Kansas Agricultural Experiment Station Research Reports

Volume 0
Issue 10 *Swine Day (1968-2014)*

Article 1091

2004

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DETERMINING THE OPTIMAL LYSINE TO CALORIE RATIO FOR GROWTH PERFORMANCE OF 20- TO 50-LB GENETIPORC 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. Exp. 1 was organized as a combination of two simultaneous experiments, with one set of diets consisting of five treatments with increasing TID lysine (0.99, 1.07, 1.14, 1.22, and 1.30%) concentrations, and the second set of diets consisting of five treatments with increasing energy density (1342, 1406, 1471, 1535, and 1600 kcal/lb). The highest l of both lysine and energy density (1.30% and 1600 kcal/lb, respectively) were combined as one diet and used in both the lysine and energy-density titrations to give a total of 10 treatments. Pigs were randomly allotted to 8 replications with 5 pigs per pen on the basis of BW. Overall (d 0 to 21) in Exp. 1 increasing true-ileal-digestible (TID) lysine increased ADG linearly and improved feed efficiency. Although increasing energy density had no effect on ADG, ADFI decreased, which resulted in a quadratic improvement in F/G. Regression analysis of the response surface was used to predict the optimal lysine-to-calorie ratio of 3.65 to 3.71 g lysine/Mcal ME for the Gentiporc pigs used in this experiment. In Exp 2, pigs were fed diets with two different energy densities (1.34 or 1.49 Mcal ME/lb) with TID lysine-to-calorie ratios ranging from 3.1 to 4.1 g/Mcal ME. There was an energy density by TID lysine-to-calorie ratio interaction observed for ADG. Pigs fed the low-energy diets had the greatest ADG at a lysine-to-calorie ratio of 3.60. For pigs fed the high energy diets, ADG improved as the lysine-to-calorie ratio improved to 3.36 g of TID lysine/Mcal ME. There was a quadratic improvement in feed efficiency as the lysine-to-calorie ratios were increased for the pigs fed the low-energy diet, with the best F/G value observed at 3.87; but the pigs fed the high-energy diets had a linear improvement in F/G as the lysine-to-calorie ratios were increased. Although there was a linear improvement in F/G for the high-energy diet, little improvement in feed efficiency was observed when the lysine-to-calorie ratio was increased from 3.36 to 4.07. On the basis of these results, we suggest that the optimal lysine-to-calorie ratio is 3.30 to 3.87 g of TID lysine/Mcal ME for 20- to 50-lb Genetiporc pigs in these facilities.

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

Introduction

The lysine requirement of nursery pigs weighing between 20 to 50 lb has been extensively studied and was determined to be 1.01% on a true-ileal-digestible (TID) basis. But there are many issues that can change the requirement for lysine. One such factor in the young rapidly growing pig could be the interaction between energy density and lysine in-

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take. Protein deposition in the nursery pig has been shown to be limited by feed or energy intake. Thus, the amino acid requirements must be expressed in relation to the energy density of the diet. But the design used in most experiments doesn't allow the determination of the correct requirement of lysine in relation to the energy density of the diet. Most studies titrate lysine concentration with a single energy level and then calculate a lysine-to-calorie ratio based on the energy level used in the experimental diets. By determining the requirements for lysine and energy at the same time, we should be able to determine an optimal ratio more precisely.

Therefore, our objectives in this study was to first determine an optimal lysine-to-calorie ratio for maximal growth and feed efficiency of the 20- to 50-lb pig by titrating a lysine and energy requirement simultaneously, and then validate the lysine-to-calorie ratio by titrating lysine at two energy levels.

Procedures

Experiment 1. Three hundred and sixty Gentiporc 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 (0.99, 1.07, 1.15, 1.22, and 1.30%), and the second set of diets consisting of five treatments with increasing energy density (1342, 1406, 1471, 1535, and 1600 kcal of ME per lb). The highest rates of both lysine and energy density (1.3% and 1600 kcal, respectively) were combined as one diet and used in both the lysine and energy-density titrations to give a total of 10 treatments. The diets containing 0.99% and 1.30% TID lysine were blended to form the other diets for the lysine titration (Table 1). The diets containing 1342 kcal and 1600 kcal were blended to form the other 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 waterier to provide ad libitum access to feed and water. Initial temperature of the facility was 90ºF for the first 7 d after weaning, and was lowered approximately 3ºF for each subsequent weeks of the experiment. 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 Genetiporc pigs (BW of 20.7 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-to-calorie ratios, with differing energy density of the diets. Energy levels (1340 and 1490 kcal of ME per lb) were selected because they were in the linear portion of the response in F/G in Exp 1. Diets for both energy-density levels were formulated by blending different percentages of the highest and lowest lysine-to-calorie ratio diets. In the low-energy-density diets, sand partly replaced corn to avoid confounding the response with changes in energy sources. Dietary mineral and vitamin content was formulated to meet or exceed National Research Council recommendations.

Analysis of variance was used to analyze the data as a randomized complete-block design using MIXED procedures of SAS. The Least Square Difference (LSD) test was used to determine differences within energy density of the treatments ($P<0.05$).

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 0.99 to 1.30%. The greatest ADG was at 1.22% TID lysine. Increasing TID lysine also improved (linear, P<0.01) F/G. Increasing the energy density from 1342 to 1600 ME in the diet had no effect on ADG, but ADFI decreased (linear, P<0.01), thus improving (quadratic, 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 and 2). 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-to-calorie ratio (Table 5). Regression analysis of the response surface resulted in an estimate lysine-to-calorie ratio for ADG and F/G of 3.71 and 3.65 g TID lysine per Mcal ME, respectively.

Experiment 2. Over the entire experiment period (Table 6), there was a energy density × lysine-to-calorie ratio interaction (P<0.03) observed for ADG. Pigs fed the diets containing 1340 kcal of ME per lb had a linear and quadratic (P<0.01; P<0.06, respectively) response to the increasing lysine-to-calorie ratio, with the greatest ADG for pigs fed the diet with 3.6 g TID lysine per Mcal ME. Pigs fed the diets containing 1490 kcal of ME per lb had a quadratic (P<0.01) response to an increasing lysine-to-calorie ratio, with the optimal response at 3.36 g TID lysine per Mcal ME. Increasing energy density decreased ADFI (P<0.01) and improved (P<0.01) F/G. Increasing the lysine-to-calorie ratio also decreased (P<0.06) ADFI and improved (P<0.01) feed efficiency. Pigs fed the diets with 1340 kcal of ME per lb had improved (quadratic, P<0.01) F/G as the lysine-to-calorie ratio increased, whereas pigs fed the diets containing 1490 kcal of ME per lb tended to have decreased (linear, P<0.03) ADFI and improved (linear, P<0.01) F/G as the lysine-to-calorie ratio increased. There was an energy density × lysine-to-calorie ratio interaction (P<0.03) observed for total lysine intake. Pigs fed both energy-density diets tended to increase (linear, P<0.01) lysine intake as the lysine-to-calorie ratio increased.

The importance of determining the appropriate lysine-to-calorie ratio for different energy densities is that, as we increase or decrease the energy density or lysine content in the diet by diet manipulation, the lysine-to-calorie ratio also changes. By establishing the optimal ratio, we can balance the diets accordingly. Increasing the energy density of the diet decreased ADFI and improved feed efficiency, but there was no response in ADG. Furthermore, it seems that these pigs require approximately 10 to 11 g/d of TID lysine intake to maximize growth performance. On the basis of these results, we suggest that the optimal lysine-to-calorie ratio is 3.30 to 3.87 g of TID lysine/Mcal ME for 20- to 50-lb Genetiporc pigs in these facilities. It may be possible that in our research environment, feed intake is already high enough to maximize ADG. These findings should be further evaluated in a commercial environment (i.e., 25 pigs per pen, etc.), in which feed intakes are typically less than in university research facilities.

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

	TID Lysine (%)/ME (kcal)		
Item, %	0.99/1600	1.30/1600	1.30/1342
Corn	59.69	58.90	53.90
Soybean meal (46.5% CP)	31.91	31.90	31.90
Choice white grease	5.00	5.00	0.00
Sand	0.00	0.00	10.00
Monocalcium P (21% P, 18% C)	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	0.20	0.20
Total	100.00	100.00	100.00

[a]Diets that were formulated to be 0.99/1600 lys/ME and 1.30/1600 lys/ME were blended to achieve true-ileal-digestible (TID) lysine concentrations of 0.99, 1.07, 1.15, 1.22, and 1.30%.
[b]Diets that were formulated to be 1.30/1342 lys/ME and 1.30/1600 lys/ME were blended to achieve ME rates of 1342, 1406, 1471, 1535, and 1600 kcal.

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

		1,340 kcal/lb[a]		1,490 kcal/lb[b]	
Item, %	Lysine-to-calorie Ratio, g/Mcal	3.08	4.13	3.13	4.07
Corn		57.39	56.57	63.39	62.61
Soybean meal (46.5% CP)		29.10	29.10	33.10	33.10
Sand		10.00	10.00	0.00	0.00
Monocalcium P (21% P, 18% C)		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	0.02	0.00	0.00
L-isoleucine		0.00	0.01	0.00	0.00
L-tryptophan		0.00	0.01	0.00	0.00
L-threonine		0.00	0.19	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		0.01	0.20	0.01	0.20
Total		100.00	100.00	100.00	100.00

[a]Diets were formulated to contain 2.89 ME with 3.08, 3.34, 3.60, 3.87, and 4.13 lysine-to-calorie ratios.
[b]Diets were formulated to contain 3.23 ME with 3.13, 3.36, 3.60, 3.83, and 4.07 lysine-to-calorie ratios.

Table 3. The Effects of Increasing TID Lysine for Growing Pigs, Exp. 1[a]

	TID Lysine, %[b]						P-value (P <)	
Item	0.99	1.07	1.15	1.22	1.30	SE	Linear	Quadratic
Day 0 to 21								
ADG, lb	1.21	1.23	1.27	1.30	1.29	0.04	0.01	0.58
ADFI, lb	2.00	1.95	1.98	2.01	1.98	0.07	0.99	0.86
F/G	1.69	1.61	1.58	1.55	1.53	0.03	0.01	0.27

[a]Each value is the mean of eight replications with 5 pigs (initially 22.5 lb) per pen.
[b]Average energy density for increasing TID lysine % is 1598 kcal and is similar for all diets.

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

	Energy Density, kcal/lb[b]						P-value (P <)	
Item	1342	1406	1471	1535	1600	SE	Linear	Quadratic
Day 0 to 21								
ADG, lb	1.26	1.34	1.32	1.29	1.29	0.04	0.90	0.14
ADFI, lb	2.33	2.25	2.13	2.03	1.98	0.07	0.01	0.62
F/G	1.84	1.67	1.61	1.58	1.53	0.03	0.01	0.01

[a]Each value is the mean of eight replications with 5 pigs (initially 22.5 lb) per pen.
[b]Average TID lysine concentration for increasing energy level is 1.30% and is similar for all diets.

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

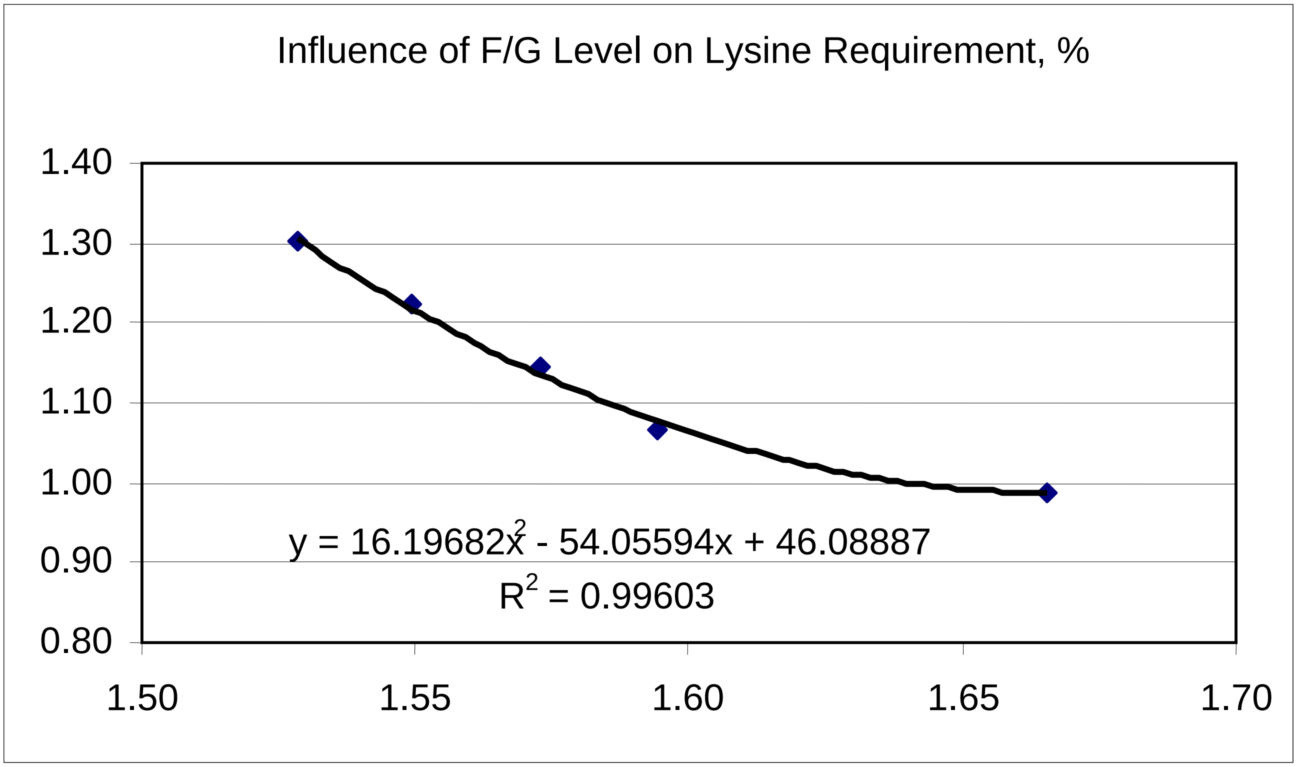
Response	TID Lysine, %	Energy Density, kcal	TID Lysine:ME, g/Mcal
F/G			
1.53	1.30	1,612	3.65
1.55	1.22	1,577	3.49
1.60	1.06	1,502	3.21
1.67	0.99	1,421	3.15
ADG			
1.29	1.27	1,548	3.71
1.28	1.23	1,500	3.71
1.27	1.19	1,422	3.80
1.265	1.17	1,371	3.88

[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-to-calorie Ratio on Pig Performance (d 0 to 21), Exp. 2[a]

ME, Mcal	Lysine/ME Ratio	ADG, lb	ADFI, lb	F/G	Total Lysine Intake, g/d
2.89	3.08	1.19	2.21	1.87	9.08
	3.34	1.23	2.19	1.77	9.80
	3.60	1.32	2.28	1.72	11.02
	3.87	1.26	2.13	1.68	11.03
	4.13	1.30	2.27	1.73	12.53
3.23	3.13	1.21	2.03	1.68	9.49
	3.36	1.31	2.07	1.56	10.37
	3.60	1.30	2.07	1.58	11.14
	3.83	1.24	1.96	1.56	11.25
	4.07	1.26	1.94	1.54	11.78
SE		0.04	0.10	0.05	0.49
		P-value (P<)			
Main Effects					
Energy		0.78	0.01	0.01	0.41
Lysine/ME		0.01	0.06	0.01	0.01
Energy × lysine/ME		0.03	0.17	0.32	0.03
2.89 ME Mcal, Lysine/ME ratio					
Linear		0.01	0.71	0.01	0.01
Quadratic		0.06	0.72	0.01	0.65
3.23 ME Mcal, Lysine/ME ratio					
Linear		0.58	0.03	0.01	0.01
Quadratic		0.01	0.15	0.11	0.10

[a]Each value is the mean of seven replications with 5 pigs (initially 20.7 lb) per pen.



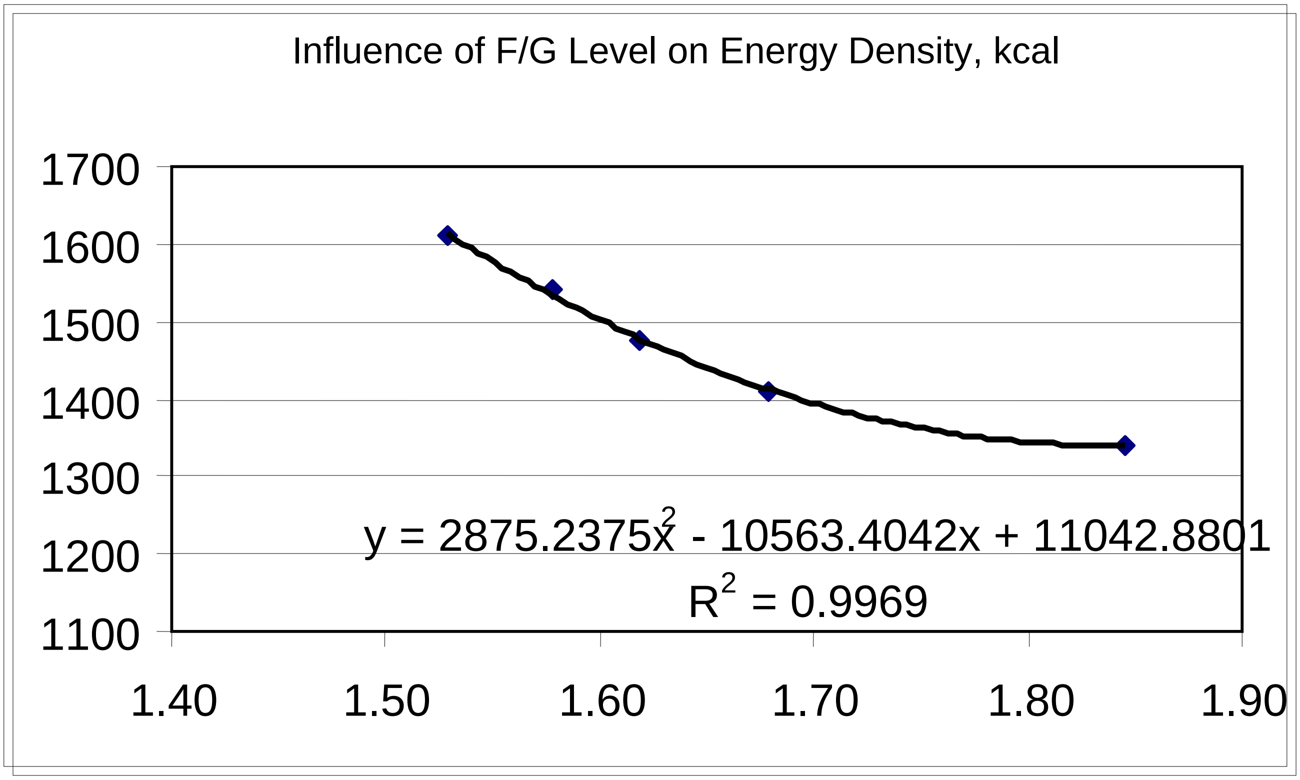
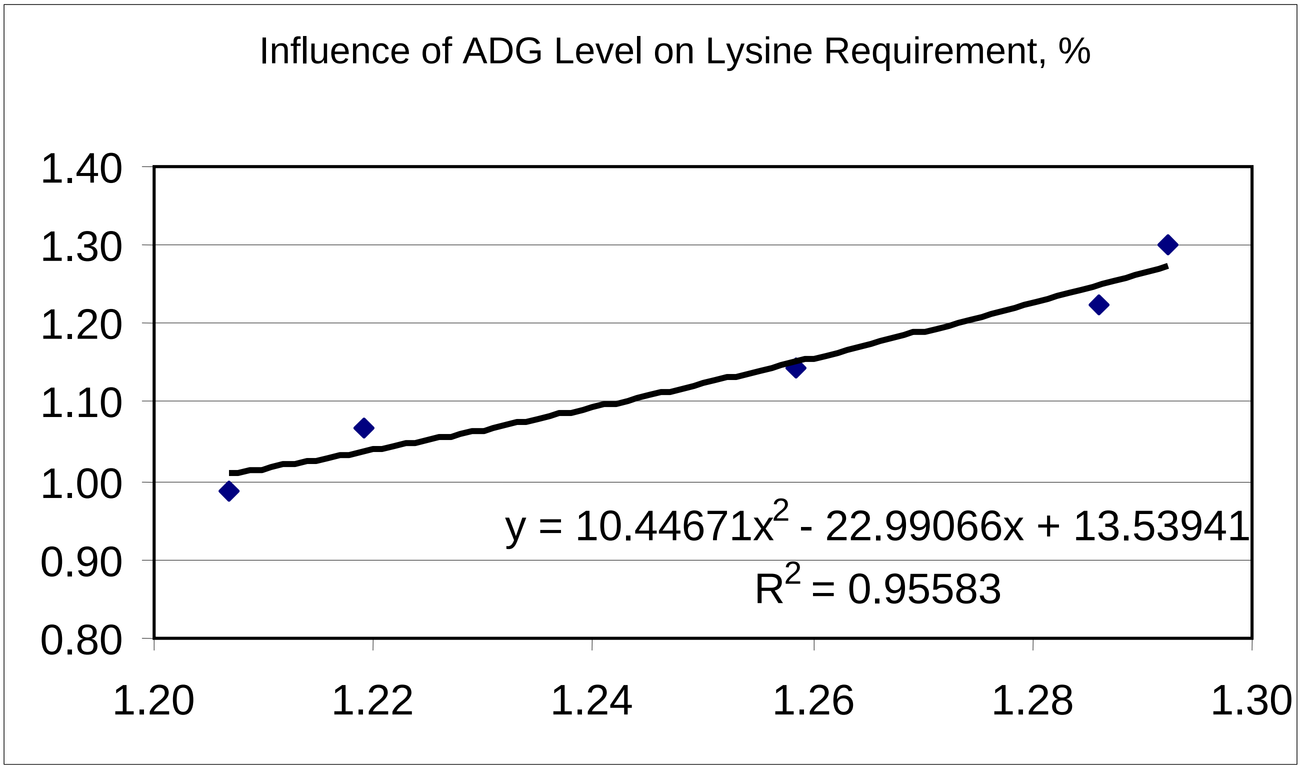


Figure 1. Regression Analysis for Lysine and Energy Density for Feed Efficiency.



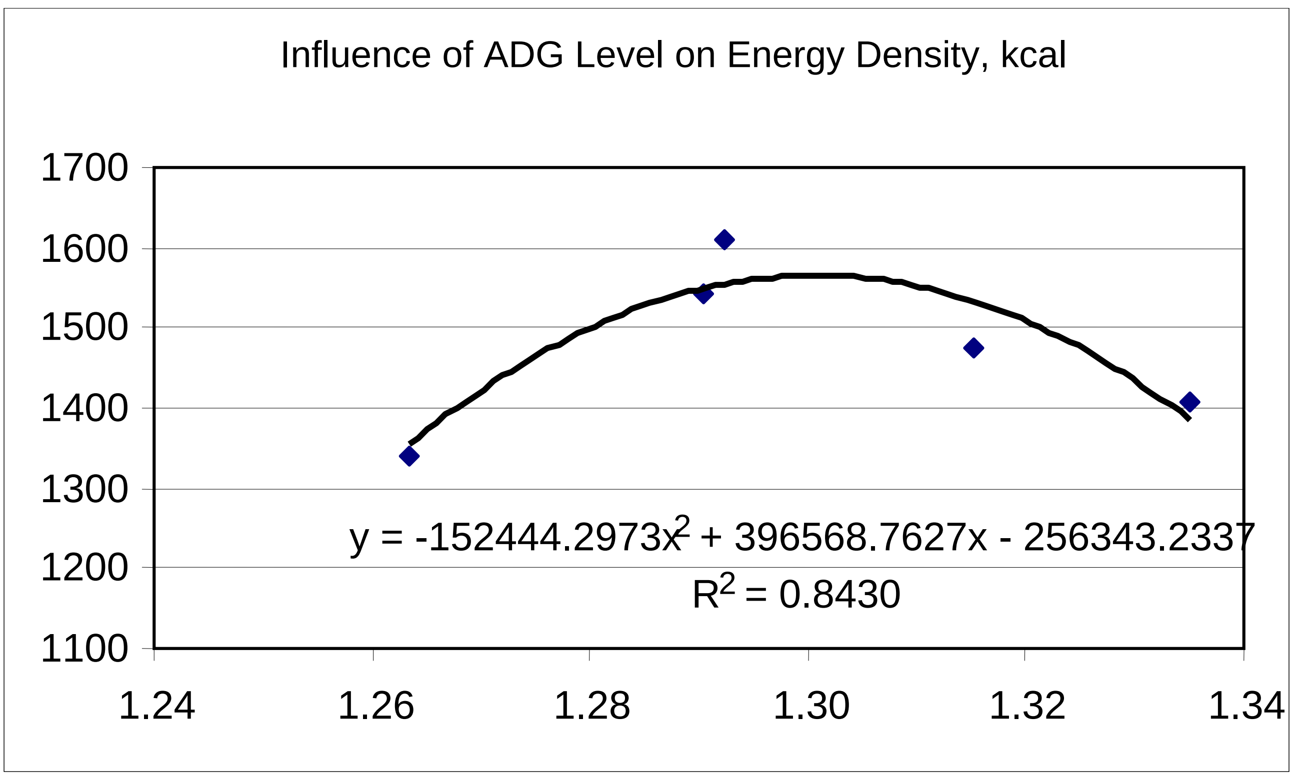


Figure 2. Regression Analysis for Lysine and Energy Density on Average Daily Gain.