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Effects of Standardized Ileal Digestible Tryptophan to Lysine Ratio on Growth Performance of PIC Line 337 × 1050 Pigs[1]

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Summary

The objective of these experiments was to evaluate the impact of varying SID Trp:Lys ratios on growth performance, removals, and mortality rates of PIC 337 × 1050 finishing pigs. In each experiment, pens of pigs were blocked by BW and randomly assigned to 1 of 5 dietary treatments in a randomized complete block design with 22 to 27 pigs per pen and 6 or 7 replications per treatment. In Exp. 1, 840 pigs (initially 101.2 ± 2.08 lb) were used from 101 to 161 lb. In Exp. 2, 801 pigs (initially 219.8 ± 3.44 lb) were used from 220 to 281 lb. Dietary treatments were corn-soybean meal-based with 30 or 20% DDGS (Exp. 1 and 2, respectively) and contained increasing SID Trp:Lys ratios at 15, 17.5, 19, 21, and 23%. Diets containing low and high Trp:Lys ratios were blended to achieve the target SID Trp:Lys treatment levels in Exp. 1, while diets containing low, medium, and high Trp:Lys ratios were blended to achieve the target SID Trp:Lys treatment levels in Exp. 2. Between experiments, all pens of pigs were placed on a common diet for 27 d and pens were reallotted to dietary treatment at the start of Exp. 2. In Exp. 1, increasing the SID Trp:Lys ratio increased (quadratic, $P \leq 0.008$) ADG, ADFI, and final BW and improved (quadratic, $P = 0.007$) F/G. As expected, increasing SID Trp:Lys increased (linear, $P < 0.001$) Trp intake, g/d. In addition, Trp intake per kg of gain and Lys intake/d increased (quadratic, $P \leq 0.009$), while Lys intake per kg of gain decreased (quadratic, $P = 0.008$) with increasing SID Trp:Lys ratio. There was no difference between Trp:Lys ratios on the percentage of removals, mortalities, or total removals ($P > 0.10$). For model analysis in 101- to 161-lb pigs, the developed broken-line linear models suggested no further improvement to ADG and F/G beyond 19.0 and 19.3% SID Trp:Lys, respectively. Meanwhile, a similar fitting quadratic polynomial (QP) model suggested minimum F/G was achieved at 21.5% SID Trp:Lys. In Exp. 2, increasing the SID Trp:Lys ratio increased (linear, $P \leq 0.001$)

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[4] Swine Vet Center, St. Peter, MN.

Trp intake and Trp intake per kg of gain (quadratic, $P = 0.050$). However, no other observed response criteria were significantly impacted ($P \geq 0.10$). Models to predict optimal Trp:Lys ratios were not analyzed for 220- to 281-lb pigs due to the lack of observed differences for ADG and F/G. In summary, these results suggest the optimal SID Trp:Lys level for 101- to 161-lb pigs was predicted at or above 19.0 and 19.3% SID Trp:Lys for ADG and F/G, respectively. With the variation in response criteria observed in Exp. 2 (220 to 281 lb), we were unable to statistically define a requirement estimate.

Introduction

Tryptophan is an indispensable amino acid, which is a vital component of numerous bodily processes including immune function, hormone production, and protein accretion.[5] The NRC (2012) recommends SID Trp:Lys ratios of 17.3 and 18.0% for pigs weighing 101 to 161 lb and 220 to 281 lb, respectively, to support maximum growth.[6] However, continuous improvements in modern swine genetics have increased growth rates, which may alter amino acid requirements for the growing-finishing pig. Therefore, the objective of this study was to evaluate the impact of varying Trp:Lys ratios on growth performance, removals, and mortality rates of PIC 337 × 1050 finishing pigs.

Procedures

The protocol for this experiment was approved by the Kansas State University Institutional Animal Care and Use Committee. The study was conducted in south-central Minnesota in a commercial research barn. The barn had slatted concrete flooring, deep pits for manure storage, and was naturally ventilated. Pens contained a 3-hole stainless steel dry self-feeder (Thorp Equipment, Thorp, WI) and a 1-cup waterer to provide *ad libitum* access to feed and water. These experiments were conducted from June to September 2022.

Animals and diets

In Exp. 1, 840 pigs (PIC 337 × 1050; initially 101.2 ± 2.08 lb) were used from 101 to 161 lb. In Exp. 2, 801 pigs (initially 219.8 ± 3.44 lb) were used from 220 to 281 lb. Pens were provided 1 of 5 dietary treatments with increasing SID Trp:Lys ratios at 15, 17.5, 19, 21, and 23% in both experiments. Diets were corn-soybean meal-based with 30 or 20% DDGS (Exp. 1 and 2, respectively). Diets containing low and high Trp:Lys ratios were blended to achieve the intermediate SID Trp:Lys treatment levels in Exp. 1. In Exp. 2 diets containing 15, 19, and 23% SID Trp:Lys ratios were formulated. The 15 and 19% SID Trp:Lys diets were blended to create the 17.5% SID Trp:Lys treatment, while the 19 and 23% SID Trp:Lys diets were blended to create the 21% SID Trp:Lys treatment (Table 1). Tryptophan was the first-limiting AA, with Lys being set approximately 10% below PIC recommendations in each experiment, while all other AA ratios were maintained above PIC requirement estimates. Treatment diets were fed for 28 and 34 d in Exp. 1 and 2, respectively. Between experiments, all pens of pigs were placed on a common diet for 27 d and pens were reallotted to dietary treatments at the start of Exp. 2. To determine ADG, ADFI, and F/G, pens of pigs were weighed, and feed

[5] Liu, J. B., H. L. Yan, S. C. Cao, J. Liu, Z. X. Li, and H. F. Zhang. 2019. The response of performance in grower and finisher pigs to diets formulated to different tryptophan to lysine ratios. Livest. Sci. 222:25-30 doi:10.1016/j.livsci.2019.01.016

[6] National Research Council. 2012. Nutrient Requirements of Swine: Eleventh Revised Edition. Washington, DC: The National Academies Press. https://doi.org/10.17226/13298.

disappearance was recorded throughout each experiment. On d 15 and 21 of Exp. 2, the 4 heaviest pigs from each pen were removed and marketed. The remaining pigs were marketed 13 d later at the conclusion of the study.

Statistical analysis

Data were analyzed as a randomized complete block design for a one-way ANOVA using the GLIMMIX procedure of SAS (v. 9.4, SAS Institute, Inc., Cary, NC). Pen was considered as the experimental unit, initial body weight served as a blocking factor, and treatment served as the fixed effect in the statistical model. Contrast coefficients were adjusted to account for unequal spacing in treatments. Results were considered significant with $P \leq 0.05$ and marginally significant with $P \leq 0.10$. Dose response curves were evaluated using quadratic polynomial (QP), broken-line linear (BLL), and broken-line quadratic (BLQ) models. The best-fitting model was selected using the Bayesian Information Criterion (BIC) with improved model fits accepted when BIC decreased at least 2.0.

Results and Discussion

Experiment 1

In 101- to 161-lb pigs, increasing the SID Trp:Lys ratio increased (quadratic, $P \leq 0.008$) ADG, ADFI, and final BW. As a result, increasing the SID Trp:Lys ratio improved (quadratic, $P = 0.007$) F/G. As expected, increasing the SID Trp:Lys increased (linear, $P < 0.001$) Trp intake. In addition, Trp intake/kg of gain and Lys intake/d increased (quadratic, $P \leq 0.009$), while Lys intake/kg of gain decreased (quadratic, $P = 0.008$) with the increasing SID Trp:Lys ratio. There was no difference between Trp:Lys ratios on the percentage of removals, mortalities, or total removals ($P > 0.10$).

Broken-line linear models suggested no further improvement to ADG and F/G beyond 19.0 and 19.3% SID Trp:Lys, respectively (Figures 1 and 2). Meanwhile, a similar fitting QP model suggested minimum F/G was achieved at 21.5% SID Trp:Lys.

Experiment 2

In 220- to 281-lb pigs, increasing the SID Trp:Lys ratio increased (linear, $P \leq 0.001$) Trp intake/d and Trp intake/kg of gain (quadratic, $P = 0.050$), however, no other observed response criteria were significantly impacted ($P \geq 0.10$). Models were not analyzed for Exp. 2 due to the lack of observed significant differences for ADG or F/G.

In summary, these results suggest the optimal SID Trp:Lys level for 101- to 161-lb pigs was predicted at or above 19.0 and 19.3% SID Trp:Lys for ADG and F/G, respectively. However, models to establish optimal dietary level of SID Trp:Lys for 220- to 281-lb pigs were not able to be completed due to the lack of statistical influence of this factor on growth performance response criteria.

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

	Exp. 1		Exp. 2		
Item	**Low**	**High**	**Low**	**Medium**	**High**
Ingredient, %					
Corn	60.11	59.73	72.75	72.70	72.66
Corn DDGS	30.00	30.00	20.00	20.00	20.00
Soybean meal	7.25	7.60	5.20	5.20	5.20
Monocalcium P, 21% P	0.09	0.08	---	---	---
Limestone	1.30	1.30	1.00	1.02	1.04
Sodium chloride	0.36	0.36	0.44	0.44	0.44
L-Lys-HCl	0.47	0.46	0.35	0.35	0.35
DL-Met	0.02	0.01	---	---	---
L-Thr	0.08	0.08	---	---	---
Thr biomass[3]	---	---	0.07	0.07	0.07
L-Trp	---	0.07	---	0.03	0.05
L-Val	0.03	0.02	---	---	---
Vitamin premix with phytase[4]	0.15	0.15	0.10	0.10	0.10
Trace mineral premix	0.15	0.15	0.10	0.10	0.10
Total	100	100	100	100	100
Calculated analysis[1]					
SID AA, %					
Lys, %	0.81	0.81	0.63	0.63	0.63
Ile:Lys	59	59	61	61	61
Leu:Lys	176	177	186	186	186
Met and Cys:Lys	59	59	61	61	61
Thr:Lys	65	65	66	66	66
Trp:Lys	15	23	15	19	23
Val:Lys	74	74	75	75	75
His:Lys	41	41	43	43	43
NE, kcal/lb	1,115	1,115	1,137	1,137	1,137
SID Lys:NE, g/Mcal	3.30	3.30	3.23	3.23	3.23
CP, %[5]	16.8	16.9	13.5	13.6	13.6
Ca, %	0.60	0.60	0.45	0.46	0.47
STTD P, %	0.33	0.33	0.30	0.30	0.30

[1]Calculated analysis is based off nutrient profiles for ingredients listed in the NRC. National Research Council. 2012. Nutrient Requirements of Swine: Eleventh Revised Edition. Washington, DC: The National Academies Press. https://doi.org/10.17226/13298

[2]Diets containing low and high Trp:Lys ratios were blended to achieve the intermediate SID Trp:Lys treatment levels in Exp. 1. In Exp. 2, diets containing 15, 19, and 23% SID Trp:Lys ratios were formulated. The 15 and 19% SID Trp:Lys diets were blended to create the 17.5% SID Trp:Lys treatment, while the 19 and 23% SID Trp:Lys diets were blended to create the 21% SID Trp:Lys treatment.

[3]THR Pro; CJ America-Bio, Downers Grove, IL.

[4]Axtra PHY (Dupont, Wilmington, DE) provided 195 and 236 phytase units (FTU/lb) for an estimated release of 0.12 and 0.14% STTD P in Exp. 1 and 2, respectively.

[5]CP = crude protein.

Table 2. Effects of increasing SID Trp:Lys on growth performance of 101- to 161-lb PIC 337 × 1050 pigs, Exp. 1[1,2]

	SID Trp:Lys, %						*P* =	
Item	**15**	**17.5**	**19**	**21**	**23**	**SEM**	**Linear**	**Quadratic**
BW, lb								
d 0	101.2	101.2	101.2	101.3	101.2	2.08	0.947	0.991
d 28	153.2	158.0	160.8	159.5	160.6	2.71	< 0.001	0.006
d 0 to 28								
ADG, lb	1.86[c]	2.01[b]	2.12[a]	2.07[ab]	2.12[a]	0.030	< 0.001	< 0.001
ADFI, lb	4.36[b]	4.63[a]	4.77[a]	4.65[a]	4.79[a]	0.079	< 0.001	0.008
F/G	2.35[a]	2.30[ab]	2.26[bc]	2.25[c]	2.26[bc]	0.015	< 0.001	0.007
Trp intake, g/d	2.57	3.10	3.44	3.71	4.19	0.061	< 0.001	0.584
Trp intake, g/kg gain	3.06	3.37	3.60	3.96	4.37	0.030	< 0.001	< 0.001
Lys intake, g/d	16.61[b]	17.66[a]	18.17[a]	17.71[a]	18.23[a]	0.304	< 0.001	0.009
Lys intake, g/kg gain	19.73[a]	19.34[ab]	18.97[b]	18.90[b]	19.00[b]	0.133	< 0.001	0.008
Removals and mortality								
Removals, %	0.00	0.60	0.00	0.00	0.00	0.603	0.999	0.999
Mortality, %	0.00	1.21	1.18	0.60	0.59	0.827	0.983	0.981
Total, %	0.00	1.81	1.18	0.60	0.59	0.827	0.983	0.981

[ab]Means within row with different superscripts differ ($P < 0.05$).

[1]A total of 840 pigs (initial BW = 101.2 ± 2.08 lb) were used in a 28-d growth performance study with 22 to 27 pigs per pen and 7 replicates per treatment.

[2]ADG = average daily gain. ADFI = average daily feed intake. F/G = feed-to-gain ratio.

Table 3. Effects of increasing SID Trp:Lys on growth performance of 220- to 281-lb PIC 337 × 1050 pigs, Exp. 2[1,2]

	SID Trp:Lys, %						*P* =	
Item	**15**	**17.5**	**19**	**21**	**23**	**SEM**	**Linear**	**Quadratic**
BW, lb								
d 0	220.8	219.2	220.6	218.1	220.3	3.44	0.550	0.436
d 34[3]	277.7	278.0	281.9	275.5	282.9	5.27	0.451	0.732
Marketing								
First cut (d 15)[4]	274.4	273.4	279.2	273.5	270.1	4.58	0.470	0.293
Second cut (d 21)[4]	283.9	277.7	279.3	286.4	284.2	5.33	0.511	0.317
Average[5]	278.2	277.1	281.0	276.8	280.7	4.36	0.569	0.766
d 0 to 34								
ADG, lb	2.03	2.04	2.11	2.06	2.11	0.061	0.340	0.846
ADFI, lb	6.28	6.28	6.35	6.38	6.48	0.115	0.151	0.620
F/G	3.11	3.09	3.02	3.10	3.09	0.049	0.846	0.367
Trp intake, g/d	2.93	3.27	3.61	4.02	4.44	0.071	< 0.001	0.175
Trp intake, g/kg gain	3.19[d]	3.57[c]	3.77[c]	4.30[b]	4.69[a]	0.060	< 0.001	0.050
Lys intake, g/d	18.80	18.80	19.00	19.08	19.41	0.345	0.145	0.609
Lys intake, g/kg gain	20.50	20.40	19.91	20.45	20.37	0.323	0.841	0.382
Removals and mortality								
Removals, %	0.43	0.44	0.00	0.47	0.00	0.670	0.998	0.999
Mortality, %	0.62	1.86	0.00	0.00	0.60	1.066	0.984	0.979
Total removals, %	1.24	2.48	0.00	0.70	0.60	1.227	0.951	0.984

[ab]Means within row with different superscripts differ ($P < 0.05$).
[1]A total of 801 pigs (initial BW = 219.8 ± 3.44 lb) were used in a 34-d growth performance study with 22 to 26 pigs per pen and 6 or 7 replicates per treatment.
[2]ADG = average daily gain. ADFI = average daily feed intake. F/G = feed-to-gain ratio.
[3]Final marketing event occurred on d 34.
[4]The 4 heaviest pigs were marketed from each pen at each marketing event.
[5]Weighted average final BW for all marketing events (d 14, 21, and 34).

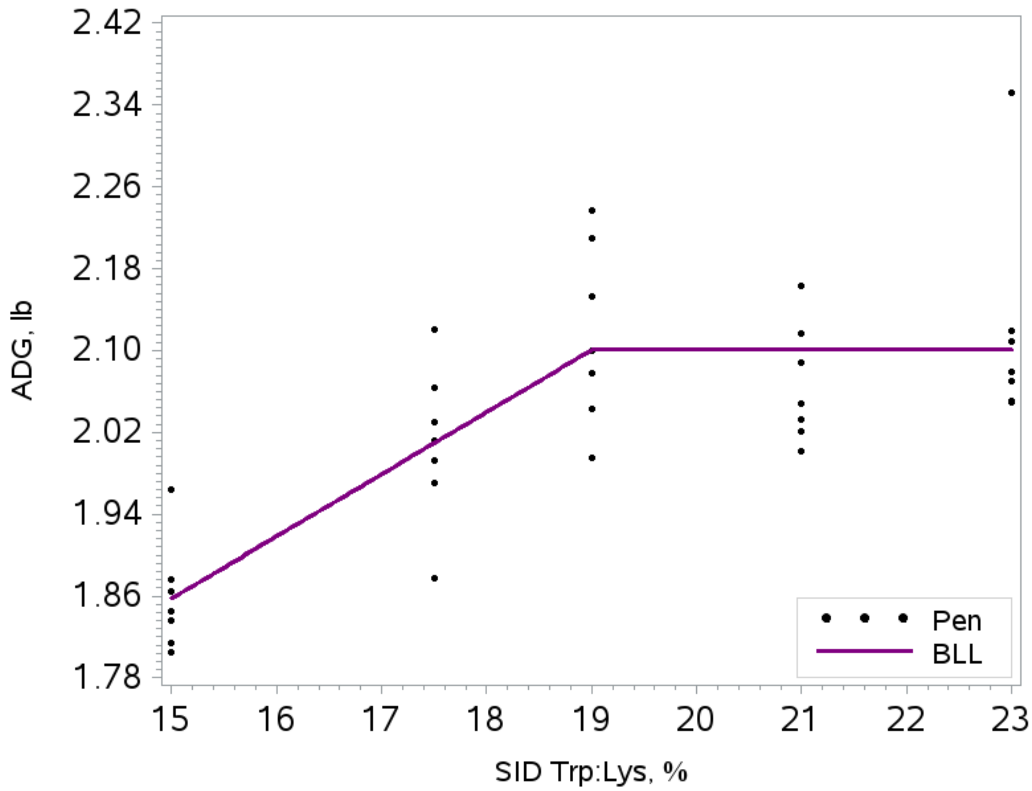

Figure 1. Estimation of SID Trp:Lys requirements to maximize ADG for 101- to 161-lb PIC 337 × 1050 pigs (Exp. 1).
A total of 840 pigs (PIC 337 × 1050; initially 101.2 ± 2.08 lb) were used in a 28-d trial. Quadratic polynomial (QP), broken-line linear (BLL), and broken-line quadratic (BLQ) models were fit to estimate the SID Trp:Lys level required to maximize ADG. The BLL model resulted in the best fit, based on Bayesian Information Criterion (BIC), with a lower number being indicative of a better fit. The BLL model predicted no further improvement beyond 19.0% SID Trp:Lys.

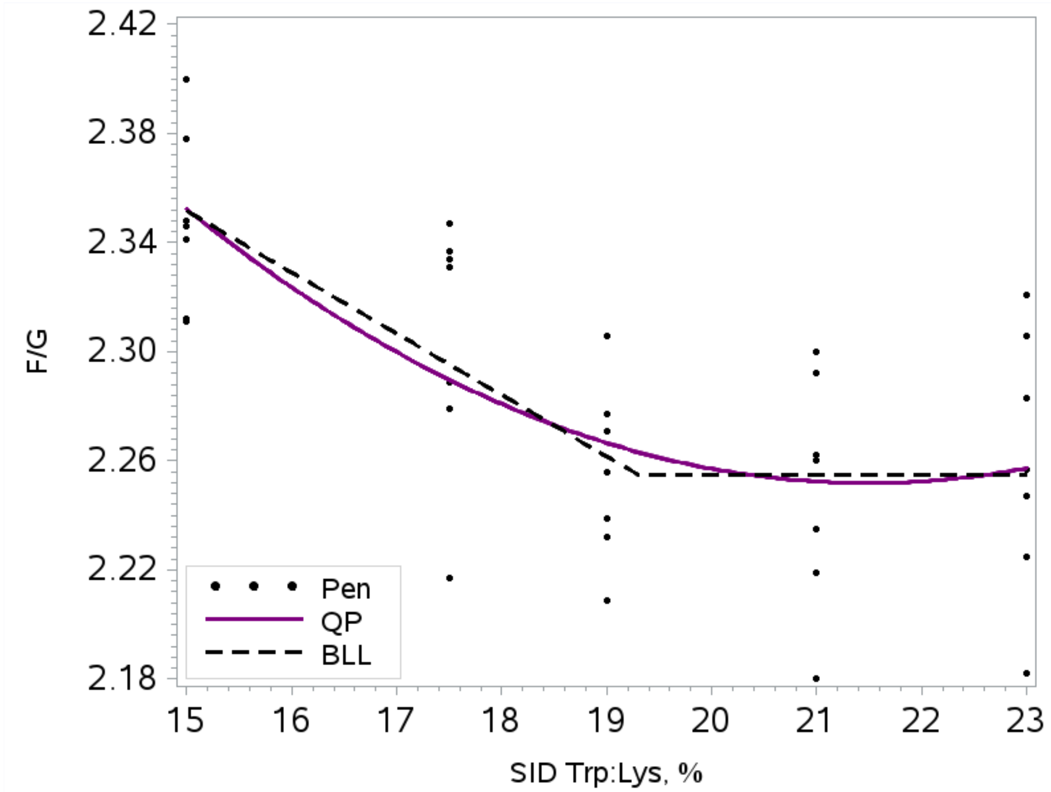

Figure 2. Estimation of SID Trp:Lys requirements to minimize F/G for 101- to 161-lb PIC 337 × 1050 pigs (Exp. 1).

A total of 840 pigs (PIC 337 × 1050; initially 101.2 ± 2.08 lb) were used in a 28-d trial. Quadratic polynomial (QP), broken-line linear (BLL), and broken-line quadratic (BLQ) models were fit to estimate the SID Trp:Lys level required to F/G. The BLL and QP models resulted in the best fit based on Bayesian Information Criterion (BIC), with a lower number being indicative of a better fit (BIC = -124.2 vs. -122.2, BLL vs. QP). The BLL model predicted no further improvement beyond 19.3% SID Trp:Lys. The QP model predicted 95 and 100% of minimum F/G at greater than 23 and 21.5% SID Trp:Lys, respectively. The developed QP model equation for F/G was: $F/G = 0.002385 \times (\text{SID Trp:Lys, \%})^2 - 0.1025 \times (\text{SID Trp:Lys, \%}) + 3.3531$.