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Abstract

The use of feed-grade tryptophan (Trp) in swine diets has become more economical recently due to the increased cost of soybean meal and the increased usage of dried distillers grains with solubles (DDGS). Therefore, the objectives of this study were to estimate the effects of the standardized ileal digestible (SID) tryptophan:lysine (Trp:Lys) ratio on growth performance and economics of 25- to 45-lb nursery pigs housed in a commercial environment. A total of 1,088 pigs (PIC 337 Ã— 1050; initially 24.8 Â± 1.2 lb BW) were used in a 21-d growth trial. Pigs were weaned at 16 d of age and grouped into pens of 27 pigs (14 gilts and 13 barrows). Pigs were fed common diets until d 28 after weaning. On d 28, pens of pigs were weighed and blocked by average BW, then randomly assigned to 1 of 7 dietary treatments in a randomized complete block design with 6 pens per treatment. Dietary treatments contained 30% DDGS and were 14.5, 16.5, 18.0, 19.5, 21.0, 22.5, and 24.5% SID Trp:Lys ratio. The SID Trp:Lys ratio was increased by adding crystalline L-Trp to the control diet at the expense of corn. The SID Lys requirement was 1.07% and was reduced by 0.10 percentage points below the estimated requirement to ensure that lysine was the second limiting amino acid throughout the experiment. Increasing SID Trp:Lys ratio increased (quadratic, $P < 0.002$) ADG, ADFI, and final BW through the 21.0% SID Trp:Lys ratio with no change thereafter. Consequently, F/G, caloric efficiency, and income over feed cost (IOFC) also improved as the SID Trp:Lys ratio increased from 14.5 to 21.0% of Lys. For ADG, pigs fed the 18% SID Trp:Lys ratio were at 97% of maximum response, whereas for IOFC, pigs fed 18% SID Trp:Lys were at 98% of the maximum. Risk of reduced performance and profitability was much greater when SID Trp:Lys was formulated below 18% than when formulated above 18%. In conclusion, formulating nursery diets below 18% SID Trp:Lys reduced feed intake and, consequently, growth performance.; Swine Day, Manhattan, KS, November 20, 2014

Keywords

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Effects of Standardized Ileal Digestible Tryptophan:Lysine Ratio on Growth Performance and Economics of 25- to 45-lb Nursery Pigs[1,2]

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Summary

The use of feed-grade tryptophan (Trp) in swine diets has become more economical recently due to the increased cost of soybean meal and the increased usage of dried distillers grains with solubles (DDGS). Therefore, the objectives of this study were to estimate the effects of the standardized ileal digestible (SID) tryptophan:lysine (Trp:Lys) ratio on growth performance and economics of 25- to 45-lb nursery pigs housed in a commercial environment. A total of 1,088 pigs (PIC 337 × 1050; initially 24.8 ± 1.2 lb BW) were used in a 21-d growth trial. Pigs were weaned at 16 d of age and grouped into pens of 27 pigs (14 gilts and 13 barrows). Pigs were fed common diets until d 28 after weaning. On d 28, pens of pigs were weighed and blocked by average BW, then randomly assigned to 1 of 7 dietary treatments in a randomized complete block design with 6 pens per treatment. Dietary treatments contained 30% DDGS and were 14.5, 16.5, 18.0, 19.5, 21.0, 22.5, and 24.5% SID Trp:Lys ratio. The SID Trp:Lys ratio was increased by adding crystalline L-Trp to the control diet at the expense of corn. The SID Lys requirement was 1.07% and was reduced by 0.10 percentage points below the estimated requirement to ensure that lysine was the second limiting amino acid throughout the experiment.

Increasing SID Trp:Lys ratio increased (quadratic, $P < 0.002$) ADG, ADFI, and final BW through the 21.0% SID Trp:Lys ratio with no change thereafter. Consequently, F/G, caloric efficiency, and income over feed cost (IOFC) also improved as the SID Trp:Lys ratio increased from 14.5 to 21.0% of Lys. For ADG, pigs fed the 18% SID Trp:Lys ratio were at 97% of maximum response, whereas for IOFC, pigs fed 18% SID Trp:Lys were at 98% of the maximum. Risk of reduced performance and profitability was much greater when SID Trp:Lys was formulated below 18% than when formulated above 18%. In conclusion, formulating nursery diets below 18% SID Trp:Lys reduced feed intake and, consequently, growth performance.

Key words: amino acid ratio, economics, nursery, tryptophan

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Introduction

Tryptophan (Trp) is an essential amino acid in swine diets and is important for increasing feed intake. Wide availability of feed-grade lysine, threonine, and methionine in swine diets increases the importance of Trp, because it is often the next limiting amino acid. As the economical availability of feed-grade Trp has improved, interest has grown in using it as a replacement for protein sources in swine diets. However, the requirement for Trp has not been well characterized in the late nursery phase using diets with high inclusion of dried distillers grains with solubles (DDGS). Although the optimum Trp requirement in swine diets can be expressed in different ways, using a standardized ileal digestible (SID) Trp requirement expressed as a ratio to lysine (Trp:Lys) is considered a practical approach for diet formulation. As a ratio to Lys, NRC (2012[6]) suggests that the SID Trp requirement is at 16.5% of Lys for 25- to 45-lb pigs, but from a practical perspective, it is important to determine not only the growth performance but also the economic impact of different SID Trp:Lys ratios. Therefore, the objectives of these studies were to estimate the effects of SID Trp:Lys ratio on growth performance and economics of 25- to 45-lb nursery pigs housed in a commercial environment.

Procedures

The Kansas State University Institutional Animal Care and Use Committee approved the protocol used in this experiment. This study was conducted at a commercial research nursery barn in southwestern Minnesota. The facility was totally enclosed, environmentally controlled, and mechanically ventilated. Pens had completely slatted flooring and deep pits for manure storage. Each pen (12 × 7.5 ft) was equipped with a 6-hole stainless steel dry self-feeder (SDI Industries, Alexandria, SD) and a pan waterer for ad libitum access to feed and water.

Five representative samples of corn, soybean meal, and DDGS were collected each week for 5 wk before the start of the experiment and were analyzed in duplicate for total amino acids and CP by Ajinomoto Heartland, Inc. (Chicago, IL). These values, along with standardized digestibility coefficients from NRC (2012) for corn, soybean meal, and DDGS, were used in diet formulation. Diets were balanced on a NE basis using NRC (2012) values.

A total of 1,088 pigs (PIC 337 × 1050; initial BW of 24.8 ± 1.2 lb, final BW of 44.7 ± 1.9 lb, respectively) were used in a 21-d growth trial. Pigs were weaned at 16 d of age and grouped into pens of 27 pigs (14 gilts and 13 barrows). After weaning, pigs were fed a common pelleted diet for 7 d, followed by common diets fed in meal form containing 10 and 20% DDGS from d 7 to 14 and 14 to 28 after weaning, respectively, both formulated to contain a minimum 20% SID Trp:Lys ratio. On d 28 after weaning, pigs were weighed in pens, and pens were ranked by average BW and randomly assigned to dietary treatments in a randomized complete block design based on BW. There were 6 pens per treatment, and d 28 after weaning was considered d 0 of the trial.

Daily feed additions to each pen were accomplished through a robotic feeding system (FeedPro; Feedlogic Corp., Willmar, MN) capable of providing and measuring feed amounts for individual pens. This system is capable of feeding each individual pen any of the individual diets as well as a blend of two diets.

[6] NRC. 2012. Nutrient Requirements of Swine. 11th ed. Natl. Acad. Press, Washington, DC.

Two experimental corn-soybean meal–based diets with 30% DDGS were formulated (Table 1) to contain 14.5 and 24.5% SID Trp:Lys ratios and then were blended using the robotic feeding system to achieve intermediate SID Trp:Lys ratios. The SID Trp:Lys ratio was increased by adding crystalline L-Trp to the control diet at the expense of corn. The percentage of low and high SID Trp:Lys blended to create the treatment diets were 100:0, 80:20, 65:35, 50:50, 35:65, 20:80, and 0:100 to achieve 14.5, 16.5, 18.0, 19.5, 21.0, 22.5, and 24.5% SID Trp:Lys ratios, respectively. The NRC (2012) model was used to estimate the SID Lys requirement of pigs fed diets with 1,120 kcal NE/lb at the expected BW at the end of the experiment (50.0 lb). The SID Lys requirement (1.07%) was reduced by 0.10 percentage points (i.e., 0.97%) below the requirement at the end of the experiment for diet formulation to ensure that lysine was the second limiting amino acid throughout the experiment. Diets were fed in meal form and were manufactured at the New Horizon Farms Feed Mill (Pipestone, MN). A preliminary experiment was conducted prior to this experiment in the same facility and with pigs of same BW to validate that diets were indeed limiting in Lys, as described by Goncalves et al. (see "Validating a Dietary Approach to Determine Amino Acid:Lysine Ratios for Pigs," p. 83).

Pig BW and feed disappearance were measured on d 0 and 21 to calculate ADG, ADFI, F/G, and grams of SID Trp intake per kilogram of gain. Caloric efficiency was calculated on a pen basis by multiplying total pen feed intake by the dietary energy level (kcal/lb) and dividing by total pen gain. The total grams of SID Trp intake based on formulated values were divided by total BW gain to calculate the grams of SID Trp intake per kilogram of gain.

Diet samples were taken from 6 feeders per dietary treatment 3 d after the beginning and 3 d before the end of the experiment and stored at -4°F, then total amino acids and CP analyses were conducted on composite samples from each dietary treatment by Ajinomoto Heartland, Inc. Diet samples were also submitted to Ward Laboratories, Inc. (Kearney, NE) for analysis of DM, crude fiber, ash, crude fat, Ca, and P.

For the economic evaluation, total feed cost per pig, cost per pound of gain, revenue, and income over feed cost (IOFC) were calculated. The total feed cost per pig was calculated by multiplying the ADFI by diet cost and the number of days it was fed. Note that since experimental diets were formulated by adding different levels of L-tryptophan, diet cost was not optimized on a least-cost basis. Cost per pound of gain was calculated by dividing the total feed cost per pig by overall pounds gained. Revenue per pig was calculated by multiplying the ADG times the total days in the trial times an assumed live price of $68.00 per cwt. To calculate IOFC, total feed cost was subtracted from pig revenue. For all economic evaluations, price of ingredients during fall of 2013 were used; therefore, corn was valued at $6.19/bu ($221/ton), DDGS at $220/ton, soybean meal at $440/ton, L-tryptophan at $10.00/lb, and L-valine at $7.00/lb.

Responses measured at the pen level were analyzed using a general linear mixed model. The model included the fixed effect of dietary treatment and average pen BW block as a random effect. Pen was the experimental unit. Linear and quadratic orthogonal polynomial contrasts were built to evaluate the functional form of the dose response to increasing dietary SID Trp:Lys ratio on ADG, ADFI, F/G, NE caloric efficiency, BW, g of SID Trp intake per kilogram of gain, feed cost/pig, feed cost/lb of gain, total revenue/pig, and IOFC. Polynomial contrast coefficients were adjusted for unequally spaced treatment intervals. Statistical models were fitted using the MIXED procedure in SAS (SAS Institute Inc., Cary, NC). Results were considered significant at $P \leq 0.05$.

Results and Discussion

The analyzed total amino acids, DM, CP, crude fiber, Ca, P, fat and ash contents of experimental diets (Table 2) were reasonably consistent with formulated estimates.

Increasing the SID Trp:Lys ratio quadratically increased (Table 3; $P < 0.002$) ADG, ADFI, and final BW through the 21.0% SID Trp:Lys ratio, with no evidence for further improvement in performance for pigs fed the 2 higher SID Trp:Lys ratios. On the contrary, larger SID Trp:Lys ratios seemed to have a detrimental effect on growth performance; consequently, F/G and caloric efficiency improved for pigs fed 14.5 to 21.0% SID Trp:Lys ratios. Similarly, the amount in grams of SID Trp intake per kilogram of gain increased in a quadratic manner with increasing SID Trp:Lys ratio (quadratic, P < 0.001). The grams of SID Trp intake per kilogram of gain was 3.5 at 21.0% SID Trp:Lys, which is higher than NRC (2012) requirement estimates of 2.5 to 2.9 g per kilogram of gain.

Feed cost per pig increased through the 22.5% SID Trp:Lys diet (quadratic, $P < 0.002$). Feed cost per pound of gain, in turn, was reduced quadratically with an estimated lowest at 16.5% SID Trp:Lys ratio ($P < 0.001$). Feed cost per pound of gain decreased quadratically when SID Trp:Lys ratio increased from 14.5 to 16.5% due to the low ADG of pigs fed 14.5% SID Trp:Lys ratio. Above 16.5% SID Trp:Lys, feed cost per pound of gain increased with increasing SID Trp:Lys ratio. Total revenue per pig increased quadratically ($P < 0.001$) up to 21.0% SID Trp:Lys ratio, with no evidence for improvement thereafter. On the contrary, larger SID Trp:Lys ratios seemed to have a detrimental effect on total revenue. The IOFC increased through the 21.0% SID Trp:Lys ratio.

The percentage of the maximum response was plotted against the SID Trp:Lys level for ADG, F/G, and IOFC (Figure 1). Note that the lowest F/G is considered the maximum pigs' response. The best performance was obtained when pigs were fed the 21% SID Trp:Lys ratio. Also, it is important to note that for pigs fed the 18% SID Trp:Lys ratio, ADG was 97% of maximum. For IOFC, pigs fed 18% SID Trp:Lys were at 98% of the maximum. In addition, when SID Trp:Lys was at 22.5%, ADG, F/G, and IOFC were at 99% of their maximum response.

Overall, growth and economic variables improved in a quadratic fashion with increasing SID Trp:Lys ratios. Although feed cost increased with the increasing Trp:Lys ratio, the increased incremental value of the increased growth negated the increased diet cost. This result suggests that increasing the margin of safety above the 16.5 to 18% range that is typically used in the U.S. diet formulation can be accomplished with little cost to economic performance. Also, the diets fed below 18.0% SID Trp:Lys were more detrimental to economic return than those fed above this range. In conclusion, formulating nursery diets below 18% SID Trp:Lys reduced feed intake and, consequently, growth performance.

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

	Standardized ileal digestible tryptophan:lysine	
Item	Low (14.5%)	High (24.5%)
Ingredient, %		
Corn	55.16	55.06
Soybean meal (46% CP)	10.91	10.92
DDGS[2]	30.00	30.00
Beef tallow	0.50	0.50
Dicalcium phosphate (18.5% P)	0.50	0.50
Limestone	1.48	1.48
Salt	0.35	0.35
Trace mineral premix[3]	0.100	0.100
Vitamin premix[4]	0.125	0.125
L-lysine HCL	0.575	0.575
DL-methionine	0.070	0.070
L-threonine	0.140	0.140
L-tryptophan	---	0.098
L-isoleucine	0.010	0.010
L-valine	0.060	0.060
Phytase[5]	0.025	0.025
Total	100	100

continued

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

	Standardized ileal digestible tryptophan:lysine	
Item	Low (14.5%)	High (24.5%)
Calculated analysis		
Standardized ileal digestible (SID) amino acids, %		
Lysine	0.97	0.97
Isoleucine:lysine	55	55
Leucine:lysine	153	153
Methionine:lysine	35	35
Met & Cys:lysine	60	60
Threonine:lysine	65	65
Tryptophan:lysine	14.5	24.5
Valine:lysine	70	70
Histidine:lysine	38	38
Tryptophan:BCAA[6]	3.9	6.6
Tryptophan:LNAA[7]	2.8	4.8
ME, kcal/lb	1,510	1,511
NE, kcal/lb	1,120	1,121
SID lysine:ME, g/Mcal	2.91	2.91
SID lysine:NE, g/Mcal	3.93	3.93
CP, %	18.1	18.2
Ca, %	0.71	0.71
P, %	0.49	0.49
Available P, %	0.40	0.40

[1] Diets were fed from 24.8 to 44.7 lb BW. Corn, dried distillers grains with solubles (DDGS), and soybean meal were analyzed for CP and total amino acid concentrations and NRC (2012) SID digestibility values were used in the diet formulation.
[2] Dried distillers grains with solubles.
[3] Provided per pound of diet: 33 ppm Mn from manganese oxide, 110 ppm Fe from iron sulfate, 110 ppm Zn from zinc oxide, 16.5 ppm Cu from copper sulfate, 0.33 ppm I from ethylenediamin dihydroiodide, and 0.30 ppm Se from sodium selenite.
[4] Provided per pound of diet: 4,000 IU vitamin A; 625 IU vitamin D3; 20 IU vitamin E; 2.0 mg vitamin K; 12.5 mg pantothenic acid; 22.5 mg niacin; 3.5 mg riboflavin and 15 μg vitamin B12.
[5] OptiPhos 2000 (Enzyvia LLC, Sheridan, IN) provided 568 phytase units (FTU) per pound of diet.
[6] Amount of tryptophan in the diet as a ratio to branched-chain SID amino acid (BCAA; Ile, Leu, Val).
[7] Amount of tryptophan in the diet as a ratio to large neutral amino acid (LNAA; Ile, Leu, Val, Phe, and Tyr) on SID basis.

Table 2. Chemical analysis of diets (as-fed-basis)[1]

Item	Standardized ileal digestible tryptophan:lysine, %						
	14.5	16.5	18.0	19.5	21.0	22.5	24.5
Proximate analysis, %							
DM	90.48 (88.26)[2]	90.06 (88.27)	90.21 (88.27)	90.25 (88.27)	90.35 (88.27)	89.91 (88.27)	89.78 (88.28)
CP	19.0 (18.1)	19.4 (18.2)	18.8 (18.2)	18.7 (18.2)	18.9 (18.2)	19.1 (18.2)	18.2 (18.2)
Crude fiber	3.8 (4.2)	3.8 (4.2)	4 (4.2)	3.9 (4.2)	3.5 (4.2)	3.8 (4.2)	4.0 (4.2)
Ca	0.88 (0.71)	0.93 (0.71)	0.97 (0.71)	1.11 (0.71)	1.04 (0.71)	1.10 (0.71)	1.25 (0.71)
P	0.52 (0.49)	0.52 (0.49)	0.55 (0.49)	0.54 (0.49)	0.52 (0.49)	0.53 (0.49)	0.54 (0.49)
Fat	4.8 (5.2)	4.7 (5.2)	4.9 (5.2)	4.9 (5.2)	4.7 (5.2)	4.7 (5.2)	4.7 (5.2)
Ash	4.89 (4.73)	4.75 (4.73)	4.82 (4.73)	5.39 (4.72)	5.35 (4.72)	5.18 (4.72)	5.57 (4.72)
Amino acids, %							
Lysine	1.19 (1.13)	1.18 (1.13)	1.22 (1.13)	1.22 (1.13)	1.17 (1.13)	1.16 (1.13)	1.19 (1.13)
Isoleucine	0.73 (0.65)	0.75 (0.65)	0.75 (0.65)	0.75 (0.65)	0.74 (0.65)	0.76 (0.65)	0.77 (0.65)
Leucine	1.82 (1.74)	1.86 (1.74)	1.86 (1.74)	1.87 (1.74)	1.85 (1.74)	1.90 (1.74)	1.89 (1.74)
Methionine	0.40 (0.39)	0.39 (0.39)	0.40 (0.39)	0.40 (0.39)	0.40 (0.39)	0.39 (0.39)	0.40 (0.39)
Met & Cys	0.70 (0.70)	0.71 (0.70)	0.72 (0.70)	0.71 (0.70)	0.72 (0.70)	0.72 (0.70)	0.73 (0.70)
Threonine	0.82 (0.78)	0.81 (0.78)	0.83 (0.78)	0.81 (0.78)	0.83 (0.78)	0.80 (0.77)	0.81 (0.77)
Tryptophan	0.19 (0.17)	0.19 (0.19)	0.19 (0.21)	0.20 (0.22)	0.23 (0.24)	0.23 (0.25)	0.24 (0.27)
Valine	0.93 (0.83)	0.96 (0.83)	0.96 (0.83)	0.96 (0.83)	0.95 (0.83)	0.96 (0.83)	0.96 (0.83)
Histidine	0.47 (0.44)	0.48 (0.44)	0.48 (0.44)	0.48 (0.44)	0.47 (0.44)	0.49 (0.44)	0.49 (0.44)
Phenylalanine	0.88 (0.81)	0.91 (0.81)	0.90 (0.81)	0.91 (0.81)	0.90 (0.81)	0.93 (0.81)	0.93 (0.81)

[1] Diet samples were taken from 6 feeders per dietary treatment 3 d after the beginning of the trial and 3 d prior to the end of the trial and stored at -20°C, then CP and amino acid analysis was conducted on composite samples by Ajinomoto Heartland, Inc. (Chicago, IL). Samples of the diets were also submitted to Ward Laboratories, Inc. (Kearney, NE) for analysis of DM, crude fiber, Ca, P, ash, and crude fat.
[2] Values in parentheses indicate those calculated from diet formulation and are based on values from NRC (2012) with the exception of CP and total amino acid content from corn, soybean meal, and dried distillers grains with solubles, which were analyzed prior to diet formulation by Ajinomoto Heartland, Inc.

Table 3. Least square mean estimates (and corresponding SEM) for growth performance and economics of 25- to 45-lb nursery pigs subjected to dietary treatments of standardized ileal digestible tryptophan:lysine (SID Trp:Lys) ratio ranging from 14.5 to 24.5%[1,2]

	SID Trp:Lys ratio, %								Probability, $P <$	
	14.5	16.5	18.0	19.5	21.0	22.5	24.5	SEM	Linear	Quadratic
d 0 to 21										
ADG, lb	0.81	0.94	0.97	0.95	1.00	0.99	0.96	0.04	0.001	0.001
ADFI, lb	1.50	1.62	1.67	1.65	1.69	1.70	1.65	0.07	0.001	0.002
F/G	1.84	1.72	1.72	1.73	1.70	1.71	1.73	0.02	0.001	0.001
NE caloric efficiency[3]	2,066	1,927	1,925	1,940	1,900	1,919	1,935	20.8	0.001	0.001
BW, lb										
d 0	24.8	24.8	24.7	24.8	24.8	24.8	24.7	1.2	0.844	0.952
d 21	41.8	44.5	45.5	44.8	45.7	45.6	45.0	1.9	0.001	0.001
SID Trp, g/kg gain	2.6	2.8	3.0	3.3	3.5	3.7	4.1	0.04	0.001	0.001
Economics, $										
Feed cost/pig	3.55	3.88	4.05	4.04	4.18	4.24	4.18	0.18	0.001	0.002
Feed cost/lb gain[4]	0.208	0.196	0.198	0.202	0.199	0.203	0.208	0.002	0.158	0.001
Total revenue/pig[5,6]	10.63	12.31	12.72	12.44	13.04	12.97	12.51	0.52	0.001	0.001
IOFC[7]	7.08	8.43	8.67	8.41	8.86	8.73	8.33	0.35	0.001	0.001

[1] A total of 1,088 pigs (PIC 337 ×1050; initially 24.8 lb BW and 28 d postweaning) were used in a 21-d growth trial with 24 to 27 pigs per pen and 6 pens per treatment.
[2] The NRC (2012) model was used to determine the lysine requirement of mixed gender pens of pigs at the end of expected the phase range (50.0 lb), and that value was reduced by 0.10 percentage point.
[3] Caloric efficiency is expressed as kcal/lb of gain.
[4] Feed cost/lb gain = total feed cost divided by total gain per pig.
[5] One pound of live gain was considered to be worth $0.68.
[6] Total revenue/pig = total gain/pig × $0.68.
[7] Income over feed cost = total revenue/pig – feed cost/pig.

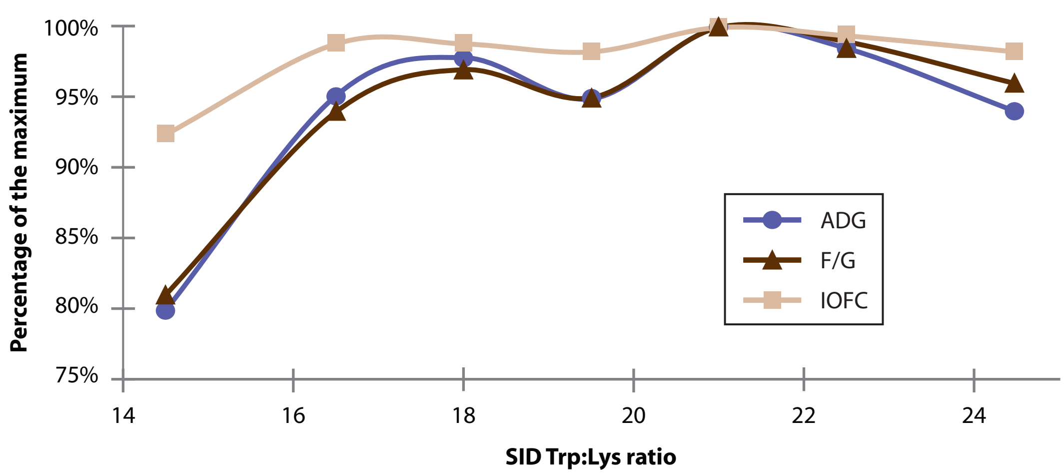

Figure 1. Effects of standardized ileal digestible tryptophan:lysine (SID Trp:Lys) ratio on ADG, F/G, and income over feed cost (IOFC) as a percentage of the maximum response observed in this experiment. (Note that the lowest F/G is considered the maximum pig response.)