

## Effects of Standardized Ileal Digestible Tryptophan to Lysine Ratio on Growth Performance of PIC Line 337 × 1050 Pigs<sup>1</sup>

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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  $101.2 \pm 2.08$  lb) were used from 101 to 161 lb. In Exp. 2, 801 pigs (initially  $219.8 \pm 3.44$  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 reallocated 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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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.<sup>5</sup> 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.<sup>6</sup> 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  $101.2 \pm 2.08$  lb) were used from 101 to 161 lb. In Exp. 2, 801 pigs (initially  $219.8 \pm 3.44$  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 reallocated to dietary treatments at the start of Exp. 2. To determine ADG, ADFI, and F/G, pens of pigs were weighed, and feed

<sup>5</sup> 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

<sup>6</sup> 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.

*Brand names appearing in this publication are for product identification purposes only. No endorsement is intended, nor is criticism implied of similar products not mentioned. Persons using such products assume responsibility for their use in accordance with current label directions of the manufacturer.*

**Table 1. Diet composition (as-fed basis)<sup>1,2</sup>**

Item	Exp. 1		Exp. 2		
	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 <sup>3</sup>	---	---	0.07	0.07	0.07
L-Trp	---	0.07	---	0.03	0.05
L-Val	0.03	0.02	---	---	---
Vitamin premix with phytase <sup>4</sup>	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 <sup>1</sup>					
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, % <sup>5</sup>	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

<sup>1</sup>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>

<sup>2</sup>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.

<sup>3</sup>THR Pro; CJ America-Bio, Downers Grove, IL.

<sup>4</sup>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.

<sup>5</sup>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<sup>1,2</sup>**

Item	SID Trp:Lys, %					SEM	P =	
	15	17.5	19	21	23		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 <sup>c</sup>	2.01 <sup>b</sup>	2.12 <sup>a</sup>	2.07 <sup>ab</sup>	2.12 <sup>a</sup>	0.030	< 0.001	< 0.001
ADFI, lb	4.36 <sup>b</sup>	4.63 <sup>a</sup>	4.77 <sup>a</sup>	4.65 <sup>a</sup>	4.79 <sup>a</sup>	0.079	< 0.001	0.008
F/G	2.35 <sup>a</sup>	2.30 <sup>ab</sup>	2.26 <sup>bc</sup>	2.25 <sup>c</sup>	2.26 <sup>bc</sup>	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 <sup>b</sup>	17.66 <sup>a</sup>	18.17 <sup>a</sup>	17.71 <sup>a</sup>	18.23 <sup>a</sup>	0.304	< 0.001	0.009
Lys intake, g/kg gain	19.73 <sup>a</sup>	19.34 <sup>ab</sup>	18.97 <sup>b</sup>	18.90 <sup>b</sup>	19.00 <sup>b</sup>	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

<sup>ab</sup>Means within row with different superscripts differ ( $P < 0.05$ ).

<sup>1</sup>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.

<sup>2</sup>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<sup>1,2</sup>**

Item	SID Trp:Lys, %					SEM	P =	
	15	17.5	19	21	23		Linear	Quadratic
BW, lb								
d 0	220.8	219.2	220.6	218.1	220.3	3.44	0.550	0.436
d 34 <sup>3</sup>	277.7	278.0	281.9	275.5	282.9	5.27	0.451	0.732
Marketing								
First cut (d 15) <sup>4</sup>	274.4	273.4	279.2	273.5	270.1	4.58	0.470	0.293
Second cut (d 21) <sup>4</sup>	283.9	277.7	279.3	286.4	284.2	5.33	0.511	0.317
Average <sup>5</sup>	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 <sup>d</sup>	3.57 <sup>c</sup>	3.77 <sup>c</sup>	4.30 <sup>b</sup>	4.69 <sup>a</sup>	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

<sup>ab</sup>Means within row with different superscripts differ ( $P < 0.05$ ).

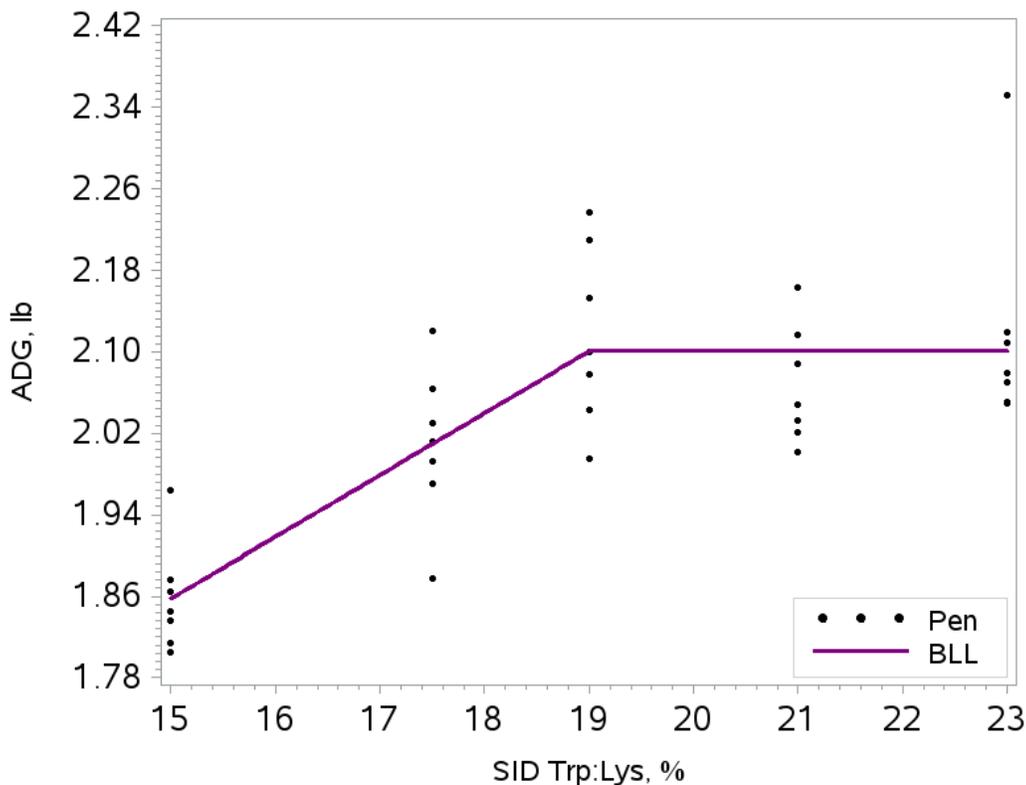
<sup>1</sup>A total of 801 pigs (initial BW = 219.8 ± 3.44 lb) were used in a 34-d growth performance study with 22 to 26 pigs per pen and 6 or 7 replicates per treatment.

<sup>2</sup>ADG = average daily gain. ADFI = average daily feed intake. F/G = feed-to-gain ratio.

<sup>3</sup>Final marketing event occurred on d 34.

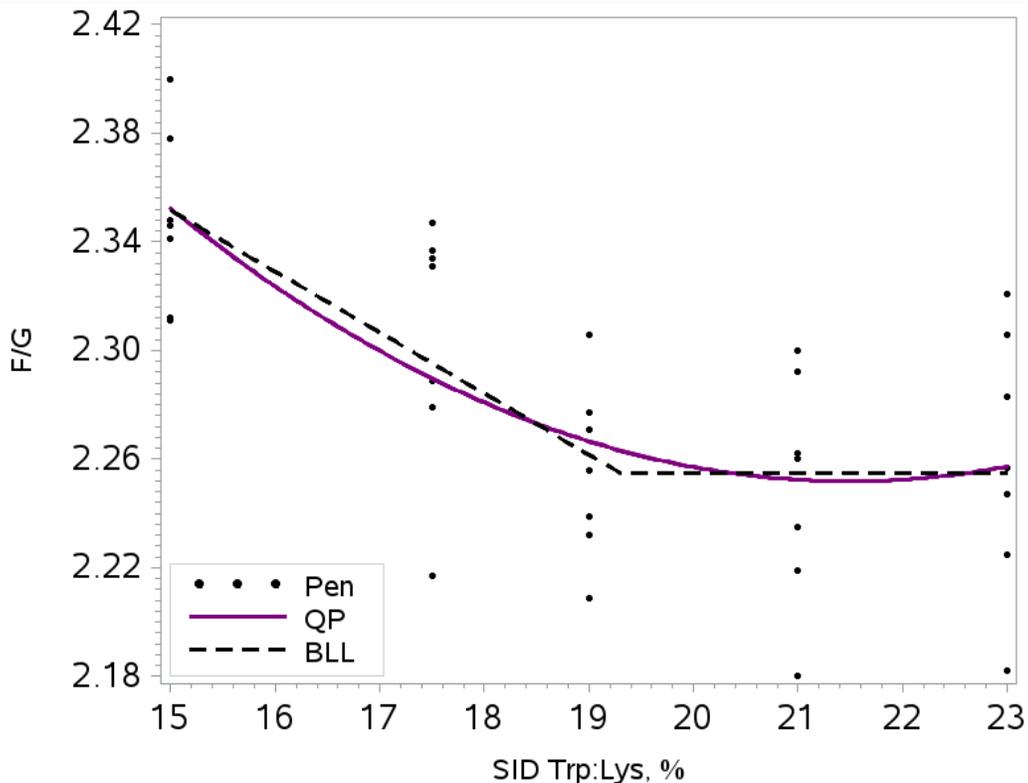
<sup>4</sup>The 4 heaviest pigs were marketed from each pen at each marketing event.

<sup>5</sup>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  $101.2 \pm 2.08$  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:  $F/G = 0.002385 \times (\text{SID Trp:Lys, \%})^2 - 0.1025 \times (\text{SID Trp:Lys, \%}) + 3.3531$ .