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Feeding Growing-Finishing Pigs to Maximize Lean Growth Rate

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In the past, when pork producers were paid strictly on a live-weight basis, it was to their advantage to optimize average daily gain and feed:gain ratio. Because the producer received top dollar return for maximum growth, little attention was given to the composition of gain. This often resulted in carcasses that contained excess fat. However, as packers began implementing carcass merit buying systems, the rate and efficiency of lean tissue growth have become more economically important traits than overall growth rate.

Recent research has shown that feeding programs designed to maximize lean growth rate in growing-finishing pigs are affected by several factors, including sex of the animal, environmental temperature, and genotype. Each of these factors must be addressed if the producer's goal is to maximize lean growth.

Sex Effects

In most genotypes, gilts will consume 10 to 12% less feed and be about 4% more efficient in converting feed to body weight gain during the finishing period as compared to barrows. To offset the reduction in feed intake, diets for gilts need to contain higher nutrient levels (namely protein or amino acids) to achieve adequate daily intakes of these nutrients.

In a recent study conducted at nine experiment stations, the effect of dietary lysine level on the growth performance and carcass traits of finishing barrows and gilts was investigated. Corn-soybean meal diets with lysine levels of 0.58, 0.66, 0.73, or 0.80% were fed from 112 to 231 lb. The results from this study *(Table 1)* demonstrate that barrows and gilts respond differently to increased levels of dietary

Table 1. Effects of dietary lysine level on the performance and carcass traits of barrows and gilts[a]

	Barrows				Gilts			
Dietary lysine, %[b]:	**0.58**	**0.66**	**0.73**	**0.80**	**0.58**	**0.66**	**0.73**	**0.80**
Performance								
Daily gain, lb	1.80	1.84	1.83	1.85	1.63	1.72	1.71	1.72
Daily feed intake, lb	6.42	6.59	6.46	6.53	5.71	5.80	5.71	5.69
Feed/gain	3.56	3.54	3.46	3.46	3.52	3.35	3.32	3.27
Carcass Traits								
Hot dressing percent	72.20	72.70	72.00	72.70	72.90	72.90	72.80	73.10
10th rib backfat, in	1.16	1.17	1.11	1.13	0.99	0.95	0.94	0.91
Loin eye area, in^2	5.01	4.96	4.01	5.01	5.21	5.21	5.46	5.67
Percent muscle	52.60	52.50	53.10	52.90	54.40	54.90	55.20	55.80
Estimated lean gain, lb/d	0.68	0.69	0.69	0.71	0.66	0.71	0.71	0.74

[a]Data from 1,088 pigs from 112 to 231 lb (J. Anim. Sci. 71:1510; 1993).
[b]Dietary protein levels were 13, 14, 15, and 16% for the diets containing 0.58, 0.66, 0.73, and 0.80% lysine, respectively.

lysine. Except for a modest improvement in feed efficiency, increasing the dietary level of lysine from 0.58 to 0.66% had little effect on performance and carcass traits of barrows. However, increasing the lysine level from 0.58 to 0.66% in diets fed to gilts improved growth rate and feed efficiency by 6 and 5%, respectively. Additionally, increasing dietary lysine for gilts from 0.58 to 0.80% resulted in the greatest reduction in backfat (9%) and the largest improvements in lean growth rate (12%), loin eye area (9%), and percent muscle in the carcass (3%). This study also provides additional evidence of the feed intake differences between barrows and gilts. Averaged across the four lysine levels, gilts consumed approximately 13% less feed than barrows (5.73 lb/day for gilts vs. 6.50 lb/day for barrows).

The differences in feed intake, together with the differences in performance and carcass parameters, provide the basis for split-sex feeding. These results (taken with the results from other published reports) would indicate there is little need to feed greater than 0.66% lysine to barrows to maximize either performance or carcass traits. On the other hand, dietary lysine levels of 0.73 to 0.80% for gilts merits consideration, particularly for producers who market on a lean value based system.

A majority of the data indicates there is little, if any, need to feed barrows and gilts separately until they reach about 120 lb. However, because pigs must be handled at the time of weaning or when they are moved to the growing-finishing facility, it is usually easier to sort pigs according to sex at that time. This eliminates the need to sort and remix pigs an additional time at a later date.

For split-sex feeding to be a viable practice for producers, the improvements in performance and carcass traits must translate into increased economic value above the "extra" costs associated with this practice. Factors that should be considered include the price difference between the grain source and the protein supplement, increased feed mixing time, cost of extra bin or storage space for additional diets, and the additional time required for feed delivery. Also, the existing facilities and pen designs should be evaluated for ease of making changes needed for the application of separate sex feeding.

However, some consideration should be given to separating the sexes even if a different feeding program cannot be implemented. As shown from the data in *Table 1,* gilts grow at a slower rate than barrows. Penning barrows and gilts separately will result in more uniform growth within each pen. Therefore, having all of the same sex within a pen will reduce the amount of time required to sort animals at market time.

Environmental Temperature Effects

The recommended temperature ranges for growing-finishing pigs are shown in *Table 2.* Due primarily to its effect on feed intake, the thermal environment can have a tremendous effect on both growth rate and feed efficiency *(Figure 1);* thus, the thermal environment also can affect the composition of gain. Pigs exposed to extremely cold temperatures will consume excessive quantities of feed in an effort to offset heat loss and maintain normal body temperature. At the other extreme, during heat stress, feed intake is decreased in order to reduce the heat production associated with the digestion and metabolism of nutrients. Because of this relationship, swine diet formulations should be adjusted to account for the variations in feed intake (just like between sexes) associated with environmental temperature changes.

Table 2. Recommended thermal conditions for growing-finishing swine[a]

Weight	Preferred temperature range
40 to 75 lb	65 to 80°F
75 to 150 lb	60 to 75°F
150 lb to market	50 to 75°F

[a]Adapted from 1992 Swine Care Handbook, National Pork Producers Council.

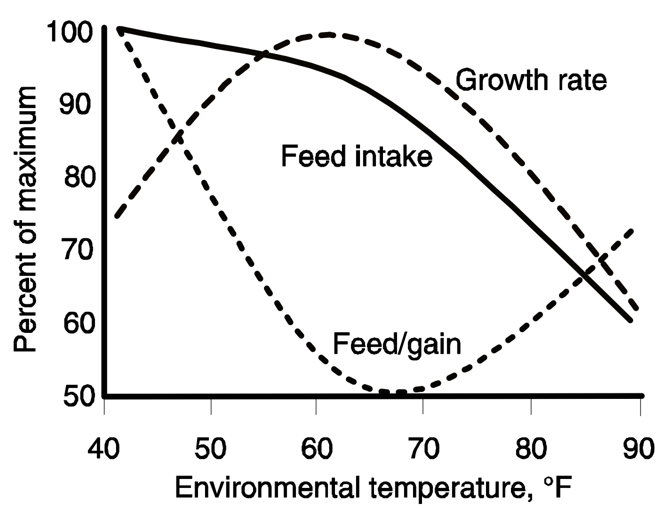

Figure 1. Effect of environmental temperature on growing-finishing pig performance

Most published nutrient and diet recommendations are intended for pigs being raised in their thermoneutral (comfort) zone. However, when pigs are exposed to temperatures outside their thermoneutral zone for prolonged periods of time, the concentration of nutrients in the diet will need to be adjusted. For example, due to the increase in feed intake, pigs housed in a cold environment will consume more lysine than is needed for maximum lean growth rate unless the level of lysine in the diet is reduced. On the other hand, during the hot summer months (when feed intake is reduced) pigs will not consume sufficient amounts of lysine for normal lean gain to occur unless the concentration of lysine in the diet is increased.

Research findings indicate that if pigs are maintained in a sufficiently cold environment (below approximately 50°F for 50 lb pigs and 40°F for finishing pigs), the concentration of lysine in the diet can be reduced by about 0.1 percentage unit. In a typical diet containing corn and soybean meal, reducing dietary lysine by 0.1 percentage unit is equivalent to reducing crude protein by 1.3 percentage units. It is important to note that this finding is only applicable to **continuous** cold exposure. If diets are reformulated to a lower lysine level and temperatures rise into the pigs' thermoneutral zone (60° to 75°F), feed intake will decrease, resulting in reduced lysine intake. Therefore, lower lysine diets should not be mixed and fed unless cold conditions are expected to persist for a prolonged period of time.

During the hot summer months, feed intake may be depressed enough by prolonged high temperatures to limit lysine intake unless diets are adjusted to contain higher levels of lysine. As a rule of thumb, research would indicate that when growing-finishing pigs are exposed to prolonged periods of temperatures between 80° and 90°F, the level of lysine in the diet should be increased by 0.1 percentage unit. To increase the lysine content of a corn-soybean meal based diet by 0.1 percentage unit, the crude protein level can be raised by 1.3 percentage units. As was the case with cold temperatures, this would only apply to **continuous** exposure to temperatures ranging from 80° to 90°F. If diets are reformulated to a higher lysine content and temperatures fall back into the pig's zone of thermoneutrality, feed intake will increase and the pig will consume more lysine than needed. While the extra lysine will most likely not have an adverse effect on pig performance, it will result in a higher than necessary feed cost.

If temperatures above 90°F are experienced for an extended period of time, feed intake will be reduced dramatically and the pig's ability to respond to increased dietary lysine will be diminished. In this case, energy intake is more limiting than lysine intake. Using all available methods to keep the pig cool is the best approach to minimize the reduction in feed intake associated with extremely hot weather.

Increasing the energy density of the diet by adding fat can also be used to help keep energy intake at an adequate level during the hot summer months. Less heat is produced by pigs when they digest and utilize fat as compared to the starch and fiber found in cereal grains and plant protein sources. Because of this, fat improves pig performance more in the summer than in the winter. Therefore, the breakeven cost of fat is higher during the summertime than in the winter *(Table 3).* If fat can be purchased at or below the prices shown in *Table 3,* it would be economical to add fat to the diet.

Table 3. Breakeven cost of fat for growing-finishing pig diets

Feed cost without added fat, $/ton	Fat cost, ¢/lb[a] Summer	Winter
100	15.5	9.5
120	18.0	11.0
140	20.5	13.0
160	23.0	15.0

[a]Assumes nonfeed costs of 8 cents per day per pig. The benefits of reducing dust are not included.

As the energy density of the diet is modified, growing-finishing pigs will adjust their consumption of feed to maintain a certain caloric (energy) intake. Less feed will be consumed when the energy density of the diet is increased by adding fat. Therefore, lysine intake will be reduced when fat is included unless the level of lysine in the diet is increased. To alleviate this problem, the diet should be formulated to maintain a constant lysine-to-metabolizable-energy ratio. For growing pigs (50 to 120 lb), the recommended lysine-to-metabolizable-energy ratio (expressed as grams of lysine per megacalorie of metabolizable energy) is 2.5, and that for finishing pigs (120 lb to market) is 2.0. *Table 4* shows how the concentration of lysine in the diet must be altered as fat is added to maintain a constant lysine-to-energy ratio.

Table 4. Lysine levels needed to maintain a constant lysine-to-metabolizable-energy ratio in diets for growing and finishing pigs[a]

Added dietary fat, %	Dietary lysine, %	
	Growing[b]	Finishing[b]
0	0.80	0.65
2	0.82	0.66
4	0.84	0.67

[a]For corn-soybean meal based diets.
[b]Formulated to maintain lysine-to-metabolizable-energy ratios of 2.5 and 2.0 for growing and finishing pigs, respectively.

Genotype Effect

To more accurately develop a feeding program that maximizes lean growth rate, producers must know the genetic potential of their pigs. The genotype of the pig is what sets the maximum level of lean growth that a pig can achieve. Unfortunately, a large amount of variation in the genetic capacity to deposit lean tissue exists among pigs. In a recent evaluation conducted at Purdue University, daily lean growth rate varied by 35% among nine different genotypes. Even more surprising, the researchers found up to 38% variation in lean growth rate within a genotype. The results from another comparative study involving 236 pigs from 18 Midwest seedstock suppliers indicated that the amount of lean deposited per day ranged from 0.38 to 0.97 lb (a difference of 159%), even though all the pigs were fed a common diet from 70 to 230 lb!

The importance of having a good handle on the genetic capability of the pig is related primarily to the protein (amino acid) needs of the pig. Compared to pigs with a low genetic potential for lean growth, high lean growth pigs have a higher peak muscle growth, and they have the ability to continue laying down muscle to heavier weights *(Figure 2).* This increased muscle growth results in greater amino acid needs for high lean growth pigs, particularly during the latter stages of the finishing period. Further complicating this issue, pigs with a high genetic potential for lean gain often (but not always) consume less feed than pigs with lower rates. The reduction in feed intake for high lean growth pigs may be as much as 20 to 25% less than average. If the pig is consuming less feed, the concentration of amino acids in the diet must be increased. The bottom line is that pigs with different rates of lean tissue gain will almost always have different amino acid requirements, whether the requirement is expressed as an absolute amount required per day or as a percentage of the diet.

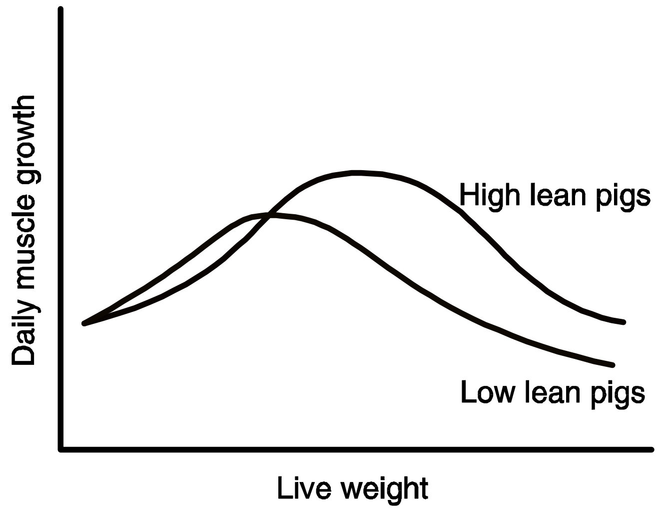

Figure 2. Genotype differences in muscle growth

What is the difference in amino acid requirements between pigs with high lean growth rates and pigs with lower lean growth rates? To address this question an experiment was conducted at the University of Kentucky that examined the effects of the lysine level in diets for growing-finishing pigs of different genotypes. The pigs used in the study included two genotypes with high capacities for lean tissue growth (0.89 lb lean per day) and two genotypes with medium capacities for lean growth (0.69 lb lean per day). The pigs were fed four dietary lysine levels (0.50, 0.65, 0.80, or 0.95%) that were attained by adjusting the amounts of corn and soybean meal in the diet. The pigs were allowed to consume feed and water *ad libitum* (free choice) from 48 to 235 lb.

The results of this study are shown in Figure 3. Daily lean gain of barrows with a medium genetic potential for lean growth was maximized with a dietary lysine level of 0.65%, while barrows with a high genetic potential for lean growth required a higher dietary level of lysine (0.80 to 0.95%) to maximize daily lean gain. This research clearly indicates that there is not a need to feed elevated levels of lysine to pigs with a moderate capacity for lean growth. However, to maximize lean growth in pigs with a high capacity for lean tissue deposition, higher levels of lysine must be fed.

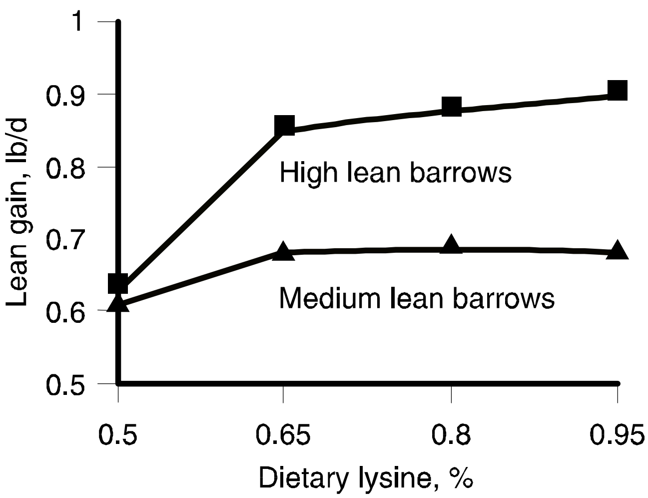

Figure 3. The effect of genotype on the lysine requirement of barrows from 48 to 235 lb (1989 Kentucky Swine Research Report, page 21)

Method for Estimating Lean Gain

Establishing the genetic potential for lean gain within an individual swine herd requires the determination of the amount of lean initially present in the pig, the amount of lean present in the pig at the time of slaughter, and the number of days on test. Once these values are obtained, daily lean gain is calculated using the following formula:

$$\text{lb lean gain per day} = \frac{\text{lb carcass lean} - \text{lb initial lean}}{\text{number of days on test}}$$

Estimating the pounds of lean in the carcass will require the producer to conduct an on-farm test and sell the test hogs on a carcass merit basis so that carcass information can be obtained. Listed below is a procedure for an on-farm test that can be used to estimate the amount of carcass lean.

Procedure for Conducting an On-Farm Test

1. If possible, the test should be conducted in the fall or spring to remove the potential effects of harsh weather that can be encountered in the summer or winter.
2. Randomly select a group of pigs (if possible, use pigs from a single farrowing group) for the test that are representative of the operation. An equal number of barrows and gilts should be used due to the effect of sex on growth rate and carcass leanness. The size of the group should be as large as possible. Bigger groups will give more accurate, meaningful results.
3. Record pig weights at the beginning of the test period. Pigs should weigh between 40 and 50 lb at the beginning of the test.
4. To ensure that pigs have the opportunity to reach their full genetic potential, a high-density amino acid diet should be fed. Formulate diets to contain 0.95% lysine from 40 lb to 120 lb and 0.85% lysine from 120 lb to 240 lb. All other management practices should be conducted as normal.
5. Record feed disappearance during the test period to estimate daily lysine intake. Although not necessary to calculate lean gain, it will be required as you determine the concentration of lysine needed in future diets. It also will give you a means of evaluating the efficiency of lean growth (pounds of feed per pound of lean gain).
6. Terminate the test when the pigs average about 240 lb. At that time, weigh the pigs, record the number of days on test, and sell the pigs as a group on a carcass merit basis. If the packer uses the Fat-O-Meter to gather carcass information, calculate the pounds of lean in the carcass (containing 5% fat) using the following equation:

$$\text{lb of carcass lean} = 2.827 + (0.469 \times \text{HCW}) - (18.470 \times \text{FD}) + (9.824 \times \text{LMD})$$

where HCW = hot carcass weight, lb
FD = fat depth, in
LMD = loin muscle depth, in

If your packer uses an alternative method to obtain carcass composition, determining the pounds of lean in the carcass will require hot carcass weight, 10th-rib backfat, and loin eye area to be obtained. However, due to more stringent quality control standards being implemented within slaughter plants, gathering this type of carcass information may be difficult. Also, if the packer will work with you to provide the needed information, you may be charged for splitting the loins to measure loin eye area. Nonetheless, with this information, pounds of lean in the carcass (containing 5% fat) can be calculated using the following equation:

$$\text{lb of carcass lean} = 7.231 + (0.437 \times \text{HCW}) - (18.746 \times \text{TRFD}) + (3.877 \times \text{LEA})$$

where	HCW	=	hot carcass weight, lb
	TRFD	=	10th rib fat depth, in
	LEA	=	loin eye area, in^2

To obtain an estimate of the initial amount of lean (containing 5% fat) in a 40 to 50 lb feeder pig, the following equation can be used:

lb of initial lean = (0.418 x live weight, lb) - 3.65

As an example, assume that a pig weighing 40 lb was on test for 100 days and produced a 175 lb carcass with 0.90 in of fat depth and 2.0 in of loin depth (based on Fat-O-Meter measurements). Using the equations described above, the estimated rate of lean gain for this pig is calculated as follows:

lb of initial lean = (0.418 x 40 lb) - 3.65
= **13.1 lb**

lb of carcass lean = 2.827 + (0.469 x 175 lb) - (18.470 x 0.70 in) + (9.824 x 2.5 in)
= **96.5 lb**

lb lean gain per day = (96.5 lb - 13.1 lb) / 100 days
= **0.83 lb/d**

If producers are using a good selection program, the genetic potential of their pigs will always be improving. Because of this, the test should be repeated at least once per year to ensure that adequate levels of lysine (protein) are being fed.

Recommendations

Table 5 lists the three most widely accepted lean growth categories based on daily lean growth rates. Producers whose pigs fall into the low lean growth category should give serious consideration to ways of improving the genetics of their pigs. Feeding diets with high levels of amino acids (protein) will not make lean pigs out of genetically fat ones. Properly formulated diets are only a tool that can be used to allow pigs the opportunity of reaching their genetic potential.

Due to the severe price deductions that packers impose on pigs with low carcass quality, the most rapid, economical means of upgrading the genetics may be to repopulate with a better genetic source. At the very least, a good selection program that is based on both growth rate and carcass quality should be implemented to help identify gilts to be retained in the herd. Once identified, only the best terminal sires should be used to mate with these gilts.

The University of Kentucky Cooperative Extension Service has developed an on-farm testing program which is designed to assist producers in identifying the best performing females within the herd. Producers who are interested in this program should contact their county agricultural Extension agent for more details.

The lysine levels shown in *Table 6* can be used as a guideline when formulating diets for pigs categorized as medium or high lean gain. As noted earlier, feed intake may vary between pigs within a lean growth category. For example, some high lean pigs will consume large quantities of feed and, therefore, may not need diets containing lysine levels as high as those listed in *Table 6.* Feed intake data should be used to more accurately determine lysine needs. Producers who do not know their pig's rate of lean growth are advised to use the lysine levels listed for medium lean growth pigs.

Table 5. Lean growth categories based on daily lean growth rate

Lean Growth Category	Lean Growth Rate (lb/day)
High	0.80
Medium	0.60 to 0.80
Low	0.60

Phase Feeding

Historically, the commercial swine industry has fed one diet containing about 16% crude protein during the growing phase (40 to 120 lb), and another diet containing approximately 14% protein during the finishing phase (120 lb to market). This two stage feeding practice was based on data that indicated pigs would reach peak lean growth rates at close to 120 lb and that feed intake would generally increase until pigs reached at least 260 lb. However, as discussed earlier, data evaluating today's high lean genotypes suggests these pigs reach peak muscle growth at heavier weights, often as high as 180 lb. Because of this, more than one diet change may be reasonable for high lean growth pigs during the growing-finishing period.

Ideally, the kind of feeding program that would be used to allow growing-finishing pigs the opportunity to maximize lean growth is one in which diet formulations are changed to accommodate the pattern of lean growth and feed intake. This type of feeding program is referred to as phase feeding. Changing the diet more frequently will reduce the chances of under- and over-feeding nutrients and, because the pig's requirement is more accurately being met, improve overall performance and reduce total feed costs.

The implementation of a complex phase feeding program is not recommended for everyone. A higher level of management and attention is required to ensure that diets are properly prepared and delivered to the correct location. Additional equipment may also be needed. Current facilities will need to be evaluated to determine if they lend themselves to phase feeding. Entire buildings or sections of buildings that can be all-in/all-out managed work best. Finally, it must be possible to pen or group together pigs of a similar weight. For many producers, the improvements in growth rate, feed efficiency, and carcass traits will more than pay for the changes and additional time required for phase feeding.

Table 6. Estimated lysine needs of medium (0.6 to 0.8 lb lean/day) and high (0.8 lb lean/day) lean gain genotypes[a,b]

	Lysine needs for *medium lean* pigs				Lysine needs for *high lean* pigs			
Pig weight	% of diet		grams/day		% of diet		grams/day	
(lb)	Barrows	Gilts	Barrows	Gilts	Barrows	Gilts	Barrows	Gilts
40-90	0.90	0.96	15.2	15.9	0.92	0.98	15.5	16.2
90-130	0.78	0.90	20.0	21.5	0.80	0.92	21.3	23.0
130-200	0.63	0.80	20.0	22.0	0.65	0.84	20.5	23.1
200-240	0.52	0.64	19.0	21.2	0.62	0.75	20.5	22.5

[a]Adapted from Stahly et al., 1991 (Nutrition Institute Proceedings, National Feed Ingredient Association).
[b]For corn-soybean-meal-based diets fed in thermoneutral conditions.

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