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DETERMINING THE OPTIMAL LYSINE:CALORIE RATIO FOR GROWTH PERFORMANCE OF PIC NURSERY PIGS

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Summary

Two studies were conducted to evaluate the effects of increasing dietary lysine and energy density on nursery pig performance. Experiment 1 was organized as a combination of two simultaneous experiments,with one set of diets consisting of five treatments with increasing true ileal digestible (TID) lysine (1.11, 1.19, 1.26, 1.34, and 1.42%) and the second set of diets consisting of five treatments with increasing energy density (1,341, 1,408, 1,475, 1,542, and 1,609 kcal/lb). The highest level of both lysine and energy density (1.42% and 1,609 kcal/lb, respectively) were combined as one diet and used in both the lysine and energy-density titrations, to give a total of 9 diets for the 10 treatments. Pigs (PIC, avg BW = 22.5 lbs) were randomly allotted to eight replications with five pigs per pen, on the basis of BW. Overall (d 0 to 21) in Experiment 1, increasing TID lysine linearly increased (P<0.01) ADG and improved (linear, P<0.01) feed efficiency. Increasing energy density had no effect on ADG, but it decreased (linear, P<0.01) ADFI, which resulted in a linear (P<0.01) improvement in F/G. Regression analysis of the response surface was used to predict the optimal lysine:calorie ratios for ADG and F/G of 4.06 and 3.92 g lysine/Mcal ME for the PIC pigs used in this experiment. In Experiment 2, pigs (PIC, avg BW = 16.6 lbs) were fed diets with two different energy densities (1.34 or 1.49 Mcal ME/lb) with TID lysine:calorie ratios ranging from approximately 3.5 to 4.5 g/Mcal ME. There was an energy density × TID lysine:calorie ratio interaction observed for F/G. Pigs fed the low-energy diets had the greatest ADG, at a lysine:calorie ratio of 4.55. For pigs fed the high-energy diets, ADG improved as the lysine:calorie ratio improved to 4.26 g of TID lysine/Mcal ME. There was a quadratic (P<0.03) improvement in feed efficiency as the lysine:calorie ratios were increased for the pigs fed the low-energy diet, with the best F/G value observed at 4.55, but the pigs fed the high-energy diets experienced a linear (P<0.01) improvement in F/G as the lysine:calorie ratios were increased. These results suggest that the optimal lysine-to-calorie ratio is 4.26 to 4.55 g of TID lysine/Mcal ME for 20- to 50-lb PIC pigs in these facilities.

(Key Words: Lysine, Energy, Nursery Pig.)

Introduction

To satisfy the demands of consumers, modern pork producers have increased the supply of lean pork though genetic selection for maximal lean gain potential. The requirements for lysine and energy for gain have increased in today’s pig, due to an increase in efficiency in depositing lean tissue. But

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dietary energy intake provided by cereal grains may be limited by the gut capacity of the growing pig. Therefore, for optimal protein utilization, the amino acid requirement of the nursery pig must be expressed in relation to the energy density of the diet.

Nutritionists and producers typically add fat to swine diets in an attempt to raise the energy value of the diet and improve growth rate and efficiency. But most studies have determined a lysine:calorie ratio based on titrating lysine on a single energy value used in the experimental treatments. Therefore, the optimum dietary lysine-to-calorie ratio may be affected by the level of energy intake. By determining the requirements for lysine and energy concurrently, a more precise ratio should be determined.

Our objectives in this study were to determine an optimal lysine:calorie ratio for maximal growth and feed efficiency of the nursery pig by titrating a lysine and energy requirement simultaneously, and then to validate the lysine:calorie ratio by titrating lysine at two energy levels.

Procedures

Experiment 1. Three hundred sixty PIC pigs were blocked by weight (initially 22.5 lb) and allotted to one of the nine diets. 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 (1.11, 1.19, 1.26, 1.34, and 1.42%) and the second set of diets consisting of five treatments with increasing energy density (1,341, 1,408, 1,475, 1,542, and 1,609 kcal of ME per lb). The highest levels of both lysine and energy density (1.42% and 1,609 kcal, respectively) diet were combined as one treatment and used in both lysine and energy-density titrations, to give a total of 9 diets for the 10 treatments. The diets containing 1.11% and 1.42% TID lysine were blended to form the intermediate diets for the lysine titration (Table 1). The diets containing 1,341 kcal and 1,609 kcal were blended to form the intermediate diets for the energy titration.

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 Kansas State University Segregated Early Weaning Facility. Each pen was 4 × 4 ft and contained one self-feeder and one nipple waterer to provide *ad libitum* access to feed and water. The pigs and feeders were weighed on d 7, 14, and 21 to determine ADG, ADFI, and F/G.

Experiment 2. A total of 350 PIC pigs (BW of 16.6 lb) were blocked by weight and allotted to one of 10 dietary treatments. There were five pigs per pen and seven replicate pens per treatment. Pigs were housed in the Kansas State University Segregated Early Weaning Facility. Each pen was 4 × 4 ft and contained one self-feeder and one nipple waterier to provide *ad libitum* access to feed and water.

The experimental diets (Table 2) were formulated to contain similar lysine:calorie ratios, with differing energy density of the diets. Energy levels (1,340 and 1,490 kcal of ME/lb) were selected because they were in the linear portion of the response in F/G in Experiment 1. Diets for both energy levels were formulated by blending different percentages of the highest and lowest lysine:calorie ratio diets. In the low-energy diets, and partly replaced corn to avoid confounding the response with changes in energy sources. Dietary mineral and vitamin amounts were formulated to meet or exceed National Research Council recommendations.

Analysis of variance was used to analyze the data as a randomized complete-block design by using MIXED procedures of SAS. The Least Squares Difference (LSD) test was used to determine differences within energy density of the treatments (P<0.10).

Results and Discussion

Experiment 1. From d 0 to 21, ADG increased (linear, P<0.01), but there was no difference in ADFI as TID lysine increased from 1.11 to 1.42%. Increasing TID lysine also improved (linear, P<0.01) F/G, although there was no improvement in feed efficiency after 1.34% TID lysine. Increasing the energy level from 1,342 to 1,609 kcal ME in the diet had no effect on ADG, but there was a trend for a linear decrease in gain as energy increased. On the other hand, ADFI decreased (linear, P<0.01), improving (linear, P<0.01) feed efficiency (Table 3 and 4). Average daily gain and F/G were plotted on the Y axis, and TID lysine or energy density was plotted on the X axis, to develop a prediction equation (Figure 1, 2, 3, and 4). Similar points between TID lysine and energy density for ADG and F/G were used to form a regression analysis and to determine an optimal lysine:calorie range (Table 5). Regression analysis of the response surface resulted in estimated optimal lysine-to-calorie ratios for ADG and F/G of 4.06 and 3.92 g TID lysine per Mcal ME, respectively.

Experiment 2. From day 0 to 21, (Table 6) increasing the lysine:calorie ratio increased (P<0.01) ADG and lysine intake, whereas increasing the energy density decreased (P<0.01) ADFI. Pigs fed the diets containing 1,340 kcal/lb of ME had a linear (P<0.01) response to ADG as the lysine:calorie ratio increased. Pigs fed the diets containing 1,490 kcal/lb of ME showed no effect on ADG as the lysine:calorie ratio increased. There was no effect on ADFI for pigs fed diets with either the 1,340 or 1,490 kcal/lb of ME, but there was a linear (P<0.11; P<0.19, respectively) trend to decreased intake. There was an energy density × lysine:calorie ratio interaction (P<0.10) observed for F/G. Pigs fed the 1,340 kcal/lb of ME had improved (quadratic, P<0.03) F/G as the lysine:calorie ratio increased, whereas pigs fed the diets containing 1,490 kcal/lb of ME tended to have improved (linear, P<0.01) F/G as the lysine:calorie ratio increased. Pigs fed both energy-density diets tended to increase (linear, P<0.01) lysine intake as the lysine:calorie ratio increased.

There are many factors that may change the lysine and energy requirement of the young, rapidly growing pig, such as feed intake and genetic potential for gain. Also, determining the optimal lysine-to-calorie ratio for different energy densities is a critical response to study based on production and feed parameters. In our lab, 20- to 50-lb Gentiporc pigs previously were used for a similar experiment and were found to require approximately 10 to 11 g/d of TID lysine intake to maximize growth performance, with a suggested optimal lysine to calorie ratio is 3.30 to 3.87 g of TID lysine/Mcal ME. In the present study, it was determined that increasing the energy density of the diet improved feed efficiency, but there was no response in ADG or ADFI for PIC pigs. In addition, it seems that these pigs require approximately 9 to 10 g/d of TID lysine intake to optimize growth performance. These results suggest that the optimal lysine-to-calorie ratio is 4.26 to 4.55 g of TID lysine/Mcal ME for 20- to 50-lb PIC pigs in this environment. These finding will need to be further investigated because the pigs in the second experiment weighed approximately 17 pounds at the beginning of the trial.

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

	True Ileal Digestible Lysine (%)/ME (kcal)		
Item, %	1.11/1,605	1.42/1,609	1.41/1,341
Corn	54.90	54.11	49.11
Soybean meal (46.5% CP)	36.66	36.65	6.65
Soybean oil	5.00	5.00	0.00
Sand	0.00	0.00	10.00
Monocalcium P (21% P, 18.5% Ca)	1.25	1.25	1.25
Limestone	0.90	0.90	0.90
Salt	0.35	0.35	0.35
Trace mineral premix	0.15	0.15	0.15
Vitamin premix	0.25	0.25	0.25
L-threonine	0.00	0.20	0.20
Antibiotic	0.50	0.50	0.50
L-lysine HCl	0.00	0.40	0.40
DL-methionine	0.00	0.24	0.24
Total	100.00	100.00	100.00

[a]Diets that were formulated to be 1.11/1,605 lys/ME and 1.42/1,609 lys/ME were blended to achieve TID lysine concentrations of 1.11, 1.19, 1.26, 1.34, and 1.42%.
[b]Diets that were formulated to be 1.41/1,341 lys/ME and 1.42/1,609 lys/ME were blended to achieve ME concentrations of 1,341, 1,408, 1,475, 1,542, and 1,609 kcal/lb.

Table 2. Composition of Diets (As-fed Basis), Experiment 2

		1,340 kcal/lb[a]		1,490 kcal/lb[b]	
Item, %	Lysine:calorie Ratio, g/Mcal:	3.50	4.55	3.55	4.49
Corn		52.41	56.57	63.39	62.61
Soybean meal (46.5% CP)		34.06	29.10	33.10	33.10
Sand		10.00	10.00	0.00	0.00
Monocalcium P (21% P, 18% Ca)		1.35	1.35	1.35	1.35
Limestone		0.90	0.90	0.90	0.90
Salt		0.35	0.35	0.35	0.35
Trace mineral premix		0.15	0.15	0.15	0.15
Vitamin premix		0.25	0.25	0.25	0.25
L-valine		0.00	0.03	0.00	0.03
L-threonine		0.00	0.20	0.00	0.19
Antibiotic		0.50	0.50	0.50	0.50
L-lysine HCl		0.00	0.40	0.00	0.40
DL-methionine		0.03	0.22	0.03	0.22
Total		100.00	100.00	100.00	100.00

[a]Diets were formulated to contain 1.34 Mcal/lb of ME, with 3.50, 3.77, 4.03, 4.29, and 4.55 lysine:calorie ratios.
[b]Diets were formulated to contain 1.49 Mcal/lb of ME, with 3.55, 3.79, 4.03, 4.26, and 4.49 lysine:calorie ratios.

Table 3. The Effect of Increasing TID Lysine for the Growing Pig, Experiment 1[a]

	TID lysine, %						Probability, P <	
Item	1.11	1.19	1.26	1.34	1.42	SE	Linear	Quadratic
d 0 to 21								
ADG, lb	1.22	1.26	1.26	1.30	1.32	0.08	0.01	0.98
ADFI, lb	1.77	1.77	1.78	1.73	1.75	0.05	0.58	0.93
F/G	1.48	1.40	1.42	1.33	1.33	0.03	0.01	0.54

[a]Each value is the mean of eight replications with 5 pigs (initially 20.5 lb) per pen.
[b]Average metabolizable energy was 1,607 kcal/lb and is similar for all diets.

Table 4. The Effect of Increasing Energy Density for the Growing Pig, Experiment 1[a]

	Metabolizable Energy, kcal/lb						Probability, P <	
Item	1,341	1,408	1,475	1,542	1,609	SE	Linear	Quadratic
d 0 to 21								
ADG, lb	1.37	1.37	1.35	1.33	1.32	0.08	0.11	0.83
ADFI, lb	2.05	1.95	1.92	1.81	1.75	0.05	0.01	0.99
F/G	1.52	1.42	1.42	1.35	1.33	0.03	0.01	0.39

[a]Each value is the mean of eight replications, with 5 pigs (initially 20.5 lb) per pen.
[b]Average TID lysine content for increasing energy density is 1.42%, and is similar for all diets.

Table 5. Regression Analysis of the Response Surface[a]

Response	TID Lysine, %	Energy Density, kcal	TID Lysine:ME, g/Mcal
F/G			
1.33	1.38	1,522	3.92
1.35	1.34	1,562	3.88
1.40	1.23	1,477	3.76
1.45	1.12	1,402	3.61
ADG			
1.32	1.43	1,597	4.06

[a]Values for F/G and ADG were similar for pigs fed diets with increasing TID lysine and energy density.

Table 6. Effects of Increasing Energy Density and Lysine:calorie Ratio on Pig Performance (d 0 to 21), Experiment 2

ME, Mcal	Lysine/ME Ratio	ADG, lb	ADFI, lb	F/G	Total Lysine Intake, g/d
1.34	3.50	0.99	1.60	1.63	7.50
	3.77	1.00	1.59	1.60	7.98
	4.03	1.04	1.66	1.61	8.93
	4.29	1.11	1.71	1.55	9.80
	4.55	1.12	1.64	1.45	10.01
1.49	3.55	1.03	1.51	1.50	8.02
	3.79	1.06	1.50	1.44	8.49
	4.03	1.05	1.48	1.42	8.88
	4.26	1.11	1.49	1.34	9.48
	4.49	1.06	1.44	1.37	9.66
SE		0.05	0.08	0.03	0.44
		Probability, P <			
Main effects					
Energy		0.61	0.01	0.01	0.68
Lysine/ME		0.01	0.55	0.01	0.01
Energy × lysine/ME		0.28	0.26	0.10	0.15
1.34 ME Mcal, Lysine/ME ratio					
Linear		0.01	0.11	0.01	0.01
Quadratic		0.71	0.41	0.03	0.46
1.49 ME Mcal, Lysine/ME ratio					
Linear		0.26	0.19	0.01	0.01
Quadratic		0.31	0.74	0.19	0.66

[a]Each value is the mean of seven replications, with 5 pigs (initially 16.6 lb) per pen.

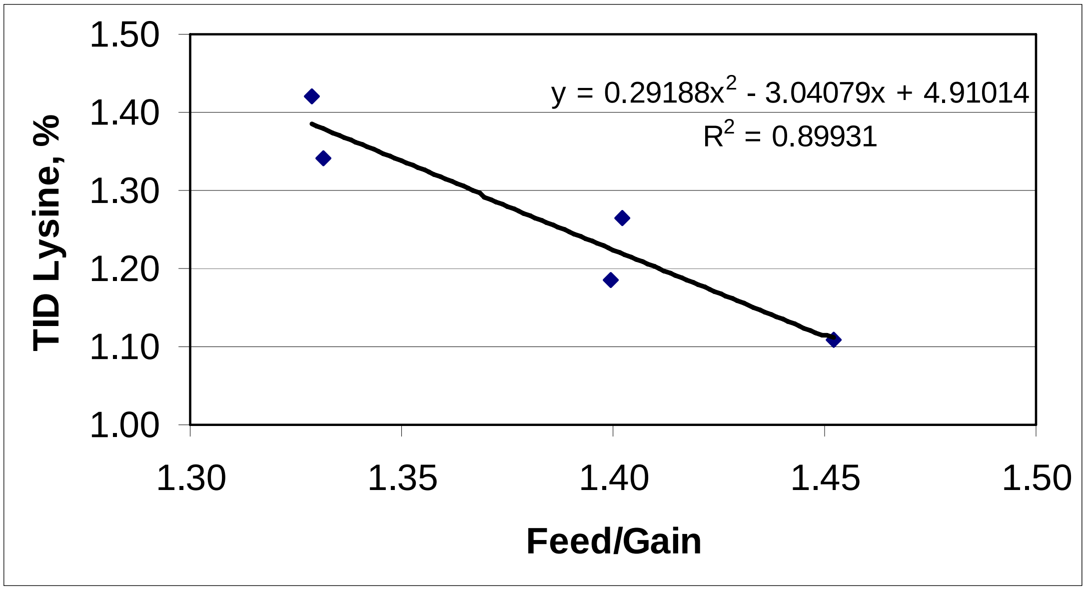

Figure 1. Regression Analysis for Feed Efficiency of Lysine.

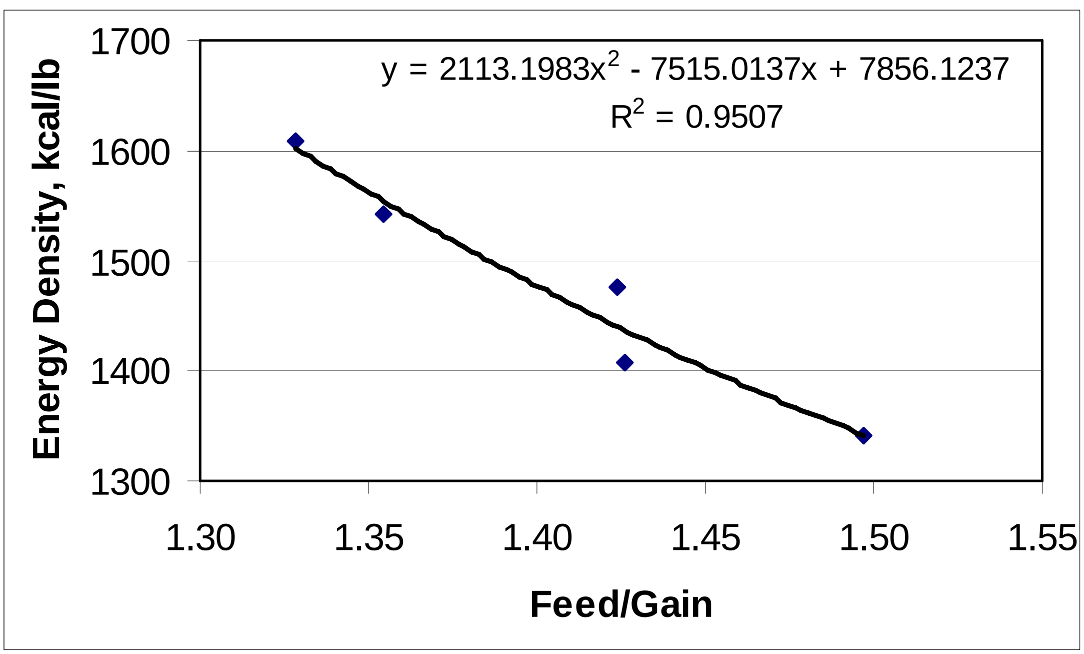

Figure 2. Regression Analysis for Feed Efficiency of Energy Density.

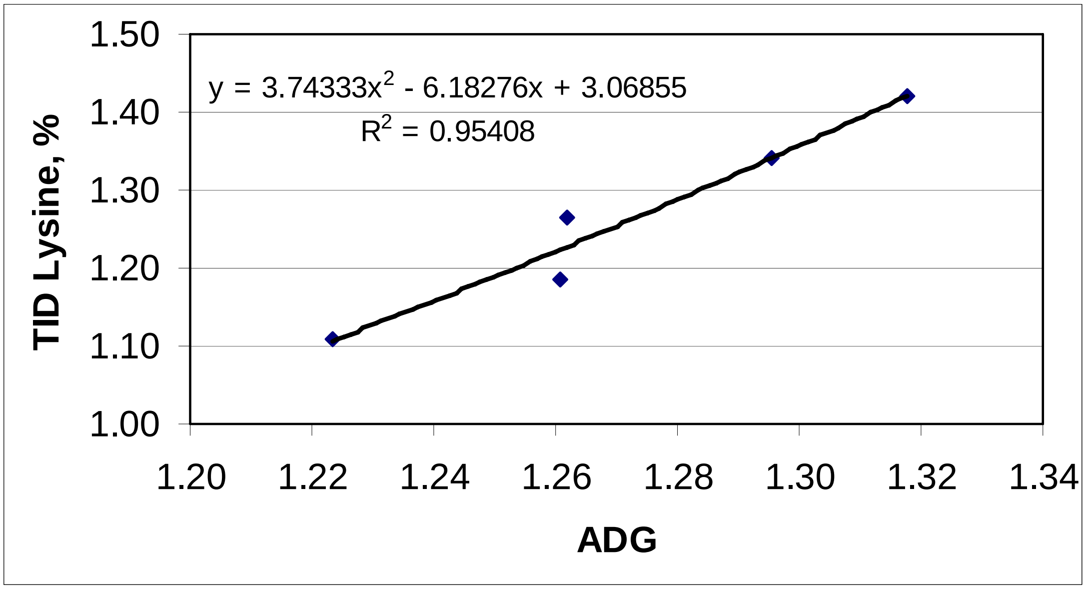

Figure 3. Regression Analysis for ADG of Lysine.

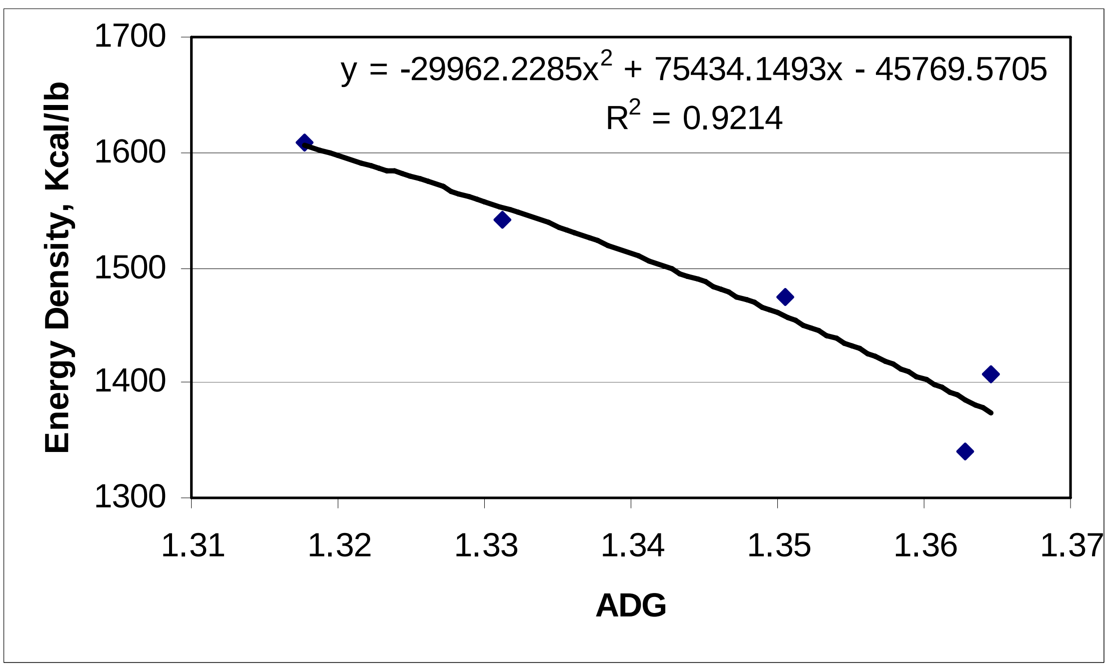

Figure 4. Regression Analysis for ADG of Energy Density.