THE OPTIMAL TRUE ILEAL DIGESTIBLE LYSINE AND THREONINE REQUIREMENT FOR NURSERY PIGS BETWEEN 25 AND 55 LB[1]

N.A. Lenehan, M.D. Tokach, R.D. Goodband, J.L. Nelssen, S.S. Dritz[2], J.M. DeRouchey, J.L. Usry[3], C.W. Hastad, M.R. Barker, N.Z. Frantz, C.N. Groesbeck, B.W. James, T.P. Keegan, K.R. Lawrence, and M.G. Young

Summary

A total of 360 pigs (initially 22.2 lb and 31 d of age) was used in a 21-d growth assay. This trial was conducted as a combination of two separate trials in order to simultaneously examine both the true ileal digestible lysine and true ileal digestible threonine requirement and determine the appropriate threonine:lysine ratio. The first part of the trial consisted of five treatments with increasing dietary lysine (1.0. 1.1, 1.2, 1.3 and 1.4% true digestible lysine). The second part consisted of five treatments with increasing dietary threonine (0.66, 0.72, 0.78, 0.84 and 0.91% true ileal digestible threonine). The highest level of both lysine and threonine (1.4% and 0.91% respectively) served as a positive control, and this diet was combined as one treatment to give a total of nine treatments. Average daily gain increased to 1.3% true ileal digestible lysine, and then plateaued, while ADG increased to 0.78% true ileal digestible threonine, suggesting a threonine:lysine ratio of 60% for ADG. Increasing dietary lysine improved F/G linearly through 1.4% true ileal digestible lysine, while F/G improved up to a level of 0.84% true ileal digestible threonine. Using a level of 1.4% true ileal digestible lysine, a threonine:lysine ratio of approximately 60% is implicated for F/G.

Amino acid and plasma urea N values were measured on d 10 of the trial. Plasma lysine concentrations were maintained steadily as the true ileal digestible lysine level increased, with a slight increase in plasma lysine concentration observed as the true ileal digestible lysine level increased from 1.3% to 1.4%. A linear increase (P<.0001) in plasma threonine concentration was observed as true ileal digestible threonine increased from 0.66% to 0.91%. Plasma urea N decreased linearly (P<0.0003) with increasing true ileal digestible lysine. As true ileal digestible threonine increased, there was no difference seen in plasma urea N concentration. Following analysis of the data, a true ileal digestible threonine to lysine ratio of 60% is suggested. A second study is in progress where the higher true digestible lysine level of 1.5% is used to verify trial results.

(Key Words: Threonine, Lysine, Nursery Pigs)

---

[1]The authors would like to thank Ajinomoto Heartland LLC, Chicago, Illinois, for partial funding of this project.

[2]Food Animal Health and Management Center

[3]Ajinomoto Heartland LLC, Chicago, Illinois.

Introduction

The current National Research Council (NRC; 1998) suggests a true ileal digestible threonine:lysine ratio of 62% for a 22- to 55-lb pig. This recommendation is derived from many trials that investigated the optimal threonine:lysine ratio by titrating different threonine levels in diets containing a predetermined lysine level. There are problems with this approach to determine a ratio, as a certain lysine level is chosen without knowledge of the actual lysine requirement for the specific group of pigs used in the various studies. We cannot be certain that the lysine level used initially is adequate for the pigs. The objective of this experiment was to determine the optimal ratio of threonine to lysine in diets to maximize growth performance of nursery pigs. To achieve our objective, two experiments were run simultaneously. One trial was conducted to determine the lysine requirement, and the second to determine the threonine requirement. By examining results of both studies, we are able to determine a threonine:lysine ratio.

Procedures

A total of 360 pigs (initially 22.2 lb and 31 d of age) was used in a 21-d growth assay. Pigs were weaned at an average age of 18 d and fed a common diet for 13 d before the experiment. Pigs were housed in an environmentally controlled nursery. Temperature was maintained at 87°F for the first week and reduced by 2°F each week to maintain pig comfort. Each pen (4-ft^2 with slatted metal flooring) contained a stainless steel self-feeder and one nipple waterer to allow ad libitum consumption of feed and water.

Diets were corn-soybean meal based (Table 1). The positive control diet was formulated with the highest lysine (1.4%) and threonine (.91%) level. In formulating the remaining diets, either L-lysine HCl or L-threonine was replaced with cornstarch. L-lysine HCl addition decreased to provide 1.3, 1.2, 1.1 and 1.0% true ileal digestible lysine. The diets for the threonine trial were set at 1.4% lysine, while crystalline L-threonine decreased to obtain 0.84, 0.78, 0.72, and 0.66% true ileal digestible threonine. Diets were fed in meal form.

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

Ingredient, %	Control Diet
Corn	61.94
Soybean meal, 46.5% CP	31.65
Soy oil	1.50
Monocalcium phosphate, 21% P	1.55
Limestone	0.95
Salt	0.35
Vitamin premix	0.25
Trace mineral premix	0.15
Antibiotic	0.50
L-Isoleucine	0.02
L-Valine	0.08
L-Tryptophan	0.03
L-Threonine	0.25
L-Lysine HCl	0.53
DL-Methionine	0.25
Cornstarch[a]	---
Total	100.0
True ileal digestible lysine, %	1.40
True ileal digestible threonine, %	0.91
Isoleucine:lysine ratio, %	55
Leucine:lysine ratio, %	114
Methionine:lysine ratio, %	38
Met & Cys:lysine ratio, %	60
Threonine:lysine ratio, %	65
Tryptophan:lysine ratio, %	17
Valine:lysine ratio, %	65
ME, kcal/lb	1,521
Protein, %	20.0
Ca, %	0.77
P, %	0.72
Available P, %	0.40
TID lysine:calorie ratio, g/mcal	4.18

[a]Cornstarch replaced L-lysine (1.0, 1.1, 1.2, 1.3, 1.4%) or L-threonine (0.66, 0.72, 0.78, 0.84, 0.91%) in the control diet to form the dietary treatments.

Experimental diets were fed for 21 d. Pigs were weighed, and feed disappearance measured on d 7, 14, and 21 to determine the response criteria of ADG, ADFI, and F/G. Blood samples were obtained by venipuncture on d 10 from two randomly selected pigs in each pen following a 3-hour period of feed deprivation. Plasma urea nitrogen (PUN) concentration was determined on each sample. Plasma from pigs in the same pen was pooled for amino acid analysis.

Data were analyzed as a randomized complete block design using the PROC MIXED procedure of SAS with pen as the experimental unit. Linear and quadratic polynomial contrasts were performed to determine the effects of increasing dietary lysine and threonine.

Results and Discussion

Overall, there was a linear increase in ADG ($P<0.003$) as dietary lysine content increased from 1.0 to 1.4% true ileal digestible lysine (Table 2). Although the response to lysine was linear, there was very little increase in ADG as true ileal digestible lysine increased from 1.3 to 1.4%. Feed efficiency improved linearly ($P<0.0001$) as true ileal digestible lysine increased, indicating that we may not have reached the pigs' requirement for lysine. Plasma urea N, measured on d 10, decreased linearly ($P<0.0003$) with increasing true ileal digestible lysine, with only a slight decrease being observed between 1.3% and 1.4% true ileal digestible lysine (Table 4). Plasma lysine concentrations were not affected by increasing true ileal digestible lysine, but numerically increased as true ileal digestible lysine increased from 1.3 to 1.4%. In the lysine trial, plasma threonine, phenylalanine, and valine concentrations continued to fall linearly up to 1.4% true ileal digestible lysine ($P<0.01$).

As dietary threonine increased, there was a quadratic ($P<0.05$) increase in ADG (Table 3). Average daily gain increased to 0.78% true ileal digestible threonine and plateaus thereafter. A linear improvement in F/G ($P<0.001$) was observed as true ileal digestible threonine increased from 0.66% to 0.84%. Plasma urea N concentration was maintained as true ileal digestible threonine increased from 0.66% to 0.91%. Plasma threonine concentration increased linearly ($P<0.001$) with increasing dietary threonine. Plasma lysine concentration decreased quadratically ($P<0.004$), while plasma methionine concentration increased quadratically ($P<0.03$) for pigs fed levels of true ileal digestible threonine increasing from 0.66 to 0.91%.

Average daily gain increased with increasing dietary lysine up to a level of 1.3%, and up to 0.78% true ileal digestible threonine. Feed efficiency improved linearly as true ileal digestible lysine increased to 1.4%, while increasing dietary threonine improved F/G up to 0.84%. Thus, a ratio of 60% is implicated for both ADG and F/G. Typically, the requirement for F/G is higher than for ADG, which is also reflected in the blood analysis. In the current lysine trial, it appears from both the AA and PUN analysis, that our highest level of lysine (1.4% true ileal digestible) may not have reached the level required by these pigs for optimum performance. The results of our experiment suggest that the true ileal digestible threonine:lysine ratio for 22- to 55-lb pigs is approximately 60%.

The results of both experiments closely reflect results of other recent trials. A series of lysine experiments at Kansas State University and the University of Missouri indicates that the optimal lysine level for 25- to 55-lb pigs may be close to 1.32% true ileal digestible lysine or 1.46% total lysine. These requirements are substantially higher than the true ileal digestible lysine requirement of 1.1% suggested by NRC (1998). Similar to the higher lysine requirement, the true ileal digestible threonine requirement of 0.78 to 0.84% is considerably higher than the level of 0.63% suggested by NRC (1998). However, when compared on a

ratio basis, the 60% true ileal digestible threonine to lysine ratio as suggested by this trial is very similar to the 62% suggested by the NRC (1998). Because the lysine response was linear through the highest level fed, further research needs to be conducted to verify the optimum ratio of true ileal digestible threonine to lysine to maximize performance in nursery pigs. A future trial at Kansas State University is planned where the highest level of lysine used will be 1.5% true ileal digestible lysine, to verify current results.

Table 2. The Optimal True Ileal Digestible Lysine and Threonine Requirement for Nursery Pigs[a]

	Lysine, %					Threonine, %						Lysine		Threonine	
Item	1.0	1.1	1.2	1.3	1.4	0.66	0.72	0.78	0.84	0.91	SED	Linear	Quadratic	Linear	Quadratic
D 0 to 14															
ADG, lb	0.800	0.827	0.801	0.879	0.899	0.815^{f}	0.849^{cf}	0.919^{cd}	0.972^{c}	0.899^{ce}	0.056	0.053	0.556	0.025	0.126
ADFI, lb	1.143	1.159	1.098	1.185	1.138	1.120	1.153	1.178	1.203	1.138	0.068	0.906	0.898	0.532	0.226
F/G	1.462^{c}	1.422^{cde}	1.457^{cd}	1.384^{cdef}	1.311^{f}	1.431^{c}	1.398^{cd}	1.330^{d}	1.248^{e}	1.311^{de}	0.042	0.002	0.174	0.000	0.156
D 0 to 21[b]															
ADG, lb	1.015^{e}	1.048^{cde}	1.033^{e}	1.129^{cd}	1.134^{c}	1.029^{f}	1.099^{cdef}	1.163^{c}	1.152^{cd}	1.134^{cde}	0.051	0.003	0.656	0.014	0.048
ADFI, lb	1.489^{cd}	1.466^{cd}	1.417^{d}	1.521^{c}	1.466^{cd}	1.420^{d}	1.476^{cd}	1.524^{c}	1.500^{cd}	1.466^{cd}	0.065	0.940	0.530	0.333	0.074
F/G	1.480^{c}	1.415^{cde}	1.428^{cd}	1.372^{def}	1.315^{f}	1.428^{c}	1.375^{cd}	1.334^{d}	1.296^{e}	1.315^{de}	0.037	<.0001	0.598	0.001	0.142

[a]A total of 360 pigs (5 pigs/pen) with an initial average BW of 22.2 lb.

[b]Treatment diets were fed from d 0 to 21.

[cdef]Means in the same row with different superscripts differ (P<0.05).

Table 3. Effect of True Ileal Digestible Threonine:Lysine Ratio on Plasma Amino Acid Profile and PUN of the Nursery Pig[a]

												Probability (P<)			
	Lysine, %					Threonine, %						Lysine		Threonine	
Amino acid, µm/L	1.0	1.1	1.2	1.3	1.4	0.66	0.72	0.78	0.84	0.91	SED	Linear	Quadratic	Linear	Quadratic
Lysine	89	82	96	103	120	219	242	195	107	120	17.79	0.15	0.56	<.0001	0.004
Threonine	648	667	482	423	319	69	86	127	216	319	37.74	<.0001	0.40	0.001	0.32
Alanine	641	696	682	667	746	593	663	770	711	746	51.99	0.27	0.81	0.83	0.06
Histidine	62	50	62	42	40	43	39	44	31	40	8.74	0.06	0.72	0.36	0.65
Isoleucine	142	158	139	138	134	128	128	137	133	134	7.83	0.16	0.47	0.93	0.48
Leucine	195	215	206	203	185	175	174	195	186	185	11.98	0.40	0.12	0.87	0.24
Methionine	49	56	60	56	50	47	44	53	58	50	3.95	0.87	0.03	0.16	0.03
Phenylalanine	108	108	102	97	81	86	85	84	95	81	5.36	0.0003	0.13	0.32	0.34
Tryptophan	37	36	40	34	29	36	31	33	35	29	3.00	0.06	0.11	0.85	0.74
Tyrosine	103	108	106	100	93	90	94	98	112	93	9.65	0.37	0.45	0.39	0.14
Valine	312	329	293	269	211	245	233	220	221	211	15.24	<.0001	0.02	0.67	0.37
PUN, mg/dL	40.51	41.33	35.38	29.49	27.58	33.05	26.86	23.46	30.89	27.58	3.07	0.0003	0.64	0.11	0.31

[a]Values are means of 8 replications (pens) of individual samples from two pigs per pen for plasma urea nitrogen (PUN) concentration and pooled samples from two pigs per pen plasma amino acid concentrations. Blood samples were collected on d 10, following 3 h feed withdrawal.