %	100	90	80	80–16% Trp:Lys	100	90	80	80–16% Trp:Lys
Corn	49.60	52.91	56.27	56.36	50.78	53.74	54.66	54.69
Soybean meal	7.51	4.25	0.93	0.87	3.86	0.79	---	---
DDGS	40.00	40.00	40.00	40.00	42.40	42.54	42.58	42.58
Limestone	1.39	1.42	1.44	1.44	1.42	1.44	1.45	1.45
Salt	0.46	0.46	0.46	0.46	0.45	0.45	0.45	0.45
L-Lys-HCl	0.68	0.65	0.63	0.63	0.67	0.65	0.55	0.55
DL-Met	0.05	0.02	---	---	0.01	---	---	---
L-Thr	0.12	0.10	0.09	0.08	0.11	0.10	0.05	0.05
L-Trp	0.07	0.07	0.07	0.04	0.08	0.07	0.06	0.04
Vitamin trace mineral premix without phytase	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Potassium chloride	---	---	---	---	0.10	0.10	0.10	0.10
Phytase[2]	0.02	0.02	0.01	0.02	0.02	0.01	0.01	0.01
Calculated analysis								
SID AA, %								
Lys	1.09	0.99	0.89	0.89	1.01	0.91	0.81	0.81
Ile:Lys	56	56	56	56	56	56	61	61
Met:Lys	31	30	30	30	30	30	33	33
Met and Cys:Lys	56	56	57	57	56	57	63	63
Thr:Lys	60	60	60	60	61	61	61	61
Trp:Lys	19.0	19.0	19.0	16.0	19.0	19.0	19.0	16.0
Val:Lys	68	70	71	71	70	71	78	78
SID Lys:NE, g/Mcal	4.75	4.28	3.80	3.80	4.37	3.93	3.50	3.50
NE, kcal/lb	1,049	1,055	1,059	1,062	1,051	1,052	1,054	1,054
Ca, %	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58
Na, %	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28
STTD P, %	0.35	0.35	0.30	0.34	0.36	0.30	0.30	0.30

[1]Experimental diets were fed for 2 and 4 weeks for Phase 1 and Phase 2, respectively.

[2]Optiphos 2000 (Huvepharma, Sofia, Bulgaria) provided 136.5 FTU per lb of diet with an estimated release of 0.10% STTD P.

Table 2. Composition of phase 3 and 4 experimental diets (as-fed basis)[1]

	Phase 3				Phase 4			
Ingredient, %	**100**	**90**	**80**	**80–16% Trp:Lys**	**100**	**90**	**80**	**80–16% Trp:Lys**
Corn	53.65	54.75	54.95	54.98	61.42	62.41	62.63	62.65
Soybean meal	1.02	---	---	---	0.87	---	---	---
DDGS	42.53	42.57	42.57	42.57	35.00	35.00	35.00	35.00
Limestone	1.31	1.32	1.32	1.32	1.26	1.27	1.27	1.27
Salt	0.45	0.45	0.45	0.45	0.49	0.49	0.45	0.45
L-Lys-HCl	0.65	0.57	0.45	0.45	0.58	0.51	0.40	0.40
L-Thr	0.11	0.07	0.01	0.01	0.10	0.07	0.01	0.01
L-Trp	0.07	0.06	0.05	0.02	0.07	0.06	0.04	0.02
Vitamin trace mineral premix without phytase	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Potassium chloride	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Phytase[2]	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.01
Calculated analysis								
SID AA, %								
Lys	0.91	0.82	0.73	0.73	0.83	0.74	0.66	0.66
Ile:Lys	56	60	68	68	56	60	67	67
Met:Lys	30	32	36	36	30	33	37	37
Met and Cys:Lys	56	61	69	69	58	63	70	70
Thr:Lys	62	62	62	62	63	63	63	63
Trp:Lys	19.0	19.0	19.0	16.0	19.0	19.0	19.0	16.0
Val:Lys	71	76	86	86	72	77	87	87
SID Lys:NE, g/Mcal	3.95	3.56	3.16	3.16	3.51	3.16	2.81	2.81
NE, kcal/lb	1,050	1,052	1,052	1,052	1,073	1,069	1,070	1,070
Ca, %	0.53	0.53	0.53	0.53	0.51	0.51	0.51	0.51
Na, %	0.28	0.28	0.28	0.28	0.28	0.28	0.26	0.26
STTD P, %	0.26	0.26	0.26	0.26	0.32	0.26	0.26	0.26

[1]Experimental diets were fed for 2 weeks.

[2]Optiphos 2000 (Huvepharma, Sofia, Bulgaria) provided 136.5 FTU per lb of diet with an estimated release of 0.10% STTD P.

Table 3. Composition of phase 5 and 6 experimental diets (as-fed basis)[1]

	Phase 5				Phase 6			
Ingredient, %	**100**	**90**	**80**	**80–16% Trp:Lys**	**100**	**90**	**80**	**80–16% Trp:Lys**
Corn	65.90	67.52	67.69	67.71	67.51	67.66	67.80	67.82
Soybean meal	1.48	---	---	---	---	---	---	---
DDGS	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00
Limestone	1.20	1.21	1.21	1.21	1.16	1.16	1.16	1.16
Salt	0.52	0.45	0.45	0.45	0.45	0.45	0.45	0.45
L-Lys-HCl	0.53	0.49	0.39	0.38	0.49	0.40	0.31	0.31
L-Thr	0.10	0.07	0.02	0.02	0.08	0.04	---	---
L-Trp	0.06	0.05	0.04	0.02	0.06	0.04	0.03	0.01
Vitamin trace mineral premix without phytase	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
Potassium chloride	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Phytase[2]	0.02	0.01	0.01	0.02	0.01	0.01	0.01	0.01
Calculated analysis								
SID AA, %								
Lys	0.79	0.71	0.63	0.63	0.71	0.64	0.57	0.57
Ile:Lys	56	58	65	66	58	64	72	72
Met:Lys	30	32	36	37	32	35	40	40
Met and Cys:Lys	58	61	69	70	61	68	76	76
Thr:Lys	63	63	63	63	64	64	65	65
Trp:Lys	19.0	19.0	19.0	16.0	19.0	19.0	19.0	16.0
Val:Lys	72	75	85	85	75	83	94	94
SID Lys:NE, g/Mcal	3.31	2.98	2.65	2.65	2.98	2.69	2.39	2.39
NE, kcal/lb	1,080	1,080	1,080	1,085	1,080	1,080	1,080	1,080
Ca, %	0.49	0.49	0.49	0.49	0.47	0.47	0.47	0.47
Na, %	0.28	0.25	0.25	0.25	0.25	0.25	0.25	0.25
STTD P, %	0.30	0.24	0.24	0.30	0.22	0.22	0.22	0.22

[1]Experimental diets were fed for 2 weeks.
[2]Optiphos 2000 (Huvepharma, Sofia, Bulgaria) provided 136.5 FTU per lb of diet with an estimated release of 0.10% STTD P.

Table 4. Composition of phase 7 experimental diet (as-fed basis)[1]

	Phase 7			
Ingredient, %	**100**	**90**	**80**	**80–16% Trp:Lys**
Corn	78.90	81.16	82.74	82.75
Soybean meal	3.62	1.54	---	---
DDGS	15.00	15.00	15.00	15.00
Limestone	1.09	1.10	1.11	1.11
Salt	0.60	0.45	0.45	0.45
L-Lys-HCl	0.40	0.39	0.35	0.35
L-Thr	0.09	0.08	0.06	0.06
L-Trp	0.03	0.03	0.03	0.02
Vitamin trace mineral premix without phytase	0.09	0.09	0.09	0.09
Potassium chloride	0.10	0.10	0.10	0.10
Phytase[2]	0.02	0.02	0.02	0.02
Lipinate[3]	0.05	0.05	0.05	0.05
Calculated analysis				
SID AA, %				
Lys	0.67	0.61	0.54	0.54
Ile:Lys	56	56	58	58
Met:Lys	29	31	33	33
Met and Cys:Lys	57	60	65	65
Thr:Lys	65	65	65	65
Trp:Lys	17.0	17.0	17.0	16.0
Val:Lys	71	73	77	77
SID Lys:NE, g/Mcal	2.77	2.49	2.22	2.22
NE, kcal/lb	1,106	1,112	1,115	1,115
Ca, %	0.45	0.45	0.45	0.45
Na, %	0.28	0.22	0.22	0.22
STTD P, %	0.24	0.24	0.24	0.24

[1]Experimental diets were fed for 3 weeks.
[2]Optiphos 2000 (Huvepharma, Sofia, Bulgaria) provided 136.5 FTU per lb of diet with an estimated release of 0.10% STTD P.
[3]Feed additive for animals used for managing carcass fat composition (Nutriquest LLC, Mason City, IA).

Table 5. Effects of reducing SID Lys and SID Trp:Lys ratio on growth performance of growing-finishing pigs[1]

	SID Lys, %[2]					$P =$[3]	
Item	100	90	80	80–16% Trp:Lys	SEM	Linear	Quadratic
Initial BW, lb							
d 0 BW, lb	71.1	71.4	71.4	71.3	1.91	0.507	0.630
d 119 BW, lb	295.4	285.9	276.5[a]	269.6[b]	3.08	0.001	0.999
Overall (d 0 to 119)							
ADG, lb	1.88	1.81	1.74[a]	1.67[b]	0.013	0.001	0.887
ADFI, lb	5.42	5.36	5.24	5.22	0.109	0.176	0.786
F/G	2.88	2.96	3.01[d]	3.12[c]	0.055	0.087	0.862

[1]A total of 1,080 pigs were used with 27 pigs per pen and 10 replications per treatment.

[2]SID Lys of the estimated requirement (100, 90, or 80%) or 80% with an additional reduction of SID Trp:Lys ratio to 16%. Treatments 100, 90, and 80 were fed 19% Trp:Lys ratio from day 0 to 98 with the exception of the last phase where the ratio of Trp:Lys was 17%, from day 98 to 119.

[3]Linear and quadratic contrasts included treatments 100, 90, and 80%.

[a,b]Treatment: 80 vs. 80–16% Trp:Lys differ ($P \leq 0.05$).

[c,d]Treatment: 80 vs. 80–16% Trp:Lys differ ($P \leq 0.10$).