NEW AMINO ACID CONCENTRATIONS FOR INDUSTRY GROW-FINISH SWINE DIETS

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BACKGROUND

Feed remains the number one cost component of raising pigs making up over 50% of the total cost of production. With today's feed costs, the cost of raising a pig from weaning to market can easily approach $65/head with as much as 45% of that cost coming from protein.

Dietary amino acid regimen has a major impact on overall growth and feed conversion in pig production. Underfeeding amino acids results in decreased growth rates, poorer feed conversion efficiency and fatter carcasses, while overfeeding increases feed costs, lowers growth rate, decreases feed conversion and increases nitrogen excretion into the environment. Therefore matching dietary amino acid regimen to the lean growth potential of the animals being fed is essential to an economically viable and environmentally sustainable production system. Genetic potential determines the ceiling for lean growth rate and therefore amino acid requirements. However, numerous factors such as disease status, stocking density, environmental temperature, and air quality affect the level of genetic potential which is achieved. With continued improvement of genetic potential, changes in pig flow and pig management and improvements in health due to bio-security and the availability of vaccines such as Porcine Circovirus, it is important to examine amino requirements on a regular basis. The following is a review of some of the factors that influence lean growth rate and how changes in lean growth rate influence amino acid requirements, recent information on amino acid requirements in specific situations so that you can practically establish amino acid levels to feed on your farm.

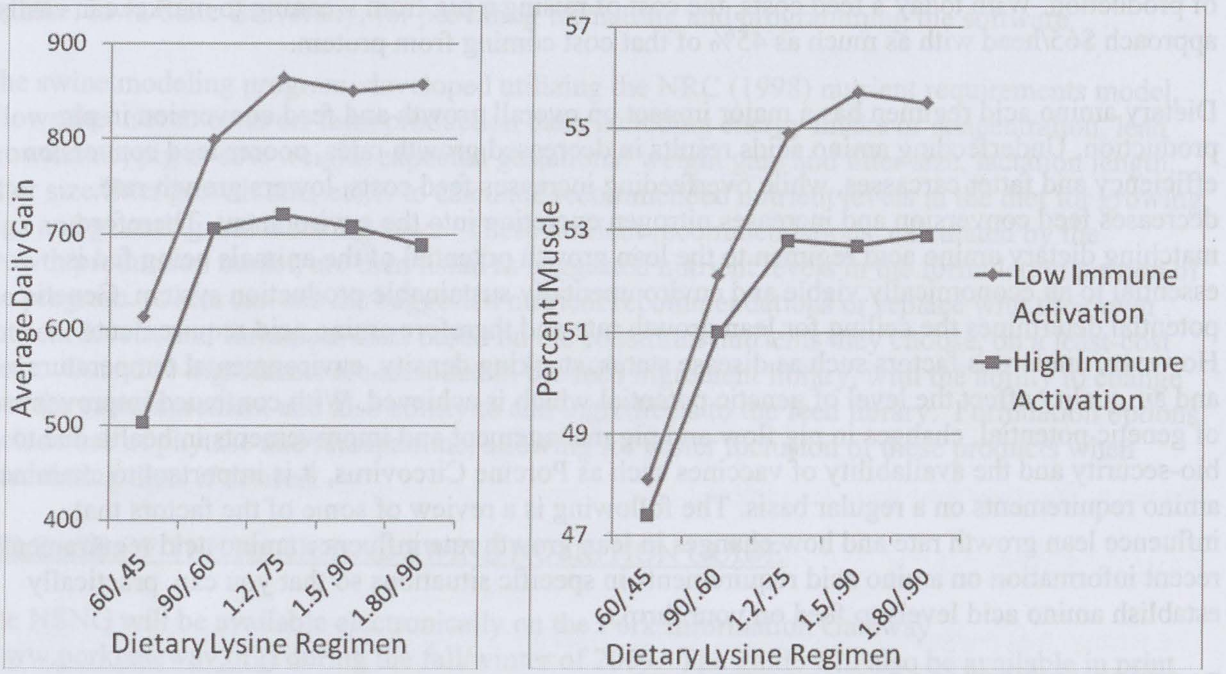
FACTORS AFFECTING LEAN GROWTH RATE

The maximum rate of lean growth is set by the genetic makeup of the animal. Genetic improvement for lean growth rate and feed conversion has been rapid. Thus the ceiling for maximum lean growth rate is much higher today than even five or ten years ago. However, the amount of this potential that is achieved by a given group of pigs is determined by a multitude of environmental and management factors the effects of many of which are additive. We will briefly review some of these factors and look at how changes in modern production practices can influence lean growth rate and as a result the amino acid requirements of pigs.

Immune Activation

Numerous reports have indicated that when an animal is exposed to pathogens and endotoxins there is an increase in the release of pro-inflammatory cytokines such as interleukin-1, interleukin-4 and tumor necrosis factor and that these cytokines result in decreases in feed intake, reductions in protein synthesis, increases in protein degradation and depression of growth rate and feed conversion efficiency (Klasing, 1988; Mrosovsky et al, 1989; Jepson et al., 1986; Klasing el al., 1987; van Heugten et al., 1984). The impact that these changes in metabolism had on lysine response was demonstrated by Williams et al. (1996) showing responses of growth rate and percent carcass muscle to increasing dietary lysine level differed depending on the level of immune system activation (Figure 1). Pigs with a lower level of immune activation had higher ADG and percent muscle and required a higher level of dietary lysine to maximize ADG and percent muscle.

Figure 1. Impact of Immune Activation and Lysine Regimen on ADG and Percent Muscle (Williams et al, 1995)



Frank et al. (1998) reported that the response of pigs to immune activation was greater in a high lean growth line than in a low lean growth line (Table 1). Growth rate and feed:gain were decreased by 7.8% and 7.4% versus 1.5% and 1.1% for the high and low lean growth lines, respectively by increasing immune activation. Variation of finishing weight was reduced 47.6% versus 24.8% in high and low lean growth animals when immune activation was decreased. Thus, in modern high lean growth systems, improvements in bio-security and health status would be expected to improve lean growth rate, increase carcass muscle percentage and as a result increase the amount of amino acids necessary to optimize production.

Recent data by Jacela et al. (2007) has shown that vaccination of pigs with a porcine circovirus vaccine increased daily weight gain and ending body weight by 3.2% and decreased mortality by 30% compared with non-vaccinated pigs. Thus, implementation of this relatively new technology would be anticipated to increase lysine requirements and the relative magnitude of this increase would be expected to be larger in more modern high lean growth animals than in lower lean growth pigs.

Table 1. Impact of Immune Activation and Lean Growth Genotype on Growth, Weight Variation and Feed/Gain. (Adapted from Frank et al., 1998)

	Low Lean Growth Line		High Lean Growth Line	
Criteria	High Immune Activation	Low Immune Activation	High Immune Activation	Low Immune Activation
Finish ADG, lb/d[a]	1.93	1.96	1.77	1.92
Final Wt CV, %[a]	12.5	9.4	16.8	8.8
Feed/Gain[a]	2.77	2.74	2.88	2.68

[a] Lean growth x immune stimulation interaction P<.10

Weaning Age

In an effort to decrease exposure to maternal pathogens and improve health status weaning age began to be decreased dramatically in the mid-1990s with many systems weaning pigs as young as 14 days. The hope was that by weaning pigs before passive maternal immunity declines disease cycles could be broken and health status of herds improved. Additionally, due to shorter lactation length, the number of litters per sow per year and pigs per sow per year could also be increased. However, shorter lactation lengths resulted in longer re-breeding intervals, smaller litter size and increased sow replacement rates. In order to optimize reproductive performance farrowing crates were added to rooms and weaning age was increased to 17 to 19 days. Main et al. (2004) reported that increasing weaning age from 15.5 to 21.5 days had dramatic impacts on wean to finish average daily gain and ending body weight. Average daily gain was increased at all stages of production, but the most dramatic increases occurred in the nursery with an increase of 56% in the older wean age animals compared with the younger. Overall wean to finish average daily gain and ending body weights were increased by 6.9%. Although body composition was not reported, if one assumes that body composition was not affected, lean growth rate would be expected to increase by 1% for each 1 day increase in weaning age. Changes of this magnitude would have significant impacts on amino acid requirements of pigs.

Sow Parity

Sow parity has been reported to have significant effects on the health status of weanling pigs and on post weaning performance. Moore (2001) reported that sows that were parity 2 or older weaned pigs that were 7.5% heavier, grew 5.5% faster in the nursery, 3.7% faster in the finisher and had 13% less variation in ending weight at finishing when compared to parity 1 offspring in a parity segregated production system. Wean-to-finish mortality was reduced 26% from 7.5 to 5.5%. Additionally, Burkey et al. (2008) reported that parity 4 sows produced colostrum and milk with higher levels of IgG and IgA and that offspring of parity 4 sows had higher serum IgG concentrations compared to offspring of parity 1 sows. Offspring of parity 4 animals were also 5.3% heavier than parity 1 offspring at weaning. These data would indicate that offspring from older parity animals would be expected in have increased lean growth rates and increased amino acid requirements. As sow management and health improve and replacement rates decrease the percentage of parity 1 offspring in a production system would be expected to decrease thus increasing the lean growth rate and resulting increased nutrient requirements to optimize growth.

Other Stressors

In many production systems pigs are subjected to multiple intermittent stressors such as temperature, social stress due to group dynamics and transportation, limitation in pen, feeder, and water space due to overstocking and optimization of building throughput. Any of these stressors individually would be expected to decrease growth rate and feed conversion efficiency, However, data would suggest that the impact of these stressors in combination is additive. MacFarlane et al, (1989) reported that as the number of stressors increased from 0 to 5 protein and fat deposition rates decreased linearly. More recently, Hyun et al. (1998) examined the impact of temperature, stocking density, and regrouping on the performance of pigs and found that these stressors imposed singly decreased growth rates by 10, 16, and 11%, respectively. However, as number of stressors increased from 0 to 3, ADG, ADFI, and G:F decreased linearly with pigs that were subjected to all three stressors simultaneously having growth rates which were 31% less than pigs subjected to none of these stressors.

In today's modern production systems, steps have been taken to reduce the impact of these stressors on production. Modern ventilation systems, optimal pen space and pig flow, improved bio-security, vaccination programs, and feeder and waterer design have converged and in conjunction with improvements in genetics have resulted in growth rates and feed conversions that in many cases are as much as 10 to 20% better than they were even 5 or 10 years ago.

IMPACT ON AMINO ACID REQUIREMENTS

We have reviewed many of the factors that impact production efficiency and lean growth rates in pigs. The implementation of the information gained from this research has resulted in dramatic improvements in health status, management and production systems and as a result improvements in lean growth rates and feed conversion efficiency. What impact has this had on requirements for amino acids and nutritional programs in today's production systems? Nutrient requirements are determined by the factorial sum of the requirements for maintenance, the sum of requirements for various tissue deposition rates and the efficiency of nutrient digestibility and utilization. These requirements can be estimated using a factorial approach to calculate the requirements for each of these functions. NRC (1998) estimates that the maintenance requirement for lysine is .36 mg/kg of metabolic body weight (body weight, $kg^{.75}$). Whole body protein is assumed to be 7% lysine and proteinaceous tissue is assumed to be 23% dry matter. TID lysine is assumed to be utilized with 58% efficiency. Making these assumptions, it is estimated that each pound of body proteinaceous tissue would require 12.6 g of lysine.

1 lb proteinaceous tissue x .23 lb protein/lb of proteinaceous tissue x .07 metabolizable protein lysine/lb protein x 1 lb TID lysine/ .58 lb of metabolizble protein x 453.6 g TID lysine/lb TID lysine = 12.6 g of TID Lysine

Martínez-Ramírez et al. (2008) reported that in ad-libitum fed barrows, proteinaceous tissue deposition comprises approximately 65% of total body weight gain during the period from 80 to 163 lb body weight. From these estimates, one would calculate that a pig would require approximately 8.2 g of lysine per lb of whole body weight gain.

Several recent studies have examined the performance of pigs when feeding iso-caloric diets increasing in TID lysine concentration. By calculating the lysine calorie ratio at which growth and feed efficiency are optimized and income over feed cost are maximized the required lysine percentage can be determined over a wide range of dietary calorie levels.

A trial run in a large production system (unpublished data, 2004) examined the impact of varying lysine levels fed in a 5 phase program from approximately 32 lb to 235 lb body weight on ADG and F:G. Diets were formulated with lysine levels for each phase that were 5% lower than current farm standard, current farm standard, 10% higher than current farm standard and 20% higher than current farm standard. All pigs were fed according to a standard feed budget and diets for each phase were iso-caloric (Table 2).

Table 2. Experimental Diet Nutrient Concentration

	Phase 1	Phase 2	Phase 3	Phase 4	Phase 5
Feed Budget, lb/pig	28	80	130	110	120
Treatment 1					
TID Lysine	1.048	.929	.808	.730	.630
ME, kcal/lb	1607	1618	1617	1624	1645
TID/ME, g/Mcal	2.960	2.606	2.266	2.038	1.736
Treatment 2					
TID Lysine	1.104	.978	.851	.768	.663
ME, kcal/lb	1607	1618	1617	1624	1645
TID/ME, g/Mcal	3.117	2.743	2.385	2.145	1.828
Treatment 3					
TID Lysine	1.213	1.076	.936	.845	.729
ME, kcal/lb	1607	1618	1617	1624	1645
TID/ME, g/Mcal	3.425	3.017	2.624	2.360	2.011
Treatment 4					
TID Lysine	1.324	1.174	1.021	.922	.796
ME, kcal/lb	1607	1618	1617	1624	1645
TID/ME, g/Mcal	3.736	3.291	2.862	2.574	2.193

During the weight periods from 32 to approximately 130 lb, ADG, feed conversion efficiency and ending pig weight were increased linearly within gender, however, during the first 2 weigh periods there was a lysine level x gender interaction with barrows having a greater incremental improvement in ADG with increasing dietary lysine level (Table 3).

Table 3. Grower Performance of barrows and gilts fed five phase feeding programs increasing in amino acid concentration.

		Lysine Level				P<	
Sex	Criteria	Low	Normal	High	Very High	Lysine Linear	Lysine Quad
Barrows	Start Wt	32.26	32.35	32.37	32.58	.30	.98
Gilts	Start Wt	32.64	32.70	32.49	32.10	.11	.53
Barrows[a]	ADG 1	1.06	1.09	1.21	1.41	.01	.29
Gilts	ADG 1	1.05	1.13	1.14	1.20	.06	.71
Barrows[b]	FG 1	1.63	1.59	1.55	1.41	.01	.62
Gilts	FG 1	1.59	1.58	1.47	1.45	.02	.47
Barrows	Wt 1	43.78	44.50	45.67	48.12	.01	.27
Gilts	Wt 1	44.20	45.18	45.07	45.13	.28	.37
Barrows	ADG 2	1.57	1.64	1.78	1.89	.01	.68
Gilts	ADG 2	1.49	1.56	1.58	1.67	.01	.98
Barrows	FG 2	1.76	1.73	1.63	1.68	.02	.07
Gilts	FG 2	1.80	1.78	1.64	1.58	.01	.73
Barrows	Wt 2	67.34	69.11	72.32	76.45	.01	.63
Gilts	Wt 2	66.58	68.59	68.83	70.17	.01	.56
Barrows	ADG 3	1.95	2.01	2.03	2.05	.11	.50
Gilts	ADG 3	1.85	1.87	1.89	1.94	.09	.75
Barrows	FG 3	1.83	1.79	1.82	1.79	.51	.94
Gilts	FG 3	1.84	1.81	1.81	1.79	.22	.93
Barrows	Wt 3	92.76	95.36	98.66	103.04	.01	.98
Gilts	Wt 3	90.62	92.85	93.35	95.37	.01	.79
Barrows	ADG 4	1.60	1.75	1.83	1.88	.01	.11
Gilts	ADG 4	1.57	1.59	1.68	1.69	.04	.60
Barrows	FG 4	2.24	2.11	2.15	2.11	.07	.35
Gilts	FG 4	2.19	2.10	1.95	2.00	.01	.01
Barrows	Wt 4	112.18	116.41	120.96	125.51	.01	.45
Gilts	Wt 4	109.64	112.27	113.50	115.63	.01	.65
Barrows	ADG 5	2.20	2.26	2.10	2.28	.79	.26
Gilts	ADG 5	1.98	2.07	2.02	2.18	.10	.60
Barrows	FG 5	2.02	2.07	2.31	2.06	.43	.05
Gilts	FG 5	2.19	2.11	2.14	2.09	.56	.91
Barrows	Wt 5	127.54	132.19	136.07	141.46	.01	.65
Gilts	Wt 5	123.49	126.75	127.67	131.72	.01	.96

[a]Treatment x Sex Interaction P<.10

[b] Treatment x Sex Interaction P<.05

As a result, barrows consuming the highest dietary lysine series were 11.4% heavier than barrows consuming the lowest lysine series while gilts were only 6.5% heavier. In subsequent weigh periods, ADG and FG were similar across dietary lysine regimens, with pigs generally maintaining the weight advantage that was gained during the period up to 130 lb (Table 4).

Table 4. Finisher Performance of barrows and gilts fed a five phase feeding programs increasing in amino acid concentration.

		Lysine Level				P<	
Sex	Criteria	Low	Normal	High	Very High	Lysine Linear	Lysine Quad
Barrows	St Wt	127.54	132.19	136.07	141.46	.01	.65
Gilts	St Wt	123.49	126.75	127.67	131.72	.01	.96
Barrows	ADG 6	2.35	2.40	2.42	2.36	.97	.39
Gilts	ADG 6	2.07	2.12	2.17	2.21	.11	.84
Barrows	FG 6	2.20	2.18	2.21	2.28	.27	.54
Gilts	FG 6	2.20	2.16	2.11	2.10	.22	.64
Barrows	Wt 6	160.83	165.77	169.92	174.45	.01	.33
Gilts	Wt 6	152.47	156.41	158.36	162.69	.01	.77
Barrows	ADG 7	2.08	2.27	2.28	2.10	.93	.12
Gilts	ADG 7	1.99	2.05	2.28	2.08	.34	.12
Barrows	FG7	2.80	2.48	2.49	2.71	.90	.09
Gilts	FG7	2.43	2.37	2.21	2.36	.63	.35
Barrows	Wt 7	175.74	181.65	186.34	189.59	.01	.07
Gilts	Wt 7	166.39	171.27	174.29	177.28	.01	.20
Barrows	ADG 8	2.27	2.06	2.07	2.22	.89	.02
Gilts	ADG 8	1.74	1.85	1.84	1.84	.41	.42
Barrows	FG 8	2.41	2.65	2.66	2.55	.34	.03
Gilts	FG 8	2.57	2.45	2.44	2.52	.73	.18
Barrows	Wt 8	194.21	198.10	202.94	207.32	.01	.46
Gilts	Wt 8	180.30	186.08	189.01	192.00	.01	.11
Barrows	ADG 9	2.25	2.23	2.15	2.21	.38	.56
Gilts	ADG 9	1.91	1.93	1.94	1.95	.55	.96
Barrows	FG 9	3.27	3.17	3.29	3.24	.85	.96
Gilts	FG 9	3.29	3.23	3.27	3.27	.97	.81
Barrows	Wt 9	209.94	213.99	218.00	222.95	.01	.68
Gilts	Wt 9	193.46	199.57	202.59	205.62	.01	.13
Barrows	ADG 10	2.59	2.50	2.36	2.25	.01	.75
Gilts	ADG 10	2.13	2.04	2.19	2.20	.21	.80
Barrows	FG 10	2.44	2.50	2.64	2.74	.01	.76
Gilts	FG 10	2.48	2.61	2.43	2.46	.27	.81
Barrows	Wt 10	228.16	231.85	234.54	238.38	.01	.19
Gilts	Wt 10	208.40	214.37	217.63	220.88	.01	.69

Over the entire growth period from 32 to 238 lb, barrows consuming the highest amino series had daily growth rates of just over 2 lb/day while gilts grew at just over 1.85 lb/day. Under these conditions, during the grower period pig performance improved linearly as average daily lysine intake increased and ADG and FG did not reach a plateau as calorie:lysine ratio increased to 3.74, 3.29 and 2.86 g TID/mcal ME from approximately 32 to 48 lb, 48 to 103 lb and 103 to 140, respectively, or with intakes of 8.5 to 9.5 grams TID lysine per pound of body weight gain (Table 5). In later finishing gain and feed conversion efficiency were maximized with calorie:lysine ratios of 2.62, 2.14, and 1.74 g TID/ Mcal ME for the periods from 140 to 175, 175 to 205 and 205 to 235, respectively, or with intakes of 8 to 9 grams TID lysine per pound of body weight gain.

In another study, Main et al. (2002) conducted a series of 6 studies over multiple weight ranges and reported that in barrows from 95 to 154 lb, gain and return over feed cost was maximized with a lysine/calorie ratio of 2.89 g TID lysine/Mcal ME or 8.8 g TID lysine per pound of body weight gain. In later finishing, ADG, feed efficiency, and income over feed cost increased linearly through 2.78 and 2.4 g TID Lysine/Mcal ME from 152-205 lb and 225 to 265 lb, respectively. This corresponded to 9.9 and 10.2 g TID lysine per pound of body weight gain. Gilt performance was maximized at lysine:calorie ratios of 3.23, 2.80, and 2.28 g TID lysine/Mcal ME from 77-132 lb, 132-187 lb and 172-223 lb, respectively. This corresponded to an intake of 9.7, 9.5 and 9.1 g TID lysine/lb of body weight gain.

More recently, Shelton et al. (2008) reported that in 85 -140 lb gilts that as SID lysine:ME ratio increased from 2.01 to 3.45 g/Mcal, ADG, FG and income over feed cost improved in a quadratic fashion through 3.16 g of TID lysine/Mcal ME. Additionally, in 185 to 245 lb gilts, ADG, FG, and income over feed cost improved linearly as TID lysine:ME ratio increased from 1.55 to 2.55 g TID/Mcal. These data indicated that pigs required approximately 10 g and at least 11 g of SID lysine intake per pound of body weight gain for the period from 85-140 lb and 185 to 245 lb body weight, respectively. Compared with data reported by Main et al. (2002) in the same production system, lysine intake per pound of body weight gain to maximize income over feed cost was 3.6% higher in the early grower period and 20% in late finishing period over this 6 year period. This level of lysine intake to maximize body weight gain would be 20 to 25% higher than what would be calculated using a factorial approach based on other published data sets.

Table 5. Lysine intake of barrows and gilts fed a five phase feeding programs increasing in amino acid concentration.

Sex	Criteria	Lysine Level Low	Normal	High	Very High	P< Lysine Linear	Lysine Quad
Barrows	TID Lys 1	8.20	8.67	10.25	11.75	.01	.57
Gilts	TID Lys 1	7.95	8.98	9.23	10.41	.01	.94
Barrows	G LYS/LB GAIN 1	7.76	7.94	8.49	8.49	.04	.44
Gilts	G LYS/LB GAIN 1	7.55	7.93	8.07	8.70	.01	.78
Barrows	TID Lys 2	13.13	14.16	15.95	19.03	.01	.12
Gilts	TID Lys 2	12.80	13.92	14.32	15.87	.01	.81
Barrows	G LYS/LB GAIN 2	8.35	8.65	8.98	10.08	.01	.09
Gilts	G LYS/LB GAIN 2	8.57	8.35	9.05	9.51	.01	.93
Barrows	TID Lys 3	15.11	16.01	18.01	19.54	.01	.67
Gilts	TID Lys 3	14.34	15.00	16.69	18.44	.01	.76
Barrows	G LYS/LB GAIN 3	7.72	7.95	8.88	9.55	.01	.97
Gilts	G LYS/LB GAIN 3	7.76	7.72	7.95	8.88	.01	.97
Barrows	TID Lys 4	13.10	14.26	16.69	18.25	.01	.27
Gilts	TID Lys 4	12.56	12.78	13.86	15.63	.01	.17
Barrows	G LYS/LB GAIN 4	8.20	8.14	9.11	9.74	.01	.44
Gilts	G LYS/LB GAIN 4	8.01	8.07	8.27	9.27	.01	.02
Barrows	TID Lys 5	16.23	18.06	19.92	21.75	.01	.17
Gilts	TID Lys 5	15.86	16.81	18.36	21.12	.01	.17
Barrows	G LYS/LB GAIN 5	7.40	7.98	9.79	9.55	.01	.05
Gilts	G LYS/LB GAIN 5	8.03	8.13	9.09	9.69	.01	.95
Barrows	TID Lys 6	18.99	20.18	22.58	24.92	.01	.94
Gilts	TID Lys 6	16.69	17.66	19.30	21.50	.01	.53
Barrows	G LYS/LB GAIN 6	8.08	8.41	9.39	10.57	.01	.50
Gilts	G LYS/LB GAIN 6	8.07	8.34	8.96	9.73	.01	.74
Barrows	TID Lys 7	18.28	19.60	21.46	23.78	.01	.94
Gilts	TID Lys 7	15.99	16.90	19.01	20.56	.01	.49
Barrows	G LYS/LB GAIN 7	9.25	8.65	9.53	11.35	.01	.07
Gilts	G LYS/LB GAIN 7	8.05	8.25	8.45	9.87	.01	.32
Barrows	TID Lys 8	17.94	18.93	21.08	23.46	.01	.73
Gilts	TID Lys 8	14.76	15.79	17.19	19.34	.01	.66
Barrows	G LYS/LB GAIN 8	7.97	9.22	10.21	10.65	.01	.03
Gilts	G LYS/LB GAIN 8	8.52	8.53	9.36	10.53	.01	.18
Barrows	TID Lys 9	20.95	21.25	23.36	25.66	.01	.21
Gilts	TID Lys 9	17.88	18.70	20.95	22.93	.01	.95
Barrows	G LYS/LB GAIN 9	9.34	9.53	10.87	11.69	.01	.99
Gilts	G LYS/LB GAIN 9	9.40	9.72	10.82	11.78	.01	.83
Barrows	TID Lys 10	17.97	18.74	20.57	22.16	.01	.92
Gilts	TID Lys 10	15.08	15.96	17.61	19.50	.01	.84
Barrows	G LYS/LB GAIN 10	6.96	7.53	8.75	9.88	.01	.93
Gilts	G LYS/LB GAIN 10	7.08	7.85	8.04	8.87	.01	.84

TAKE HOME MESSAGE

As we have improved our production and health management practices there has been a dramatic increase in pig performance due to decreasing stress levels and improved genetic lines. As production levels increase, amino acid levels need to be re-evaluated and increased to meet the demands for lean tissue growth rate. It is important to establish growth and feed intake curves for your production system to allow you to calculate TID lysine requirements. It appears that in the early grower period, lysine intake should be 8.5-9.5 g per pound of body weight gain. In late finishing, data is conflicting. Factorial estimates would say that no more than 8.5 g TID lysine/pound of body weight should be required. Literature estimates range from 8.0 to 11 g/lb of body weight gain for pigs gaining 2 to 2.3 lb/day. If your feeding program is on the low end of these estimates you should expect to see improvements in ADG, FG and income over feed cost by increasing lysine in the diet. If you are on the upper end of these estimates it is likely that you are overfeeding lysine and decreasing your income over feed costs.

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