THE OPTIMAL TRUE-ILEAL-DIGESTIBLE LYSINE AND TOTAL SULFUR AMINO ACID REQUIREMENT FOR NURSERY PIGS BETWEEN 20 AND 50 LB[1]

J. D. Schneider, M. D. Tokach, S. S. Dritz[2], R. D. Goodband,
J. L. Nelssen, and J. M. DeRouchey

Summary

An experiment was conducted with 360 pigs (PIC, avg BW = 22.7 lb) to determine the appropriate true-ileal-digestible (TID) lysine and total sulfur amino acid (TSAA) requirement of nursery pigs, and consequently to determine the optimal TSAA-to-lysine ratio. This trial was organized as a combination of two simultaneous experiments, with one set of diets consisting of five treatments with increasing TID lysine (0.9, 1.0, 1.1, 1.2, and 1.3%) and the second set of diets consisting of five treatments with increasing TID TSAA (0.56, 0.62, 0.68, 0.74, and 0.81%). The highest concentrations of both lysine and TSAA (1.3% and 0.81%, respectively) were combined as one diet and used in both the lysine and TSAA titrations, to give a total of 10 treatments. Pigs were randomly allotted to eight replications with five pigs per pen, on the basis of BW. Average daily gain increased (linear, P<0.01), but ADFI decreased (linear, P<0.06) with increasing TID lysine. Increasing TID lysine also improved (linear, P<0.01; and quadratic P<0.05) F/G. Increasing TID TSAA from 0.56 to 0.81% increased (linear, P<0.02) ADG and improved (linear, P<0.01) F/G. The arrangement of treatments in this experiment determined both the lysine and TSAA requirements simultaneously, which allowed the use of a regression approach in the establishment of a TID TSAA-to-lysine ratio. In this approach, ADG and F/G values are plotted as the dependent variables on the X axis and the TID lysine and TSAA concentrations are plotted on the Y axis. A trend line is fit through the data to develop a regression equation to predict the TID lysine and TSAA requirements, which can be used to estimate the TID TSAA-to-lysine ratio. The values for ADG and F/G from the individual lysine and TSAA trials must overlap to allow this approach to work. Regression analysis of the response surface resulted in an estimated TID TSAA-to-lysine ratio range of 55 to 61% for ADG and 57 to 61% for F/G.

(Key Words: Lysine, TSAA, Nursery Pigs, Pigs.)

Introduction

In practical corn-soybean meal diets, total sulfur amino acid (TSAA) concentrations are adequate for optimal swine growth. A recent fluctuation in soybean meal price has increased the use of synthetic amino acids in most diets. Coupled with this is the growing acceptance of the concept that estimates requirements of individual amino acids expressed relative to lysine. Therefore, it is essential to accurately define ratios of other amino acids to lysine.

The TSAA requirements for 20- to 50-lb pigs have recently been estimated to be .58%, with a range from .31 to .81%. Continued improvements in lean growth potential may give the pig the ability to deposit a greater amount of protein, which, in turn, may alter their requirements for certain amino acids.

A frequent limitation of experiments with amino acid ratios is determining the actual lysine requirement of the pig. Most studies calculate a ratio on the basis of the lysine concentrations used in the experimental diets; others may estimate lysine requirements from previous studies or National Research Council estimates to extrapolate a ratio. But certain drawbacks may exist for these methods. The former may create more variation of the estimate for lysine requirement if the lysine concentrations used differ too widely from the actual requirement. In the latter method, the optimal amino acid estimate derived in a titration study, by definition, would be related to the lysine rate used in that particular study and not to a predetermined lysine requirement from earlier research.

The objective of these experiments was to concurrently determine the optimal dietary lysine and TSAA requirements, and hence, obtain the appropriate TSAA-to-lysine ratio for maximum growth performance in the nursery pig.

Procedures

Three hundred and sixty pigs were blocked by weight (initially 22.66 lb) and were allotted to one of the nine dietary treatments. There were five pigs per pen and eight replicate pens per treatment. This trial was organized as a combination of two separate experiments, with one set of diets consisting of five treatments with increasing TID lysine (0.9, 1.0, 1.1, 1.2, and 1.3%); other crystalline amino acids were added to meet minimum ratios and to ensure that lysine was first limiting.

The second set of five diets were formulated to 1.3% TID lysine with increasing TID TSAA (0.56, 0.62, 0.68, 0.74, and 0.81%). The highest concentrations of both lysine and TSAA (1.3% and 0.81%, respectively) were combined as one treatment and used in both lysine and TSAA titrations to give a total of 10 treatments. The diets containing 0.9% TID lysine with 0.61% TID TSAA, 1.3% TID lysine with 0.56% TID TSAA, and 1.3% TID lysine with 0.81% TID TSAA were blended to form all other diets (Table 1).

All experimental diets were based on corn-soybean meal and were fed in a meal form throughout the 21-d experiment. Pigs were housed in the K-State Segregated Weaning Facility and allowed ad libitum access to feed and water through a dry feeder and one nipple waterer per pen. The pigs and feeders were weighed on d 7, 14, and 21 to determine ADG, ADFI, and F/G.

Blood samples were obtained by venipuncture on d 12 from two randomly selected pigs in each pen after a 3-h period of feed deprivation, and were analyzed for plasma urea N (PUN).

Data were analyzed as a randomized complete-block design with pen as the experimental unit. Pigs were blocked by weight at d 18 postweaning, and analysis of variance was performed by using the PROC MIXED procedure of SAS (SAS Inst. Inc., Cary, NC). Linear and quadratic polynomial contrasts were performed to determine the effects of increasing dietary lysine and TSAA.

Results and Discussion

From d 0 to 21, increasing TID lysine increased (linear, $P<0.01$) ADG and decreased ADFI (linear, $P<0.06$). Increasing TID lysine improved (quadratic $P<0.02$) F/G, but the biggest improvement in feed efficiency occurred as TID lysine increased from 0.9 to 1.1%, with smaller improvements from 1.1 to 1.3%. In-

creasing TID TSAA increased (linear, P<0.03) ADG and improved (linear, P<0.01) F/G. Although there was a linear response to ADG and feed efficiency, only small improvements were observed as TID TSAA increased from 0.68 to 0.81%.

Blood analysis showed a decrease (linear, $P < 0.01$) in plasma urea N as both TID lysine and TSAA were increased in the experimental diets. This suggests that when dietary TSAA was insufficient, protein deposition was limited, resulting in increased urea in plasma. As dietary methionine increased, however, and approached the pig's requirement, N was redirected from urea to protein synthesis. In a typical amino acid dose-titration study, PUN and amino acid concentrations should decrease as the limiting amino acid is increased and approaches the pig's requirement.

Average daily gain and F/G were plotted on the Y axis, and TID lysine or TSAA were plotted on the X axis, to develop a trend line equation (Figures 1 and 2; Table 4). Similar points between TID lysine and TSAA for ADG and F/G were used to form a regression analysis and to determine an optimal lysine-to-TSAA ratio. Regression analysis of the response surface resulted in an estimated TID TSAA-to-lysine ratio range of 55 to 61% for ADG and 57 to 61% for F/G. The resulting TSAA-to-lysine ratio is slightly higher than the 57% value reported by the National Research Council.

The economic importance of determining the appropriate TSAA-to-lysine ratio is evident in that, as we increase or decrease the lysine content in the diet by increasing or decreasing soybean meal, the TSAA-to-lysine ratios also change. By establishing the optimal ratio, we can balance the diets accordingly. On the basis of this research, we suggest that the TSAA-to-lysine ratio for the pig up to 50 lb is from 57 to 61%.

Table 1. Composition of Diets (As-fed Basis)[ab]

	TID Lysine/TSAA, %		
Item, %	0.9/0.61	1.3/0.81	1.3/0.56
Corn	65.90	65.90	65.90
Soybean meal, 46.5% CP	27.65	27.65	27.65
Choice white grease	1.50	1.50	1.50
Monocalcium P (21% P, 18% C)	1.55	1.55	1.55
Limestone	0.95	0.95	0.95
Salt	0.35	0.35	0.35
Vitamin premix	0.25	0.25	0.25
Trace mineral premix	0.15	0.15	0.15
Antibiotic	0.50	0.50	0.50
L-isoleucine	---	0.02	0.02
L-valine	---	0.08	0.08
L-tryptophan	---	0.03	0.03
L-threonine	---	0.25	0.25
Alimet®	---	0.29	---
L-Lysine HCl	0.02	0.53	0.53
Corn starch	1.18	0.01	0.30
Total	100.00	100.00	100.00

[a]Diets that were formulated to contain 0.90/0.61 TID lysine/TSAA and 1.30/0.81 TID lysine/TSAA were blended to achieve TID lysine concentrations of 0.99, 1.07, 1.15, 1.22, and 1.30%.
[b]Diets that were formulated to be 1.30/0.56 TID lysine/TSAA and 1.30/0.81 TID lysine/TSAA were blended to achieve TID TSAA concentrations of 0.56, 0.62, 0.68, 0.74, and 0.81%.

Table 2. Effect of Increasing True-ileal-digestible (TID) Lysine in 20- to 50-lb Nursery Pigs[a]

| Item | TID lysine, % | | | | | SE | P-value (P <) | |
	0.9	1.0	1.1	1.2	1.3		Linear	Quadratic
Day 0 to 21								
ADG, lb	1.09	1.15	1.18	1.15	1.21	0.04	0.01	0.51
ADFI, lb	1.99	1.94	1.92	1.86	1.91	0.08	0.06	0.34
F/G	1.83	1.68	1.63	1.62	1.57	0.03	0.01	0.02
Plasma urea N, mg/dL	4.32	2.79	3.04	2.23	1.88	0.35	0.01	0.29

[a]Each value is the mean of eight replications with 5 pigs (initially 22 lb) per pen.

Table 3. Effect of Increasing True-ileal-digestible (TID) Total Sulfur Amino Acids in 20- to 50-lb Nursery Pigs[a]

| Item | TID TSAA, % | | | | | SE | P-value (P <) | |
	0.56	0.62	0.68	0.74	0.81		Linear	Quadratic
Day 0 to 21								
ADG, lb	1.13	1.16	1.20	1.19	1.21	0.04	0.03	0.41
ADFI, lb	1.94	1.91	1.94	1.91	1.91	0.08	0.66	0.88
F/G	1.71	1.65	1.61	1.61	1.57	0.03	0.01	0.40
Plasma urea N, mg/dL	3.31	3.07	1.91	2.64	1.88	0.35	0.01	0.49

[a]Each value is the mean of eight replications with 5 pigs (initially 22 lb) per pen.

Lysine on F/G

$$y = 8.7024x^2 - 31.223x + 28.898$$
$$R^2 = 0.9632$$

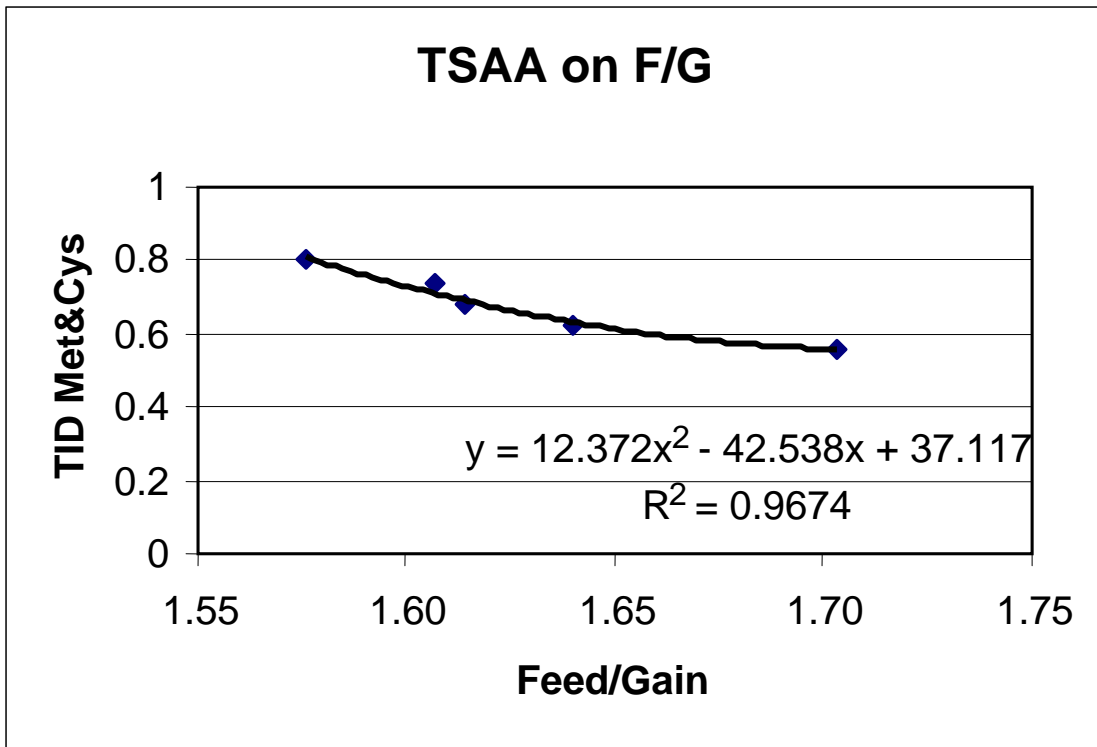**TSAA on F/G**

$$y = 12.372x^2 - 42.538x + 37.117$$
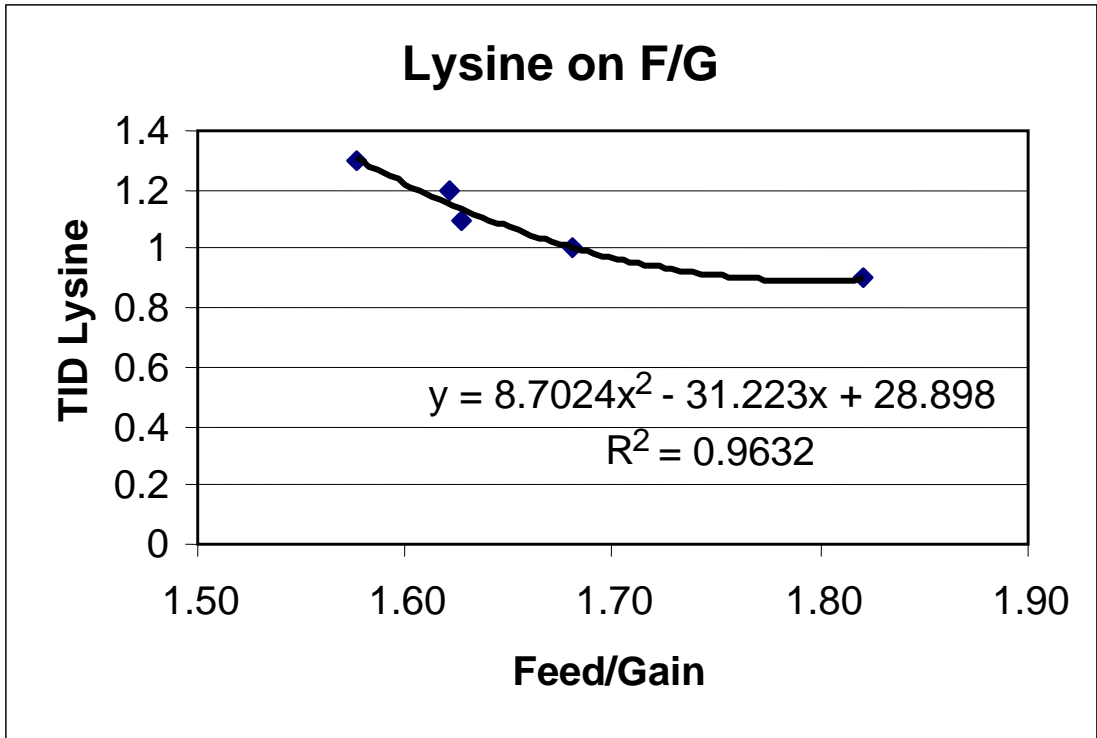$$R^2 = 0.9674$$

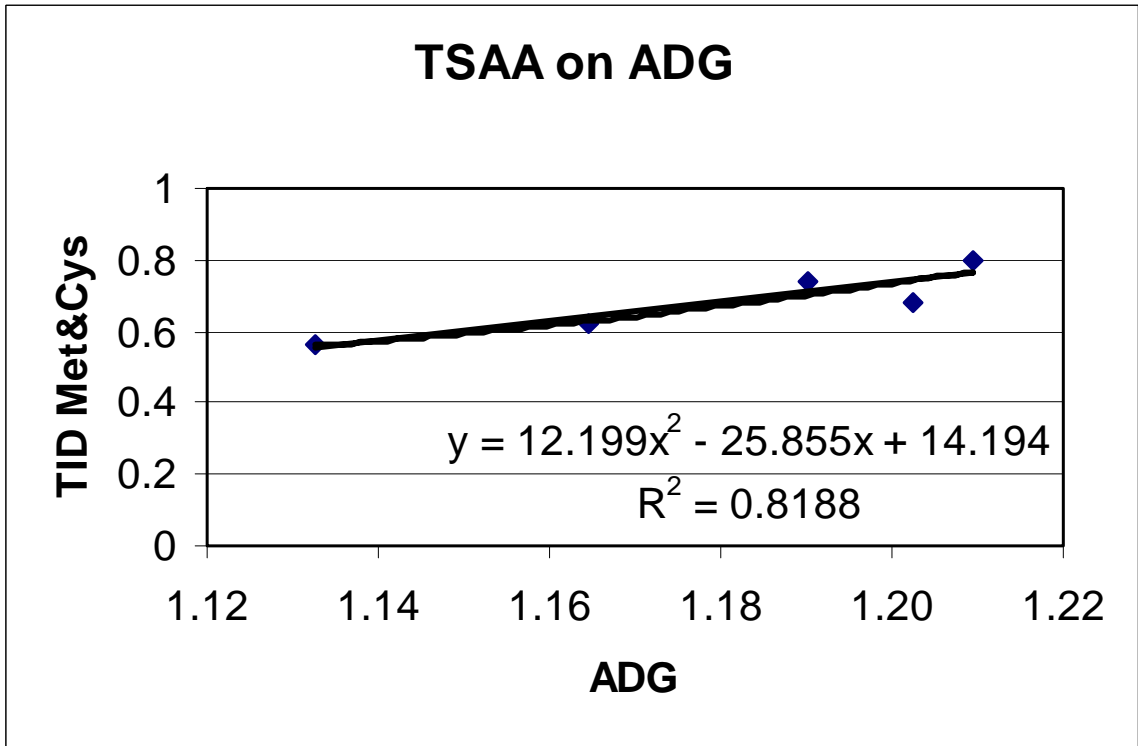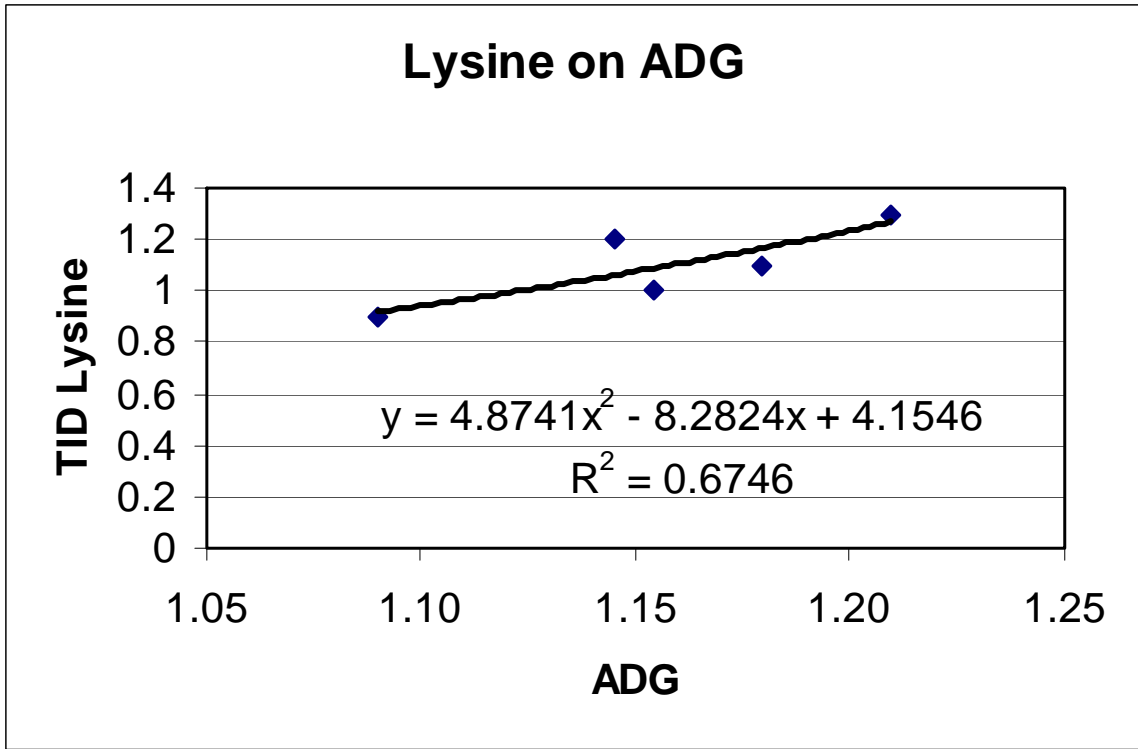**Figure 1. Regression Analysis for Lysine and TSAA for Feed Efficiency.**

Figure 2. Regression Analysis for Lysine and TSAA on ADG.

Table 4. Regression Analysis of the Response Surface[a]

Response	TID Lysine	TID TSAA	TID TSAA-to-Lysine ratio
F/G			
1.69	0.98	0.55	56.7
1.67	1.03	0.58	56.2
1.64	1.10	0.63	56.9
1.59	1.26	0.76	60.3
ADG			
1.13	1.03	0.56	54.6
1.16	1.10	0.61	55.6
1.18	1.17	0.67	57.4
1.21	1.27	0.77	60.7

[a]Values for F/G and ADG were similar for pigs fed diets with increasing TID Lysine and TSAA.