EFFECTS OF INCREASING LYSINE:CALORIE RATIO IN PIGS GROWN IN A COMMERCIAL FINISHING ENVIRONMENT[1]

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Summary

Seven experiments using 7,801 pigs (75 to 265 lb) were conducted to determine the biologic and economic effects of increasing dietary lysine in commercially reared grow-finish pigs. Each study was generally 28 d long and evaluated a different weight range of the grow-finish period for barrows (3 trials) and gilts (4 trials), respectively. All studies contained six dietary treatments of incrementally increasing lysine:calorie ratio. The primary response criteria measured were growth, carcass, and economic performance. Pigs fed high-energy diets in early finishing (< 150 lb) have only moderate biological responses to a wide range of dietary lysine. However, increasing dietary lysine levels in late finishing (>150 lb) has more quantitatively significant effects on growth and carcass performance. Due the magnitude of the biological responses observed, economic penalties for feeding below the lysine requirement were modest early and severe later in the grow-finish period. These studies indicate that income over marginal feed cost (IOMFC) is consistently optimized near the biological requirement for optimal growth and feed conversion. However, feed cost per pound of gain is consistently minimized below these biological requirements. Therefore, diet costs alone provide little value in developing cost effective feeding strategies. In addition, prediction equations to calculate the optimum lysine:calorie ratio based on body weight (BW, lb) were developed. The lysine:calorie ratio prediction equation is: lysine:calorie ratio, g total lysine/Mcal ME = -.006045 × BW + 3.694 for barrows and lysine:calorie ratio = -.00744 × BW + 4.004 for gilts.

Introduction

Understanding lysine requirements is an essential component to developing cost-effective grow-finish feeding strategies. Lysine requirements are commonly expressed as a lysine:calorie ratio (glysine/Mcal ME). Expressing lysine requirements relative to dietary energy content enables these requirements to be used across a broad range of feeding situations. Although grow-finish lysine requirements have been well studied, ongoing efforts are needed to better understand the biological needs of ever evolving high-lean genotypes in commercial environments. Because feed is such a large portion of the cost of production, it is equally necessary to gain an appreciation for the economic implications of either feeding below, at, or above the biological requirements at the different phases of the grow-finish period. The objective of these trials was

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to determine the biologic and economic effects of feeding increasing dietary lysine concentrations to pigs grown in a commercial finishing environment. Understanding these responses will illustrate both the biological lysine requirements and economic implications of increasing lysine:calorie ratio during the grow-finish period.

Procedures

A series of seven trials (3 barrow, 4 gilt) were conducted to determine the effects of increasing lysine:calorie ratio in barrows and gilts (PIC 337 × C22) grown in commercial finishing facilities. Each trial independently evaluated one phase (weight range) of the grow-finish period. Each trial had six dietary treatments of incrementally increasing lysine:calorie ratio. All diets were corn-soybean meal-based with 6% added choice white grease. The desired lysine:calorie ratio was obtained by replacing corn with soybean meal. No crystalline lysine was utilized to ensure lysine was the first limiting amino acid. All other nutrients were formulated to be non-limiting. An overview describing phases of growth evaluated, midpoint weight, trial duration, pigs per pen, and total pigs used in each trial is outlined in Table 1. Likewise, dietary treatments, calculated dietary analysis, and costs are illustrated in Tables 2 and 3 for the barrow and gilt trials, respectively. The lysine:calorie ratios discussed in this paper are expressed as total grams lysine:Mcal of ME. True ileal digestible lysine as a percent of diet is listed in Tables 2 and 3. A subsample of each diet was analyzed for lysine content and all values were within analytical variation of the calculated values.

Pigs were allotted to one of the six dietary treatments in a randomized completed block design with seven pens per treatment. Each pen was 10 × 18 ft with a 4-hole self-feeder and one cup waterer. Finishing facilities were total slatted, deep pitted, and double curtain-sided with a total of 48 pens per barn. Pig weights by pen and feed disappearance were measured throughout all trials. In trials not ending at slaughter (barrow Trials 1 and 2, gilt Trials 1, 2, and 3), five pigs per pen were individually identified, weighed, and scanned with real-time ultrasound to measure fat depth and loin eye area at the 10th rib. These five selected pigs were identified, weighed, and scanned at the beginning and at the end of the trial. The scanning data served to study the effects of dietary lysine on body compositional changes during the feeding period. In the trials terminating at slaughter (barrow Trial 3, gilt Trial 4), pen identity was maintained through slaughter. Maintaining pen identification enabled carcass data (carcass yield, fat and loin depth at the 10th rib, lean percentage, and grade premium) to be collected for each pen.

Gain, feed intake, feed conversion, feed cost per pound of gain, and income over marginal feed costs (IOMFC) were measured in each study. Income over marginal feed costs is defined as the value of the pigs weighed off-test less the feed costs incurred during the trial period. In the trials not terminating at slaughter, an average pig value was calculated by assessing value to the weight gain during trial period (at $42.50/CWT), and subsequently subtracting feed costs incurred during the trial period. In trials terminating at slaughter, an average pig value was calculated by using the calculated carcass weight and carcass grade premium data from each pen. Because there were no treatment differences in carcass yield, the trial mean carcass yield for all pens was applied to all pens off-test weights to attain a calculated carcass weight for each pen. The average feed cost per pig was then subtracted from the derived pig value to attain the IOMFC for each pen. Data were analyzed for linear and quadratic effects of increasing lysine:calorie ratio with pen being the experimental unit in all data analyses.

Results and Discussion

Barrow Trials: (Tables 4 to 6). In Trial 1 (95–155 lb barrows), ADG and F/G improved (quadratic, P<0.01, Table 4) with increasing lysine:calorie ratio. Gain was optimized at 2.89 g lysine/Mcal ME, while F/G was optimized at 3.23 g lysine/Mcal ME. Feed intake tended to be reduced (linear, *P*=0.06) as lysine:calorie ratio increased. This trend is due to the reduced intake observed at the highest level of lysine fed (3.91 g lysine/Mcal ME). This reduction in intake may be due to the level of soybean meal (42% of total diet) that was needed to meet this lysine:calorie ratio without the use of crystalline lysine. Fat deposition, as measured by a change in 10th rib backfat during the feeding period, was reduced (linear, *P*<0.0001) with increasing lysine:calorie ratio. The change in loin eye area (LEA) increased (quadratic, *P*<0.008) with increasing dietary lysine. However, only the lowest lysine:calorie ratio fed (2.21 g lysine/Mcal ME) had a different (*P*<0.05) change in LEA than all other treatments. Feed cost per pound of gain increased (quadratic, *P*<0.01) with increasing lysine:calorie ratio. However, numeric increases continued to occur through the highest lysine level fed. Income over feed costs improved (quadratic, *P*<0.005) with increasing dietary lysine. Income over feed cost was maximized at 2.89 g lysine/Mcal ME. These data indicate feeding barrows from 95 to 155 lb a 2.89 g lysine/Mcal ME diets adequately meets biological lysine requirements for growth and maximizes return over feed costs. However, feed cost per pound of gain was minimized while feeding below these biological requirements at 2.55 g lysine/Mcal of ME.

In Trial 2 (150 to 205 lb barrows), ADG and F:G improved (linear, P<0.0001, Table 5) with increasing lysine:calorie ratio. Although gain improved at a steady rate through the highest lysine level fed (2.78 g lysine/Mcal ME), feed conversion was minimally improved beyond 2.53 g lysine/Mcal ME. Feed intake was not (P>0.15) affected by increasing lysine:calorie ratio. Fat deposition as measured by a change in fat depth during the feeding period was reduced (quadratic, *P*<0.008) with increasing lysine:calorie ratio. Reduction in fat deposition was not seen beyond 2.53 g lysine/Mcal of ME. Loin eye area tended to increase (quadratic, *P*<0.06) with increasing dietary lysine. The greatest change in LEA was observed as lysine:calorie ratio increased from 2.28 to 2.53 g lysine/Mcal ME, with little change thereafter. However, an increased change in LEA was not observed beyond 2.53 g lysine/Mcal ME. Increasing lysine:calorie ratio did not (*P*>0.46) affect feed cost per pound of gain due the magnitude of the linear improvements in feed conversion. However, IOMFC improved (linear, *P*<0.0001) with increasing dietary lysine. Although growth responses and subsequently income over marginal feed costs were improved linearly, improvements in feed efficiency and carcass composition were not significantly improved beyond 2.53 g lysine/Mcal ME. It seems probable that a combined optimal requirement for growth, feed efficiency, and carcass performance lies between 2.53 and 2.78 g lysine/Mcal ME. These data suggest that feeding barrows from 150 to 205 lb a 2.65 g lysine/Mcal ME diet provides an adequate blend of meeting biological requirements and optimizing return over marginal feed costs.

In Trial 3 (225 to 265 lb barrows), ADG and F/G improved (linear, *P*<0.03, Table 6) with increasing lysine:calorie ratio. Although the response in ADG to increasing lysine was linear, improvement was minimal beyond 2.0 g lysine/Mcal ME. Increasing lysine:calorie ratio did not affect (*P*>0.42) feed intake. Carcass yield was not affected (*P*>0.27) by dietary treatment. However, fat depth, loin depth, and lean percentage were improved (quadratic, *P*<0.0002) by increasing lysine:calorie ratio. The improvement in backfat and percent lean was apparently optimized at 2.20 g lysine/Mcal ME. However, pigs fed the lowest level of lysine (1.40 g lysine/Mcal of ME) had similar backfat (*P*>0.05) as those fed the highest level (2.4 g lysine/ Mcal of ME). Loin depth was increased over all other treatments (*P*<0.05) in pigs fed 2.40 g lysine/Mcal ME. Although statistical improvements in grade premium were not evident (*P*>0.21), incremental numeric improvements were observed with increasing lysine:calorie ratio. Dietary lysine concentration did not affect (*P*>0.58) feed cost per pound of gain due to the linear improvements in feed conversion. Although IOMFC did not statistically improve (*P*=0.12) with increasing lysine:calorie ratio, step-wise numeric improvements in IOMFC were observed as dietary lysine increased. These numeric improvements were due to improved gain, feed conversion, as well as numeric improvements in lean premium. These data indicate feeding barrows from 225 to 265 lb a 2.20 g lysine/Mcal ME diet adequately meets biological requirements and optimizes IOMFC.

Gilt Trials: (Tables 7 to 10). In Trial 1 (75 to 135 lb gilts), ADG and F/G improved (quadratic, *P*<0.03, Table 7) with increasing lysine:calorie ratio. Gain and feed conversion were optimized at 3.23 g lysine/Mcal ME. Increasing lysine:calorie ratio from 2.55 to 4.25 g lysine/Mcal ME decreased (linear, *P*=0.05) ADFI from 4.30 to 4.18 lb/d. Fat deposition as measured by a change in fat depth during the feeding period was reduced (linear, *P*<0.0001) with increasing lysine:calorie ratio. Increasing lysine:calorie ratio did not affect (*P*>0.60) a change in LEA. Feed cost per pound of gain increased (quadratic, *P*<0.03) with increasing lysine:calorie ratio. However, step-wise numeric increases in feed cost per pound of gain were observed through 4.25 g lysine/Mcal ME. IOMFC improved (quadratic, *P*<0.02) with increasing dietary lysine, and was maximized at 3.23 g lysine/Mcal ME. These data indicate feeding gilts from 75 to 135 lb a 3.23 g lysine/Mcal ME diet adequately meets biological requirements and optimizes IOMFC. However, due to the relatively modest magnitude of the biological responses, feed cost per pound of gain numerically increased with lysine:calorie ratio.

In Trial 2 (130 to 190 lb gilts), ADG and F/G improved (quadratic, *P*<0.02, Table 8) with increasing lysine:calorie ratio. Feed and gain conversion were optimized at 2.80 g lysine/Mcal ME. Feed intake was not (*P*>0.11) affected by increasing lysine to calorie ratio. Fat deposition as measured by a change in fat depth during the feeding period was reduced (linear, *P*<0. 0002) with increasing lysine: calorie ratio. Increasing dietary lysine did not affect (*P*> 0.43) the change in LEA. Feed cost per pound of gain increased (quadratic, *P*<0.02) with increasing lysine:calorie ratio, with the largest increase occurring as the lysine:calorie ratio increased from 2.80 to 3.08 g lysine/Mcal ME. However, numeric increases in feed cost per pound of gain were observed through the highest dietary lysine diet fed. Income over feed costs improved (quadratic, *P*<0.002) with increasing dietary lysine and was maximized at the apparent biological requirement of 2.80 g lysine/Mcal ME. These data indicate feeding gilts from 130 to 190 lb a 2.80 g lysine/Mcal ME diet will meet biological requirements for optimizing growth and feed conversion, as well as maximize income over feed costs. However, feed cost per pound of gain was numerically reduced through the lowest dietary lysine level fed (1.96 g lysine/Mcal ME) in this study.

In Trial 3 (170 to 225 lb gilts), ADG and F/G improved (quadratic, *P*<0.003, Table 9) with increasing lysine:calorie ratio. Feed and gain conversion were optimized at 2.28 and 2.53 g lysine/Mcal ME respectively. Increasing lysine:calorie ratio did not affect (P>0.43) feed intake. Change in fat depth at the 10th rib was reduced (linear, P<0.0001) and LEA tended to increase (quadratic, P<0.10) with increasing dietary lysine. The improvements in LEA were optimized at 2.53 g lysine/Mcal ME. Feed cost per pound of gain and IOMFC were improved (quadratic, P<0.001) as lysine:calorie ratio increased. Feed cost per pound of gain was optimized at 2.03 g lysine/Mcal ME, which again is below the biological lysine requirement. Income over feed cost improved (quadratic, P<0.001) with increasing dietary lysine and was optimized at 2.28 g lysine/Mcal ME. However, due to the more quantitatively significant effect dietary lysine is having on carcass composition in this phase of growth, the derived IOMFC value needs to be interpreted with caution. The standard IOMFC value illustrated does not account for differences in carcass lean at slaughter. When carcass lean values (Table 9) are calculated from the fat depth and LEA information and valued as if sold to slaughter, IOMFC improves in greater magnitude (linear, P<0.0002, quadratic, P<0.06) with increasing lysine:calorie ratio. These data illustrate the need to understand the quantitatively important effects that dietary lysine has on carcass composition during this phase of the growing period. These data indicate feeding gilts from 170 to 225 lb a 2.53 g lysine/Mcal ME diet adequately meets biological requirements and optimizes IOMFC when the implications on carcass lean are understood.

In Trial 4 (220 to 265 lb gilts), ADG improved (linear, P<0.0001) and F/G improved (quadratic, P<0.04) with increasing lysine:calorie ratio (Table 10). Although the response in gain was linear through the highest lysine level fed (2.40 g lysine/Mcal ME), quantitative improvement in gain was not observed above 2.20 g lysine/Mcal ME. Likewise, feed conversion was optimized at 2.20 g lysine/Mcal ME. Carcass yield was not affected (P>0.18) by increasing lysine:calorie ratio. Fat depth and lean percentage were improved (quadratic, P<0.04), as was loin depth with increasing lysine:calorie ratio. Numeric improvements in these carcass lean parameters were maximized in pigs fed 2.40 g lysine/Mcal ME. Grade premium also increased (linear, P<0.02) with increasing lysine:calorie ratio. Feed cost per pound of gain tended to be reduced (quadratic, P=0.06) as dietary lysine increased. Feed cost per pound of gain was equivocally low at 2.00 and 2.20 g lysine/Mcal ME. However, IOMFC increased (linear, P<0.0001) with increasing dietary lysine. These linear responses in IOMFC were due to improvements in growth performance and lean premium associated with increasing lysine:calorie ratio. However, numeric improvements in IOMFC were not observed above 2.20 g lysine/Mcal ME. These data suggest feeding gilts from 220 to 265 lb a 2.20 g lysine/Mcal of ME diet adequately meets biological requirements and optimizes IOMFC.

Prediction Equations. The determined optimum lysine:calorie ratios from both the barrow and gilt trials were plotted at the midpoint weight from each study. These data were utilized to develop regression equations to predict the optimum lysine:calorie feeding regimen based on body weight. Separate regression equations were developed for barrows and gilts. These curves describe the lysine:calorie ratio that best met the biological requirements for growth performance and optimized IOMFC for barrows and gilts used in this series of trials (Figure 1). In the barrow studies (midpoint weights 130 to 245 lb), the linear equation: lysine:calorie ratio, g total lysine/Mcal ME = -.006045 × BW + 3.694, describes the optimum lysine:calorie ratio observed. The linear equation: lysine:calorie ratio, g total lysine/Mcal ME = -.00744 × BW + 4.004, describes the optimum lysine:calorie ratio observed in the gilt studies (midpoint weights = 105 to 243 lb). As expected, the optimum ratio declines with increasing body weight. These regressed optimum requirements also illustrate that the observed lysine requirements become more similar in the barrows and gilts as body weight increases.

These studies illustrate the biological and economical effects of increasing lysine:calorie ratio, and how the magnitude of the effects changes during the grow-finish period. In the trials with initial pig weights of less than 150 lb, the biologic and resulting economic effects were relatively modest in magnitude as compared to responses later in finishing. In these early finishing (<150 lb initial weight) trials, feed cost per pound of gain incrementally increased with lysine:calorie ratio. However, IOMFC was optimized when the biological requirements for growth were achieved. In late finishing (>150 lb initial weight), the biologic and economic responses to increasing lysine were more quantitatively significant. Feed cost per pound of gain was either not affected or reduced quadratically as lysine:calorie ratio increased. However, finishing feed cost per pound of gain was numerically minimized below the lysine:calorie ratio required for optimum biologic performance and IOMFC.

These studies indicate barrows and gilts (PIC 337 × C22) fed high fat diets in commercial facilities have a modest response to increasing dietary lysine in early finishing (<150 lb initial weight). However, penalties for feeding below the lysine requirement in late finishing (>150 lb initial weight) are severe due to the more quantitatively significant effects on gain, feed efficiency, and lean deposition. Contrary to being below the requirement, these studies suggest the penalties for being above the perceived requirement for optimal growth are minimal in late finishing. In the late finishing trials (>150 lb start weight), IMOFC tended to plateau or incrementally improve as lysine:calorie ratio increased beyond the requirement for optimal growth performance. These studies indicate feed cost per pound of gain is consistently minimized below the biological requirement for optimal growth performance and IOMFC. In summary, these studies illustrate the need to understand the dynamic biology and economic implications involved when making strategic nutritional decisions. Diet costs alone provide little value in developing cost effective feeding strategies.

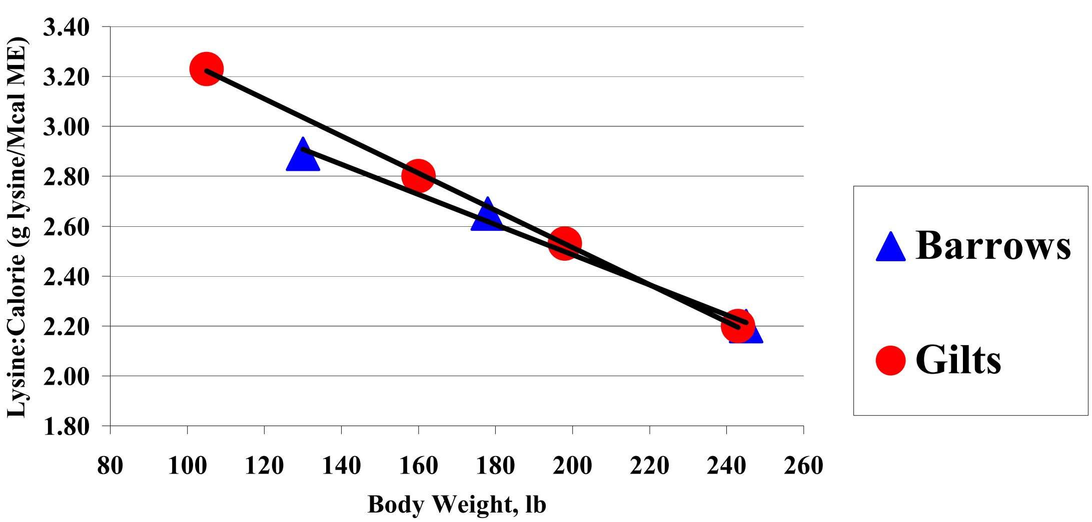

Figure 1. Predicted Optimal Lysine:Calorie Regimen for Pigs (PIC L337 × C22) Grown in Commercial Finishing Facilities[ab].

[a]A total of 7 trials (3 barrow, 4 gilt) were conducted using 7,801 pigs (PIC L337 × C22) to determine effects of increasing lysine:calorie ratio (g lysine/Mcal ME) in commercial finishing research facilities, and to subsequently derive prediction equations for an optimal lysine:calorie regimen for barrows and gilts respectively. [b]The lysine:calorie ratio prediction equation is: lysine:calorie ratio, g total lysine/Mcal ME = -.006045 × BW, lb + 3.694 for barrows and lysine:calorie ratio = -.00744 × BW, lb + 4.004 for gilts.

Table 1. Overview of Increasing Lysine: Calorie Ratio Studies[a]

	Weight Range, lb	Midpoint, lb	Duration, d	Pigs per pen, n	Pigs on test, n
Barrows					
Trial 1	95 to 155	130	28	26 to 28	1,166
Trial 2	150 to 205	178	27	25 to 28	1,147
Trial 3	225 to 265	245	21	22 to 24	968
Gilts					
Trial 1	75 to 135	105	28	28	1,176
Trial 2	130 to 190	160	28	27 to 28	1,163
Trial 3	170 to 225	198	28	27 to 28	1,160
Trial 4	220 to 265	243	25	21 to 25	1,021

[a]Studies were conducted to evaluate effects of increasing lysine: calorie ratio (g lysine/Mcal ME) in grow-finish pigs (PIC 337 × C22, n= 7,801) in a commercial finishing environment.

Table 2. Barrow Studies: Dietary Treatments, Formulated Composition, and Cost[a,b]

Item	Diet, Step-wise Lysine:Calorie Ratio					
Trial 1 (95 to 155 lb)						
Lysine:calorie, (g lysine/Mcal ME)	2.21	2.55	2.89	3.23	3.57	3.91
Total lysine, %	0.79	0.91	1.04	1.16	1.28	1.40
True digestible lysine, %	0.69	0.80	0.91	1.02	1.13	1.24
ME, kcal/lb	1624	1624	1624	1624	1623	1623
Diet cost/ton, $	118.10	121.71	125.37	129.02	133.39	137.04
Trial 2 (150 to 205 lb)						
Lysine:calorie, (g lysine/Mcal ME)	1.53	1.78	2.03	2.28	2.53	2.78
Total lysine, %	0.55	0.64	0.73	0.82	0.91	1.00

True digestible lysine, %	0.47	0.55	0.63	0.72	0.80	0.88
ME, kcal/lb	1631	1631	1631	1631	1631	1631
Diet cost/ton, $	109.57	112.26	114.94	117.65	120.33	123.04
Trial 3 (225 to 265 lb)						
Lysine:calorie, (g lysine/Mcal ME)	1.40	1.60	1.80	2.00	2.20	2.40
Total lysine, %	0.51	0.58	0.65	0.72	0.80	0.87
True digestible lysine, %	0.43	0.50	0.56	0.63	0.69	0.76
ME, kcal/lb	1640	1640	1640	1639	1639	1639
Diet cost/ton, $	107.29	109.48	111.55	113.75	115.91	118.07

[a]Increasing lysine: calorie ratios were achieved by replacing corn with soybean meal, as no crystalline lysine was used to ensure lysine was the first limiting amino acid.

[b]Diets costs were calculated with $ 1.85/bu corn and $150/ton, 46.5% soybean meal, along with a $12/ton manufacturing and delivery charge.

Table 3. Gilts Studies: Dietary Treatments, Formulated Composition, and Cost[a,b]

Item	Diet, Step-wise Lysine:Calorie Ratio					
Trial 1 (75 to 135 lb)						
Lysine:calorie, (g lysine/Mcal ME)	2.55	2.89	3.23	3.57	3.91	4.25
Total lysine, %	0.91	1.04	1.16	1.28	1.40	1.52
True digestible lysine, %	0.80	0.91	1.02	1.13	1.24	1.35
ME, kcal/lb	1624	1624	1624	1623	1623	1623
Diet cost/ton, $	121.71	125.37	129.02	133.39	137.04	141.03
Trial 2 (130 to 190 lb)						
Lysine:calorie, (g lysine/Mcal ME)	1.96	2.24	2.52	2.80	3.08	3.36
Total lysine, %	0.71	0.81	0.91	1.01	1.11	1.21
True digestible lysine, %	0.61	0.70	0.79	0.88	0.98	1.07
ME, kcal/lb	1628	1628	1628	1628	1628	1627
Diet cost/ton, $	114.92	117.91	120.93	123.91	127.27	130.65
Trial 3 (170 to 225 lb)						
Lysine:calorie, (g lysine/Mcal ME)	1.53	1.78	2.03	2.28	2.53	2.78
Total lysine, %	0.55	0.64	0.73	0.82	0.91	1.00
True digestible lysine, %	0.47	0.55	0.63	0.72	0.80	0.88
ME, kcal/lb	1631	1631	1631	1631	1631	1631
Diet cost/ton, $	109.57	112.26	114.94	117.65	120.33	123.04
Trial 4 (220 to 265 lb)						
Lysine:calorie, (g lysine/Mcal ME)	1.40	1.60	1.80	2.00	2.20	2.40
Total lysine, %	0.51	0.58	0.65	0.72	0.80	0.87
True digestible lysine, %	0.43	0.50	0.56	0.63	0.69	0.76
ME, kcal/lb	1640	1640	1640	1639	1639	1639
Diet cost/ton, $	107.29	109.48	111.55	113.75	115.91	118.07

[a]Increasing lysine:calorie ratios were achieved by replacing corn with soybean meal, as no crystalline lysine was use to ensure lysine was the first limiting amino acid.

[b]Diets costs were calculated with $ 1.85/bu corn and $150/ton, 46.5% soybean meal, along with a $12/ton manufacturing and delivery charge.

Table 4. Barrow Study, Trial 1, Effect of Lysine:Calorie Ratio on 95 to 155 lb Barrows[a]

	Lysine:Calorie (g lysine/Mcal ME)								
	2.21	2.55	2.89	3.23	3.57	3.91			
	Total Lysine, %							Probability (*P*<)	
Item	0.79	0.91	1.04	1.16	1.28	1.40	SE	Linear	Quadratic
Initial weight, lb	95.6	96.4	96.0	96.4	96.1	95.8	2.15	0.99	0.30
ADG, lb	2.01	2.14	2.19	2.13	2.12	2.08	0.05	0.50	0.007
ADFI, lb	4.56	4.60	4.65	4.50	4.55	4.42	0.09	0.06	0.14
Feed/gain	2.27	2.15	2.13	2.11	2.15	2.12	0.03	0.002	0.0086
Off-test weight, lb[b]	152.5	155.8	157.3	155.6	155.5	154.3	0.75	0.05	0.0001
10th rib fat depth change, mm[c]	4.8	3.9	4.1	3.3	3.4	2.5	0.24	0.0001	0.86
LEA change, cm^2 [c]	7.7	8.7	8.5	9.0	8.8	8.5	0.29	0.03	0.008
Feed cost/lb of gain, $	0.134	0.131	0.133	0.136	0.143	0.146	0.002	0.0001	0.01
IOMFC, $/head[d]	16.41	17.61	17.86	17.22	16.77	16.29	0.46	0.27	0.005

[a]A total of 1166 barrows (PIC) housed at the rate of 26- 28 pigs/pen and 7 replications per treatment in the 28-day trial.

[b]Off-test weight = Start weight + (ADG * number of days of test); and adjusts all treatments to a common start weight.

[c]Change in fat depth and LEA = Difference in fat depth and LEA on the 5 animals/pen ultrasounded at the beginning and at the end of the feeding period. These differences in fat depth and LEA were adjusted to a common change in liveweight.

[d]IOMFC, Income over marginal feed costs, = Value of gain on a $42.50/CWT liveweight basis - feed costs during trial period.

Table 5. Barrow Study, Trial 2, Effect of Lysine:Calorie Ratio on 150 to 205 lb Barrows[a]

	Lysine:Calorie (g lysine/Mcal ME)								
	1.53	1.78	2.03	2.28	2.53	2.78			
	Total Lysine, %							Probability (*P*<)	
Item	0.55	0.64	0.73	0.82	0.91	1.00	SE	Linear	Quadratic
Initial weight, lb	151.2	153.5	153.8	152.4	152.0	152.6	3.91	0.92	0.27
ADG, lb	1.80	1.83	1.97	1.99	2.02	2.09	0.04	0.0001	0.51
ADFI, lb	5.02	5.08	5.10	5.19	5.04	5.18	0.07	0.15	0.66
Feed/gain	2.79	2.78	2.59	2.62	2.50	2.49	0.04	0.0001	0.34
Off-test weight, lb[b]	201.3	202.3	206.2	206.3	207.3	209.2	1.05	0.0001	0.02
10th rib fat depth change, mm[c]	5.0	4.7	3.7	3.9	3.5	4.2	0.29	0.003	0.008
LEA change, cm^2 [c]	7.6	8.0	8.5	9.3	9.7	8.6	0.45	0.006	0.06
Feed cost/lb of gain, $	0.153	0.156	0.149	0.154	0.150	0.153	0.002	0.46	0.47
IOMFC, $/head[d]	13.27	13.27	14.68	14.55	14.99	15.33	0.39	0.0001	0.50

[a]A total of 1147 barrows (PIC) housed at the rate of 25- 28 pigs/pen and 7 replications per treatment in the 27-day trial.

[b]Off-test weight = Start weight + (ADG * number of days of test); and adjusts all treatments to a common start weight.

[c]Change in fat depth and LEA = Difference in fat depth and LEA on the 5 animals/pen ultrasounded at the beginning and at the end of the feeding period. These differences in fat depth and LEA were adjusted to a common change in liveweight.

[d]IOMFC, Income over marginal feed costs, = Value of gain on a $42.50/CWT liveweight basis - feed costs during trial period.

Table 6. Barrow Study, Trial 3, Effect of Lysine:Calorie Ratio on 225 to 265 lb Barrows[a]

	Lysine:Calorie (g lysine/Mcal ME)							Probability (*P*<)	
	1.40	1.60	1.80	2.00	2.20	2.40			
	Total Lysine, %								
Item	0.51	0.58	0.65	0.72	0.80	0.87	SE	Linear	Quadratic
Initial weight, lb	226.5	226.8	227.0	227.0	226.9	226.8	3.20	0.77	0.67
ADG, lb	1.80	1.80	1.89	1.91	1.91	1.93	0.05	0.03	0.66
ADFI, lb	5.77	5.78	5.83	5.87	5.73	5.74	0.09	0.75	0.39
Feed/gain	3.21	3.22	3.09	3.08	3.00	2.97	0.05	0.0002	0.99
Off-test weight, lb[b]	264.7	264.7	266.5	266.9	267.0	267.4	0.44	0.0001	0.14
Carcass yield, %	76.16	76.06	76.18	76.26	75.41	76.11	0.24	0.27	0.96
10th rib backfat, in[c]	0.77	0.78	0.80	0.79	0.76	0.76	0.01	0.01	0.0001
Loin depth, in[c]	2.31	2.33	2.32	2.29	2.32	2.35	0.01	0.01	0.0002
Lean, %[c]	53.94	53.90	53.58	53.63	54.17	54.18	0.15	0.003	0.0001
Grade premium, $/CWT	2.96	2.97	2.81	2.88	3.10	3.19	0.17	0.26	0.21
Feed cost/lb of gain, $[d]	0.172	0.176	0.173	0.175	0.174	0.176	0.003	0.58	0.87
IOMFC, $/head[e]	106.64	106.66	106.98	107.09	107.60	107.81	1.40	0.12	0.78

[a]A total of 968 barrows (PIC) housed at the rate of 22- 24 pigs/pen and 7 replications per treatment in the 21-day trial.

[b]Off-test weight = Start weight + (ADG * number of days of test); and adjusts all treatments to a common start weight.

[c]10th-rib backfat, loin depth, and lean percent were all adjusted to a common carcass weight for statistical analysis.

[d]IOMFC, Income over marginal feed costs, = Carcass value - feed costs during trial period.

[e]Base meat price of $53.33 CWT, actual feed costs and lean premium, and carcass weights attained by applying the trial mean carcass yield (76.03%) to pen off-test weights were utilized in the IOMFC analysis.

Table 7. Gilt Study, Trial 1, Effect of Lysine:Calorie Ratio on 75 to 135 lb Gilts[a]

	Lysine:Calorie (g lysine/Mcal ME)								
	2.55	2.89	3.23	3.57	3.91	4.25			
	Total Lysine, %							Probability (P<)	
Item	0.91	1.04	1.16	1.28	1.40	1.52	SE	Linear	Quadratic
Initial weight, lb	77.26	77.39	77.24	77.33	77.33	77.69	1.76	0.46	0.60
ADG, lb	1.97	2.01	2.05	2.00	1.99	1.96	0.03	0.50	0.03
ADFI, lb	4.30	4.24	4.29	4.20	4.19	4.18	0.06	0.05	0.99
Feed/gain	2.18	2.11	2.09	2.11	2.11	2.14	0.03	0.35	0.03
Off-test weight, lb[b]	132.7	133.5	134.8	133.4	133.2	132.1	0.91	0.007	0.0001
10th rib fat depth change, mm[c]	2.5	2.5	2.3	2.1	1.9	1.5	0.21	0.0002	0.3
LEA change, cm^2 [c]	9.3	9.8	9.6	9.4	10.1	9.7	0.56	0.60	0.86
Feed cost/lb of gain, $	0.133	0.133	0.135	0.141	0.144	0.151	0.002	0.0001	0.03
IOMFC, $/head[d]	16.16	16.43	16.65	15.94	15.69	15.08	0.34	0.001	0.02

[a]A total of 1176 gilts (PIC) housed at the rate of 28 pigs/pen and 7 replications per treatment in the 28-day trial.

[b]Off-test weight = Start weight + (ADG * number of days of test); and adjusts all treatments to a common start weight.

[c]Change in fat depth and LEA = Difference in fat depth and LEA on the 5 animals/pen ultrasounded at the beginning and at the end of the feeding period. These differences in fat depth and LEA were adjusted to a common change in liveweight.

[d]IOMFC, Income over marginal feed costs, = Value of gain on a $42.50/CWT liveweight basis - feed costs during trial period.

Table 8. Gilt Study, Trial 2, Effect of Lysine:Calorie Ratio on 130 to 190 lb Gilts[a]

	Lysine:Calorie (g lysine/Mcal ME)								
	1.96	2.24	2.52	2.80	3.08	3.36			
	Total Lysine, %							Probability (P<)	
Item	0.71	0.81	0.91	1.01	1.11	1.21	SE	Linear	Quadratic
Initial weight, lb	132.1	131.4	131.7	131.3	131.8	131.9	1.84	0.89	0.17
ADG, lb	2.02	2.07	2.12	2.15	2.10	2.06	0.03	0.09	0.001
ADFI, lb	5.09	5.09	5.21	5.12	5.24	5.10	0.05	0.32	0.11
Feed/gain	2.52	2.48	2.46	2.39	2.50	2.47	0.03	0.27	0.02
Off-test weight, lb[b]	188.1	189.4	190.9	191.8	190.3	189.4	0.42	0.0001	0.0001
10th rib fat depth change, mm[c]	4.0	3.3	3.3	3.3	2.9	2.9	0.23	0.0002	0.34
LEA change, cm^2 [c]	9.3	9.6	9.9	9.5	9.6	9.5	0.38	0.78	0.43
Feed cost/lb of gain, $	0.145	0.146	0.149	0.148	0.159	0.161	0.002	0.0001	0.02
IOMFC, $/head[d]	15.83	16.12	16.38	16.64	15.60	15.25	0.29	0.06	0.002

[a]A total of 1163 gilts (PIC) housed at the rate of 27-28 pigs/pen and 7 replications per treatment in the 28-day trial.

[b]Off-test weight = Start weight + (ADG * number of days of test); and adjusts all treatments to a common start weight.

[c]Change in fat depth and LEA = Difference in fat depth and LEA on the 5 animals/pen ultrasounded at the beginning and at the end of the feeding period. These differences in fat depth and LEA were adjusted to a common change in liveweight.

[d]IOMFC, Income over marginal feed costs, = Value of gain on a $42.50/CWT liveweight basis - feed costs during trial period.

Table 9. Gilt Study, Trial 3, Effect of Lysine:Calorie Ratio on 170 to 225 lb Gilts[a]

	Lysine:Calorie (g lysine/Mcal ME)								
	1.53	1.78	2.03	2.28	2.53	2.78			
	Total Lysine, %							Probability (*P*<)	
Item	0.55	0.64	0.73	0.82	0.91	1.00	SE	Linear	Quadratic
Initial weight, lb	172.3	173.0	172.7	173.0	172.9	172.5	2.53	0.93	0.65
ADG, lb	1.78	1.79	1.98	2.02	2.01	1.98	0.04	0.0001	0.003
ADFI, lb	5.60	5.62	5.62	5.61	5.54	5.56	0.09	0.43	0.73
Feed/gain	3.15	3.14	2.84	2.78	2.75	2.82	0.04	0.0001	0.0003
Off-test weight, lb[b]	222.6	222.9	228.3	229.3	229.0	228.1	0.65	0.0001	0.0001
10th rib fat depth change, mm[c]	4.7	4.1	3.1	3.4	3.6	2.6	0.28	0.0001	0.27
LEA change, cm^2 [c]	5.4	6.5	7.7	7.2	9.3	8.4	0.47	0.0001	0.10
Lean, %[d]	53.0	53.5	54.7	53.6	54.5	55.3	0.37	0.0001	0.93
Feed cost / lb of gain, $	0.173	0.176	0.163	0.164	0.166	0.173	0.003	0.16	0.001
IOMFC, $/head[e]	12.57	12.49	14.57	14.82	14.61	13.94	0.39	0.0001	0.001
IOMFC with lean, $/head[f]	83.3	84.03	87.34	86.46	87.25	87.16	1.29	0.0002	0.06

[a]A total of 1160 gilts (PIC) housed at the rate of 27 - 28 pigs/pen and 7 replications per treatment in the 28-day trial.

[b]Off-test weight = Start weight + (ADG * number of days of test); and adjusts all treatments to a common start weight.

[c]Change in fat depth and LEA = Difference in fat depth and LEA on the 5 animals/pen ultrasounded at the beginning and at the end of the feeding period. These differences in fat depth and LEA were adjusted to a common change in liveweight. Calculated lean percentage from established equations (National Pork Board) from ultrasound fat depth and LEA data.

[d]IOMFC, Income over marginal feed costs, = Value of gain on a $42.50/CWT liveweight basis - feed costs during trial period.

[e]Projected carcass value (as if pigs were sold to slaughter at the off-test weight) - feed costs during trial period.

[f]Assigns an average carcass value to each pen using calculated lean percentage, packer lean payment grid (John Morrell & Company), and a standard carcass yield (75%) to the pen off-test weights, with a base meat price of $53.33 / CWT.

Table 10. Gilt Study, Trial 4, Effect of Lysine:Calorie Ratio on 220 to 265 lb Gilts[a]

	Lysine:Calorie (g lysine/Mcal ME)							Probability (P<)	
	1.40	1.60	1.80	2.00	2.20	2.40			
	Total Lysine, %								
Item	0.51	0.58	0.65	0.72	0.80	0.87	SE	Linear	Quadratic
Initial weight, lb	221.6	221.5	222.4	222.2	222.2	221.8	3.28	0.73	0.60
ADG, lb	1.59	1.6	1.69	1.85	1.94	1.94	0.04	0.0001	0.90
ADFI, lb	5.36	5.26	5.14	5.29	5.45	5.43	0.09	0.15	0.05
Feed/gain	3.37	3.32	3.05	2.87	2.81	2.81	0.06	0.0001	0.04
Off-test weight, lb[b]	262.2	262.3	264.5	268.4	270.8	270.8	0.60	0.0001	0.99
Carcass yield, %	75.4	76.0	76.3	76.2	75.7	76.2	0.30	0.28	0.25
10th rib backfat, in[c]	0.71	0.69	0.72	0.69	0.68	0.67	0.009	0.0001	0.003
Loin depth, in[c]	2.21	2.25	2.25	2.29	2.30	2.31	0.015	0.0001	0.07
Lean, %[c]	54.7	55.1	54.6	55.2	55.3	55.5	0.16	0.0001	0.04
Grade premium, $/CWT	3.52	3.76	3.48	3.8	3.83	4.02	0.16	0.02	0.51
Feed cost/lb of gain, $	0.181	0.182	0.170	0.163	0.163	0.166	0.003	0.0001	0.06
IOMFC, $/head[d,e]	105.66	106.19	107.46	108.87	109.64	109.64	1.57	0.0001	0.47

[a]A total of 1021 gilts (PIC) housed at the rate of 21- 25 pigs/pen and 7 replications per treatment in the 25-day trial.

[b]Off-test weight = Start weight + (ADG * number of days of test); and adjusts all treatments to a common start weight.

[c]10th-rib backfat, loin depth, and lean percent were all adjusted to a common carcass weight for statistical analysis.

[d]IOMFC, Income over marginal feed costs, = Carcass value - feed costs during trial period.

[e]Base meat price of $53.33 CWT, actual feed costs and lean premium, and carcass weights attained by applying the trial mean carcass yield (75.94%) to pen off-test weights were utilized in the IOMFC analysis.