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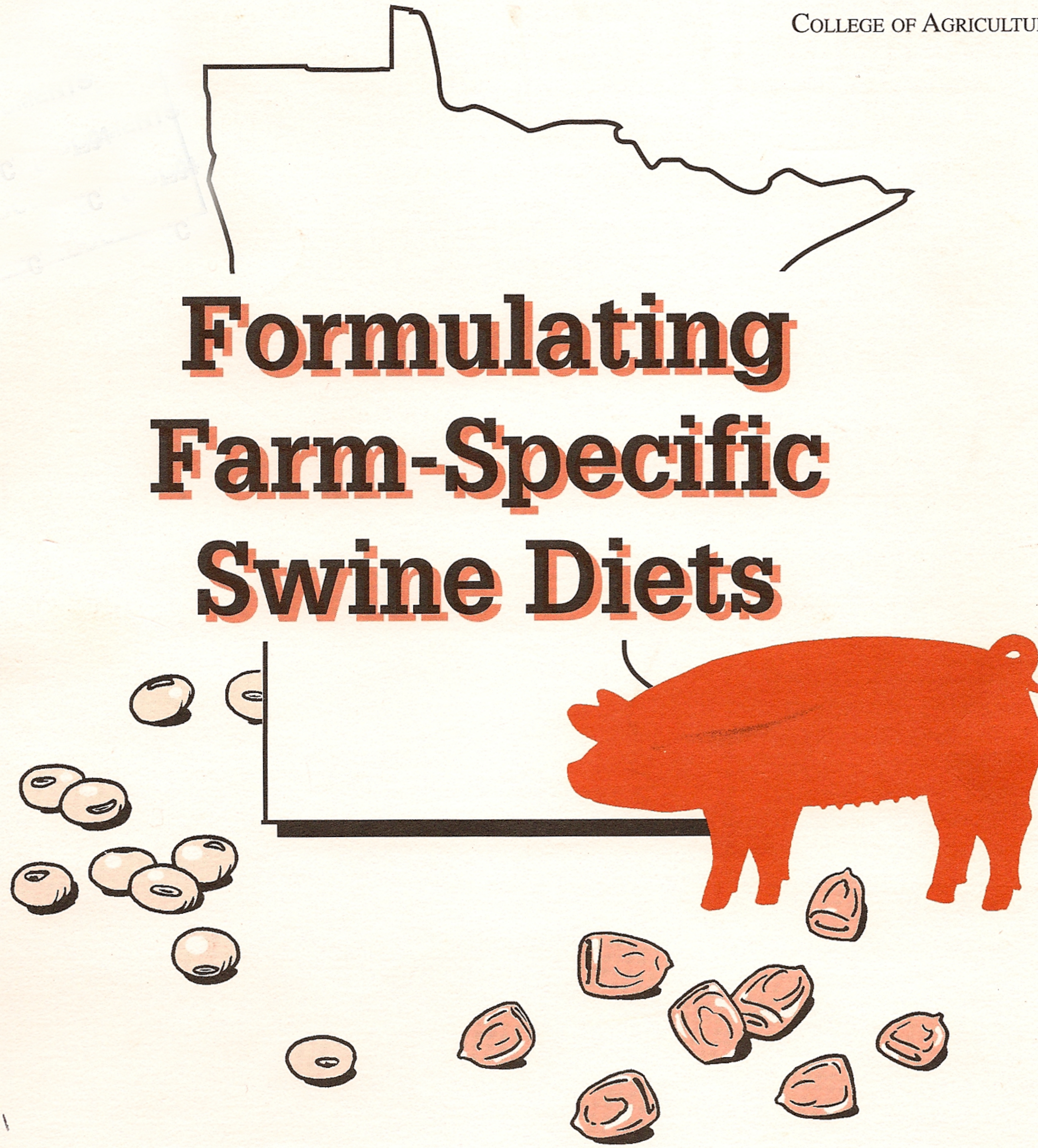
College of Agriculture

Formulating Farm-Specific Swine Diets



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Conversion Factors

1 lb = 454 grams (g)
1 kilogram (kg) = 1000 grams = 2.2 lb
1 gram = 1000 milligrams (mg)
1 megacalorie (Mcal) = 1000 kilocalories (kcal)
1 milligram = 1000 micrograms (mcg)
1 mg/kg = 1 part per million (ppm)
1 inch = 2.54 centimeters
1 IU = 1 USP

To convert from % to ppm, move 4 decimal places to the right.
(.05% = 500 ppm)

To convert from ppm to %, move 4 decimal places to the left.
(40 ppm = .004%)

Tailoring Diets to Your Farm

Modern research and management suggests feeding programs for swine herds be modified to optimize nutrition for new conditions and objectives. A key component of better swine feeding for the future is improving the accuracy of determining and meeting nutrient requirements. Nutrient requirements of pigs depend on many factors. Thus, one set of diets is inadequate to meet the needs of all pigs in different swine operations.

The objective of this publication is to present a broader approach to swine herd nutrition: tailoring diets to conditions and objectives specific to each farm.

The process for developing and managing nutritional programs for swine is summarized in **Figure 1** (page 2). A series of steps must be completed to properly formulate a feeding program for any swine operation. At each step, several factors must be evaluated relative to the goals of the feeding program, the prevailing economic conditions and the resources available to the pork producer.

The National Research Council (NRC) periodically publishes a summary of recent research findings entitled *Nutrient Requirements for Swine,* which is the basis for many nutrient recommendations. The NRC presents percents and amounts of dietary nutrients required to achieve listed growth rates, feed conversions and reproductive levels when corn-soybean meal diets are fed under ideal conditions. These **nutrient requirements** represent minimum levels and do not include any surpluses. Consequently, nutrient levels recommended by feed industry representatives are **nutrient allowances**, which include a "margin of safety" over NRC levels. Recommendations contained in this publication are intended to ensure that nutrient levels are adequate and cost effective, and can be tailored to specific conditions.

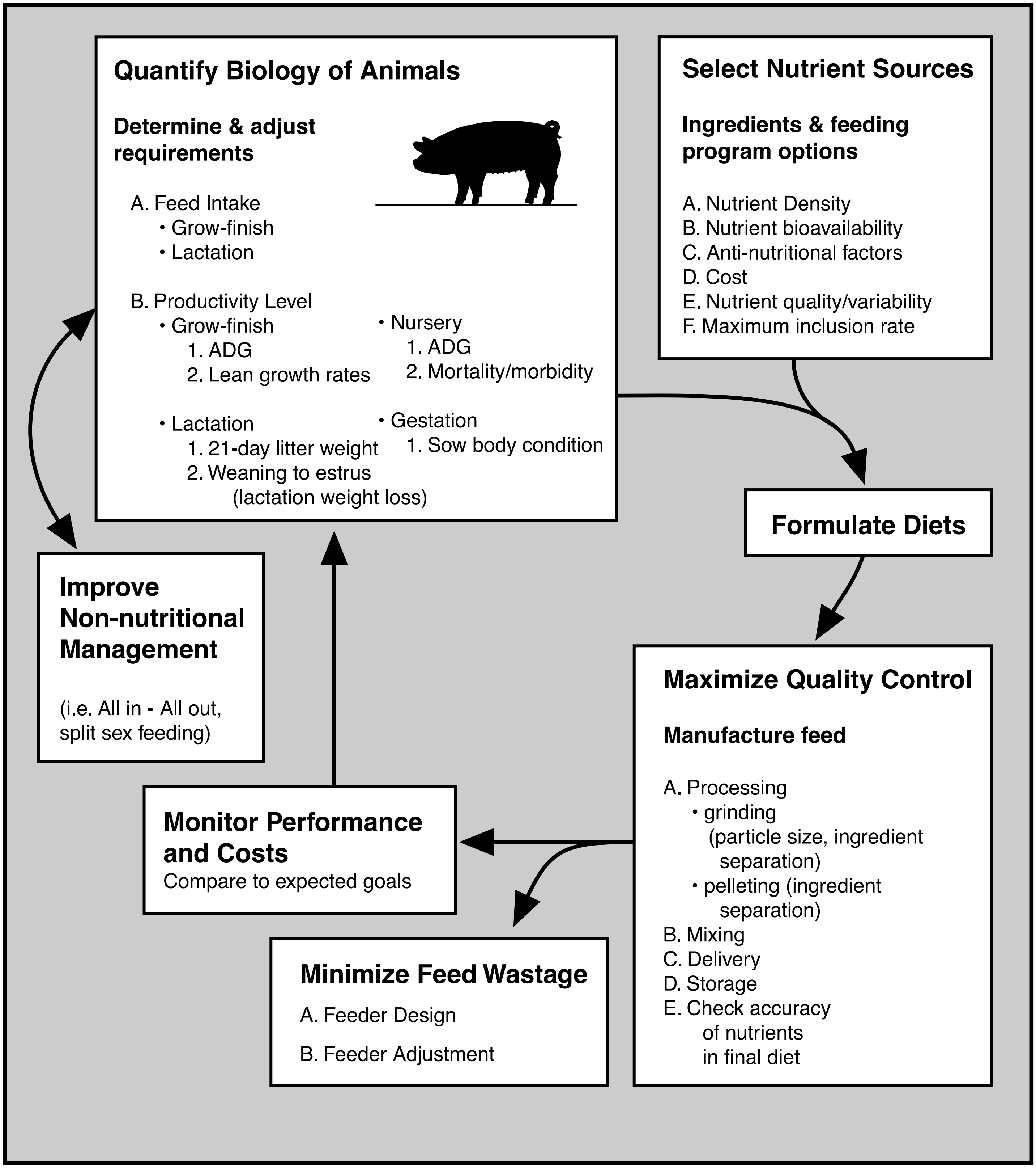
When formulating or evaluating a swine feeding program, you need to understand the two ways of expressing nutrient allowances: **1) amount of nutrient per day, or 2) concentration of nutrient in the diet.** Nutrient allowances expressed on a daily basis are relatively constant and relate to the pig's nutrient needs to maintain its body plus nutrient needs for productive functions (growth, lactation, etc.). For example, a sow producing 16 lb of milk daily requires about 19.4 Mcal of metabolizable energy (ME) daily. This energy need is relatively constant if she eats 8 or 18 lb of feed.

In contrast, nutrient allowances expressed on a concentration basis depend on feed intake. Are the energy needs of the sow in our example satisfied with a corn-soybean meal diet containing 1.47 Mcal ME/lb? It depends on feed intake! If she eats 13.2 lb of feed daily, her energy needs will be satisfied (13.2 lb x 1.47 Mcal ME/lb = 19.4 Mcal ME). But if she eats 10 lb of feed daily, she will not satisfy her energy needs (10 lb x 1.47 Mcal ME/lb = 14.7 Mcal ME).

Objectives of a swine feeding program should be specific for each producer. Possible objectives may be divided into goals for performance, cost and production scheduling (barn throughput).

Improved performance is often associated with greater efficiency and profitability. Producers may set performance goals for lean gain per day, feed conversions, 21-day litter weight, etc. Refer to the Pork Industry Handbook factsheet 100, "Performance Guidelines for the Swine Operation," for a more complete discussion of performance measures and attainable goals for each measure.

Figure 1. Management of Nutritional Programs



Many performance measures are greatly influenced by nutrition. Questions to consider when establishing performance goals are:

1) What is the current level of performance in my herd?

2) Can and should a higher level of performance be attained?

3) Will improved nutrition help attain increased performance?

4) If so, what specific components of my nutrition program can be changed to improve performance?

5) Will an adjustment in my feeding program improve profitability?

Production flow (barn throughput) is also an important consideration for planning a swine feeding program. Facility cost and diet cost are components of total cost of production. If facility costs are high, a producer may choose an expensive feeding program that supports rapid growth thus reducing fixed cost per pig. This scheme may reduce total cost of production. In contrast, if facility costs are low, total cost of production may be lowered by feeding a diet that results in slower gains but is less costly.

Estimating Nutrient Requirements

Factors That Influence Nutrient Levels

Feed Intake

Feed intake is one of the most critical, and often overlooked, factors that determine nutrient levels in feed. Pigs have daily requirements for a quantity of nutrients to maintain their bodies and support productive functions (growth, milk production). Measuring feed intake is the only way to determine the amount of each nutrient consumed by pigs. Once feed intake is known, dietary concentration of nutrients can be adjusted to ensure that pigs consume the proper amount of each nutrient required for maintenance and productive functions.

For example, if a 60 lb barrow requires 20.0 grams of lysine daily and consumed 3.5 lb of a diet that contained 0.9% lysine, he would receive 14.3 grams of lysine daily (3.5 lb feed x 0.009 x 454 g/lb). If the pig consumed 5.5 lb of this feed he would receive 22.5 grams of lysine daily. Underfeeding nutrients results in suboptimal performance (e.g., slow growth). Overfeeding nutrients often increases feed costs.

Feed intakes can be measured and diet formulations adjusted to more accurately meet nutrient requirements. There are several methods for determining feed intake that are discussed for each phase of production below. It is important to note that these methods measure "feed disappearance." Feed wastage can significantly inflate estimates of feed intake. Therefore good feeder design and management are essential.

Productivity Level

A second major factor affecting nutrient requirements is level of performance. A sow raising 12 pigs will produce more milk and therefore require more nutrients than a similar sow raising 8 pigs. Likewise, a pig gaining 0.75 lb of lean tissue daily requires a larger quantity of nutrients than one depositing 0.6 lb of lean tissue daily.

On a given farm under specific conditions, a producer can measure the current productivity level of the swine herd. However, *potential* performance level is usually not known. You should set nutrient levels somewhat above those that support current performance levels. As new diets are fed, performance levels should be measured. If performance improves, nutrient levels can be adjusted progressively upward until the optimal level of performance is achieved. Many factors such as genetics, season, age/stage of growth, health status, feed form and palatability of feed impact feed intake and productivity level. Consequently, feed intake must be measured when these conditions change so that diets can be re-formulated to satisfy nutrient needs of the pig.

Importance of Water

While much attention focuses on feed intake and formulation of diets, water is the most important nutrient to the pig. Water makes up about 80% of the pig's body at birth and 50% of the market hog's body. A pig housed in thermoneutral conditions will consume 2 to 3 lb of water for every pound of dry feed consumed. Under heat stress or during lactation this may increase to 4 or 5 lb of water for every lb of feed. Estimated water consumption for various classes of pigs is listed in **Table 1.**

Water quality should also be considered. Water quality guidelines are listed in **Table 2.** These guidelines are similar to but more lenient than water quality standards for humans.

Table 1. Estimated Water Consumption of Pigs[a]

Class of pig	Water intake (gal/head/day)
Sow and litter	8
Nursery pig	1
Growing pig	3
Finishing pig	4
Gestating sow	6
Boar	8

[a]Midwest Plan Service, 1983

Table 2. Water Quality Guidelines for Swine[a]

Water analysis	Acceptable range
pH	6-8
Total dissolved solids (TDS)	0-3000ppm[b]
Nitrate nitrogen	0-100 ppm
Nitrite nitrogen	0-10 ppm
Sulfate	0-1000 ppm[c]
Total bacteria	0-1000/ml
Coliform bacteria	0-50/ml

[a]Adapted from Bergsrud and Linn (1989).
[b]Levels up to 5000 ppm can be tolerated with some adaptation.
[c]Levels up to 1500 ppm can be tolerated with some adaptation.

Estimating Nutrient Needs at Each Production Stage

Feeding Gestating Sows

The primary objective for nutrition of gestating sows is precise control of weight gain and body condition while supporting optimal fetal development. Sows must be limit-fed to minimize excessive weight gain.

Measuring Feed Intake for Gestating Sows

Scoop method Fill a scoop to a designated level. Weigh the contents of the scoop and record the weight. Repeat this procedure several times to determine an average amount of feed the scoop will hold. Count and record the number of scoops given to each animal at feeding. Periodically recheck the weight of feed the scoop will hold. Changes in density of feed reduce the accuracy of this method, but it is better than not measuring feed intake at all. Check calibration of automatic feed drop systems.

Producers commonly feed a gestation diet at about 4-6 lb/day to sows under most environmental conditions. This quantity of feed per day is only a target and the actual amount fed should be varied according to individual animals and situations. Reducing daily feed allowance to less than 3 lb/hd may cause inadequate intake of vitamins and minerals with typical gestation diets.

Size of Sow

Larger, heavier animals have higher maintenance requirements than smaller, lighter animals. Energy requirements increase about 200 kcal ME for each 20 lb increase in body weight.

Housing and Feeding Method

When breeding stock are housed and fed in groups, they require about 15% more feed than individually fed animals because timid sows will not consume their full share.

Environmental Temperature

Sows housed at temperatures below their lower critical temperature require more feed to maintain body temperature than sows housed in a warm environment. For every 20°F below 60°F, feed allowance should increase 1 lb. This rule of thumb applies to the temperature sensed by the animal, which is not necessarily the same as the thermometer reading.

Body Condition

Thin animals have less fat and insulation and require more feed than animals in good body condition to maintain body temperature when housed in low environmental temperatures.

The consequences of undesirable body condition for sows include increased culling rate, increased numbers of gilts in the sow herd and decreased pigs/sows per year.

Overfat sows are more likely to experience:

- increased embryonic mortality
- increased farrowing difficulty
- more crushed pigs
- decreased feed intake during lactation
- lower milk production, and
- increased susceptibility to heat stress.

Thin sows may exhibit:

- failure to return to estrus
- lower conception rates
- smaller subsequent litter sizes
- downer sow syndrome (bone breakage and spinal injuries due to excessive mobilization of minerals from bones).

There are two methods to evaluate a gestation feeding program:

1) Condition scoring. This method combines visual appraisal and estimated backfat to arrive at a number from 1 to 5. The desirable condition score at farrowing is 3. Daily feed offered should be adjusted if average score is above or below 3 (see Figure 2).

For mature sows of lean genotype, approximate last rib backfat measurements are:

score 1	< 0.6 in.
score 2	0.6-0.7 in.
score 3	0.7-0.8 in.
score 4	0.8-0.9 in.
score 5	> 0.9 in.

For younger sows and fatter genotypes, last rib backfat measurements may be higher.

2) Weigh animals. Weight gains depend on environmental conditions, genetics, and amount of weight lost during the previous lactation.

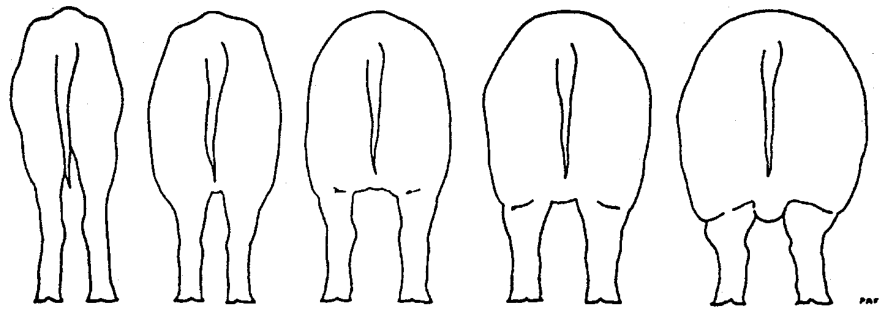
Approximate weight gains during gestation (114 days) should be:

Parity 1	80-100 lb
Parity 2-5	80-90 lb
Parity 5+	55 lb

To achieve the desired body condition score and weight gain, target daily nutrient intake for gestating sows should be:

Metabolizable energy (ME)	6000-8000 kcal
Crude protein	240-260 g
Lysine	8-13
Calcium	18-20 g
Phosphorus	16-18 g

Figure 2. Condition Scores of Sows (Patience and Thacker, 1989)



Score	Condition	Body Shape
1	Emaciated	Hips, backbone prominent to the eye
2	Thin	Hips, backbone easily felt without applying palm pressure
3	Ideal	Hips, backbone felt only with firm palm pressure
4	Fat	Hips, backbone cannot be felt
5	Overfat	Hips, backbone heavily covered

Table 3. Example Gestation Diet

Ingredient	Amount (lb)
Corn (.25% lysine)	1655
Soybean meal, 44%	260
Dicalcium phosphate (18.5% P; 21% Ca)	52
Limestone (39% Ca)	15
Salt	10
Vitamin premix[a]	6
Trace mineral premix[a]	2
	2000
Calculated analysis	
Metabolizable energy, kcal/lb	1430
Protein, %	13.0
Lysine, %	.55
Calcium, %	.91
Phosphorus, %	.80

[a]See Table 10. for suggested vitamin and trace mineral levels.

Table 4. Nutrients Consumed/Day at Various Intakes of the Example Diet for Gestating Sows

	Feed allowance/day, lb				
Nutrient	**4.0**	**4.5**	**5.0**	**5.5**	**6.0**
Met. Energy, kcal	5720	6435	7150	7865	8580
Protein, g	236	266	295	325	354
Lysine, g	10.0	11.2	12.5	13.7	15.0
Calcium, g	16.5	18.6	20.6	22.7	24.8
Phosphorus, g	14.5	16.3	18.2	20.0	21.8

A typical corn-soybean meal diet **(Table 3)** fed at 4.5 lb/day will meet the target nutrient intakes listed above. Feeding level may have to be adjusted to achieve the desired weight gain or body condition for some sows.

Daily nutrient intake can be calculated using Equation 2 listed in **Table 12.** Calculations using the example diet at 4.5 lb daily feeding level:

Metabolizable energy intake/day:

1430 kcal ME/lb x 4.5 lb of feed/day = 6435 kcal ME/day

Daily nutrient consumption at various feed allowances of the example gestation diet are presented in **Table 4.** Note that 4 lb/day of the example gestation diet will not satisfy the gestating sow's daily needs for calcium and phosphorus. If feed intake of fat sows is severely limited to control weight gain, or young, timid sows in group housing do not consume 4.5 lb of feed daily, nutrient density of the diet should be increased. Conversely, if feed intake is greater than 4.5-5.0 lb/day, one may choose to decrease nutrient density of the diet to control over-feeding of nutrients on a daily basis.

This sample diet is designed for limit-feeding of sows. Limit-feeding can be achieved by feeding in small groups, use of gestation/feeding stalls or computerized feeding stations. Synthetic lysine should not be used during pregnancy if sows are fed one meal daily. Under this management scheme, utilization of synthetic lysine is less efficient than that of lysine derived from natural protein in common feed ingredients. There does not appear to be a difference in efficiency of lysine utilization between synthetic and protein-bound lysine for full-fed sows.

Lysine intake/day:

$$\frac{0.55\%\ \text{lysine}}{100} \times 4.5\ \text{lb of feed/day} \times 454\ \text{g/lb} = 11.2\ \text{g of lysine/day}$$

A variety of alternative feedstuffs can often be included in gestation diets to replace part or all of the corn and soybean meal without causing detrimental effects on performance. Alternative feed ingredients may partially or completely replace corn and soybean meal as energy and protein sources. These may include alfalfa, barley, sorghum, canola meal, meat and bone meal and many others. **Economics and nutrients provided are the main considerations for use of alternative feedstuffs.** Other important considerations include ingredient consistency and quality, palatability, geographic availability, nutrient availability and presence of toxic or anti-nutritional factors. For a more complete discussion of alternative feed ingredients, refer to Pork Industry Handbook factsheets 3, 5, 73, 108, 112 and 126.

Feeding Mature Boars

As with gestating sows, the primary objective for nutrition of boars is control of weight gain and body condition while supporting optimal breeding performance. Mature boars can be limit-fed after reaching a body weight of 240 lb to control weight gain. Overfeeding boars can result in reduced libido and large size, which is incompatible with mating small females.

Feed intake can be measured by the **scoop method** discussed for gestating sows. Producers commonly feed their sow gestation diet to boars at 5-6.5 lb/day under most environmental conditions. This amount of feed per day is a target and the actual amount fed should be varied according to individual animals and situations (size of the boar, housing and feeding method, environmental temperature and body condition.)

While it is a common practice to feed the sow gestation diet to breeding boars, recent research suggests that this may not optimize reproductive performance. Limit-feeding the gestation diet to control weight gain limits protein intake, which may decrease libido and semen production. Mature boars should consume about 6000 kcal of metabolizable energy and 17 g of lysine daily to control weight gain and optimize reproductive performance. Feeding 4.5 lb daily of the example gestation diet **(Table 3)** will provide 6400 kcal ME but only 11.5 g of lysine. Therefore, a boar diet should be formulated that contains .85% lysine.

For smaller herds, it may not be feasible to formulate and handle a special diet for boars. A reasonable alternative is to limit-feed the sow lactation diet to breeding boars. Protein and lysine concentration of the lactation diet is higher than the gestation diet, while energy density of the two diets is similar, assuming there is no fat added to the lactation diet. Limit-feeding the lactation diet will control weight gain and provide a higher daily protein intake. If the lactation diet contains supplemental fat at greater than 1%, then a separate boar diet should be formulated.

For boars, breeding load is also an important consideration. Young boars (< 1 yr) may need more feed than older boars because they are still growing and developing. Feed intake may have to be increased when boars are used heavily to maintain body condition.

Feeding Lactating Sows

The main objective for nutrition of the lactating sow is to minimize negative nutrient balance while optimizing milk production. Lactating sows produce 15 to 25 lb of milk per day resulting in daily nutrient requirements that are about three times higher than during gestation. Level of nutrient intake during lactation is directly related to the amount of milk produced and growth rate of nursing piglets. For highly prolific and productive sows, nutrients from body tissue reserves and feed are used to support lactation. This results in loss of body weight (negative nutrient balance). Excessive body weight loss can lead to short-term reproductive problems such as extended weaning-to-estrus interval and smaller subsequent litter size. Long-term problems include a high culling rate of the sow herd resulting in low average parity, reduced pigs weaned per reproductive lifetime and higher genetic cost per pig produced. Negative nutrient balance can be minimized by increasing feed intake and/or increasing nutrient concentration in the diet.

The **first step** in minimizing negative nutrient balance is to **determine the current level of feed intake in gestation and lactation.**

This process will:

- reveal if feed intake is inadequate
- provide a base level of intake against which future intakes can be evaluated
- provide nutritionists with information necessary to accurately formulate sow diets for a specific herd.

Feed Intake Card

Sow ID No. ____________ Date Farrowed _________ Parity ________________ Crate _________ Room _________

No. Pigs																												
Event Date																												

Notes

Day of Farowing	12 12	12 12	12 12	12 12	12 12	12 12
	11 11	11 11	11 11	11 11	11 11	11 11
	10 10	10 10	10 10	10 10	10 10	10 10
	9 9	9 9	9 9	9 9	9 9	9 9
	8 8	8 8	8 8	8 8	8 8	8 8
7 7	7 7	7 7	7 7	7 7	7 7	7 7
6 6	6 6	6 6	6 6	6 6	6 6	6 6
5 5	5 5	5 5	5 5	5 5	5 5	5 5
4 4	4 4	4 4	4 4	4 4	4 4	4 4
3 3	3 3	3 3	3 3	3 3	3 3	3 3
2 2	2 2	2 2	2 2	2 2	2 2	2 2
1 1	1 1	1 1	1 1	1 1	1 1	1 1
A P MM	A P MM	A P MM	A P MM	A P MM	A P MM	A P MM
1	2	3	4	5	6	7

12 12	12 12	12 12	12 12	12 12	12 12	12 12
11 11	11 11	11 11	11 11	11 11	11 11	11 11
10 10	10 10	10 10	10 10	10 10	10 10	10 10
9 9	9 9	9 9	9 9	9 9	9 9	9 9
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8	9	10	11	12	13	14

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15	16	17	18	19	20	21

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2 2	2 2	2 2	2 2	2 2	2 2	2 2
1 1	1 1	1 1	1 1	1 1	1 1	1 1
A P MM	A P MM	A P MM	A P MM	A P MM	A P MM	A P MM
22	23	24	25	26	27	28

__________ (Total lb Feed) ÷ __________ (No. of Days) = __________ (Avg. Daily Intake)

Days to Peak Intake_________

Peak Feed Intake (lb) _______

Measuring Feed Intake for Lactating Sows

Scoop method Fill a scoop to a designated level. Weigh the scoop and record the weight of the contents. Repeat this procedure several times to determine an average amount of feed the scoop will hold. Count and record the number of scoops given to each animal at each feeding. Recheck the weight of feed the scoop will hold periodically. Changes in density of feed reduces the accuracy of this method, but it is better than not measuring feed intake at all. Feed consumed can be recorded on a feed intake card such as the one shown above.

Container method Weigh a bag or other large container of feed and record the weight. Place this container near the crate and feed the sow from this container only. When the container is empty, repeat the process until the end of lactation. At weaning, weigh the feed remaining in the container and feeder and subtract it from the total amount of feed offered. Divide this amount by the number of days of lactation for each sow.

Use the nutrient concentrations of the lactation diet currently being fed and feed intakes measured in step one to calculate current nutrient intake for each sow utilizing Equation 2 **(Table 12).** For example, a sow consuming 11 lb of a lactation diet containing 1450 kcal ME/lb would receive 15,950 kcal ME daily (11 lb feed x 1450 kcal/lb).

The **second step** is to establish nutrient intake goals based on level of milk production by the sow. The most practical method of assessing sow milk production is to measure average daily weight gain of the litter. To do this, use Equation 3 listed in **Table 12.**

Using the average daily litter weight gain calculated, and sow body weight, compare nutrient intake levels for each sow with target nutrient intakes given in **Table 5.** For example, a 400 lb sow with a litter gaining 4.0 lb/day has a target daily intake of 19.36 Mcal ME and 46 g of lysine.

Table 5. Recommended Energy, Protein and Lysine Intake for Lactating Sows by Level of Production*

	Sow Body Weight, lb								
	300			400			500		
Litter Gain (lb/day)	Energy (Mcal ME/d)	Protein (g/d)	Lysine (g/d)	Energy (Mcal ME/d)	Protein (g/d)	Lysine (g/d)	Energy (Mcal ME/d)	Protein (g/d)	Lysine (g/d)
3.0	14.82	592	33	15.88	621	34	16.87	648	34
3.5	16.56	681	39	17.62	710	40	18.61	737	40
4.0	18.30	770	45	19.36	799	46	20.35	826	46
4.5	20.04	860	51	21.10	889	52	22.09	916	52
5.0	21.78	949	57	22.84	978	57	23.83	1005	58
5.5	23.52	1038	63	24.58	1067	63	25.57	1094	64
6.0	25.25	1127	69	26.31	1156	69	27.30	1183	70

*Adapted from Pettigrew, 1993.

The nutrient intakes listed in **Table 5** crudely attempt to account for lysine and protein derived from breakdown of body tissue. We assumed that sows mobilize 4 g of lysine and 61 g of protein daily from body tissue during lactation. The energy liberated from mobilization of body tissue is not considered. Consequently, the estimates of daily energy needs assume zero weight loss and may seem higher than is required for commercial production. The values listed in **Table 5** should be viewed as intake goals rather than strict requirements.

The **third step** is to make appropriate management adjustments to maximize nutrient intake during lactation. These are:

1) Do not overfeed during gestation.

2) Feed 2 or 3 times per day.

3) Ensure that water intake is not restricted.

4) Keep farrowing room temperature between 65^0 and 70^0 F.

5) Use drip or snout coolers to lessen summer heat stress.

6) Remove spoiled or moldy feed.

7) Ensure that feeder design does not restrict intake.

The **fourth step** is to determine whether to increase dietary nutrient concentrations. After feed intake has been maximized, compare actual nutrient intakes with target intakes in **Table 5.**

Sows producing a large quantity of milk may be unable to consume the volume of feed required to supply them with adequate nutrients. Excessive body weight loss (> 40 lb) and depressed milk production relative to their genetic potential may occur. Increasing the concentration of nutrients in the diet may partially offset these effects. Use Equations 4 and 5 in **Table 12** to calculate the appropriate nutrient concentration of the diet.

For example, supplemental fat can be added to lactation diets in an effort to increase energy intake of sows. Supplemental fat may reduce weight loss and backfat loss and increase daily gain of nursing piglets. However, there are practical limits to this process. Supplemental fat increases diet cost. Addition of fat above 5% increases the risk of feed becoming rancid if a preservative is not used and causes bridging and caking of feed in feeders and bulk bins. For more information about supplemental fat, refer to Pork Industry Handbook factsheet 3, "Dietary Energy for Swine" and "Fat in Swine Nutrition," Chapter 7, in *Swine Nutrition* by E.R. Miller, D.E. Ullrey and A.J. Lewis.

In general, lactation diets for highly productive sows should contain ingredients that are concentrated sources of energy and protein such as corn and soybean meal. Feed ingredients high in moisture or fiber content such as beet pulp, alfalfa hay, oats or wheat bran dilute the nutrient content of the diet and may limit nutrient intake. Recently, researchers have studied the balance of essential amino acids in diets for lactating sows. Early studies would suggest that branched chain amino acid (i.e., valine) concentration of many diets formulated for high producing sows may be too low to maximize milk production. Additional studies are needed to verify this observation and to further clarify the appropriate pattern of essential amino acids before recommendations on branched chain amino acid concentration of lactating sow diets can be offered with confidence.

Feeding Starter Pigs

The primary objective for nutrition of weanling pigs is to optimize growth performance during the first few weeks after weaning. The increasing practice of weaning pigs at a young age (10-21 days) has resulted in problems with postweaning lag seen as decreased gains, low feed intake and increased morbidity (sickness) and mortality (death) on many swine farms. Environment, health, management practices and nutrition impact the success of a weaning program. Environment (temperature, air quality, pen and equipment characteristics) is the most critical factor. After a satisfactory environment has been provided, nutrition is the next most critical factor.

In addition to other stresses at weaning, the change from liquid sow's milk to a dry starter diet is quite a challenge for the young pig. Information on the characteristics and level of nutrients in sow's milk and the ability of pigs to utilize various nutrients from commonly available feedstuffs has been used to formulate diets that promote satisfactory performance of early weaned pigs.

Dried milk products contain forms of protein (casein) and energy (lactose) that are highly digestible by the young pig. Pigs weaned at a young age (<21 days) are very sensitive to anti-nutritional factors present in conventionally processed soybean meal. Thus, the level of soybean meal fed to these pigs should be limited. These young pigs develop a transient hypersensitivity response (allergy) to soybean proteins which increases incidence of diarrhea and reduces growth rate (postweaning lag). After about 2 weeks, pigs become tolerant of soybean protein, the hypersensitivity response wanes and growth performance improves. Complex diets containing small amounts of soybean protein are fed to newly weaned pigs to avoid postweaning lag.

Diets containing high levels of dried milk products, specially processed soybean products, animal by-products (i.e., spray-dried porcine plasma, spray-dried blood meal, fish meal), and highly digestible carbohydrate sources (i.e., oat groats) are often called "complex starter diets" in contrast to "simple" corn-soybean meal starter diets. Quality of these specialized feed ingredients varies greatly among suppliers. Use only high quality ingredients in complex starter diets even though they are more expensive than the same ingredients of lower quality. A list of ingredient specifications is beyond the scope of this publication. Contact a competent nutritionist for advice concerning quality of specialized feed ingredients for starter pig diets. Feeding complex starter diets to pigs weaned at less than 4 weeks of age results in significantly improved performance compared to simple diets. In some experiments, feeding complex starter diets containing high levels of milk products has resulted in improved subsequent performance during the grower and finisher phases of production.

As the pig grows, its digestive system can better utilize protein and energy from plant sources and becomes less sensitive to anti-nutritional factors. Thus, the performance boost gained by feeding complex diets instead of simple diets decreases over time. Furthermore, simple diets are considerably less expensive.

Phase Feeding

Due to dramatic changes in digestive capacity and feed intake after weaning, the practice of phase feeding has been developed. Phase feeding involves feeding several diets for a relatively short period of time to more accurately and economically meet the pig's nutrient requirements. Phase feeding programs for starter pigs provide an expensive, complex diet containing a high proportion of high quality ingredients in the immediate postweaning period. High quality, expensive ingredients are gradually replaced with less expensive, lower quality ingredients that the pig can better utilize as it matures. This approach seems to be a reasonable compromise between the pig's nutritional needs and the economic constraints of profitable pork production. Nutrient and ingredient suggestions for a phase feeding program are presented in **Table 6.** Example starter diets are shown in **Table 7.**

The segregated early weaning (SEW) diet should be fed to pigs until they weigh about 11 lbs. It should contain limited amounts of corn and soybean meal and large amounts of highly digestible ingredients such as dried skim milk, fish meal, dried whey and spray-dried porcine plasma. Pigs weaned onto this diet should have very limited exposure to soybean protein (5% soybean meal) because of the relative immaturity of this young pig's digestive system. High quality fat from plant sources (soybean oil, corn oil) is usually added at a rate of 3% to facilitate pelleting. A sub-therapeutic level of antibiotic and copper sulfate are added for growth promotion.

Table 6. Suggested Nutrient Levels and Ingredients for Phase Feeding Programs for Starter Pigs

Item	SEW[a]	Phase 1	Phase 2	Phase 3
Weaning age	2.5 weeks to 11 lb	3 weeks 11-15 lb	4 weeks 15-25 lb	6 weeks or more 25-45 lb
Feeding period	(About 1 week)	(About 1 week)	(About 2 weeks)	(About 3 weeks)
Feed form	Pellet	Pellet	Pellet/Meal	Meal
Nutrient:	—— % of diet ——			
Lysine	1.70	1.50	1.25	1.25
Methionine + cystine	1.02	.90	.75	.75
Ingredient:	—— % of diet ——			
Dried skim milk	0-20	0-10	——	——
Dried whey	15-30	10-20	10-20	0-10
Fishmeal	0-10	0-10	0-5	——
Special soy products[b]	0-20	0-20	——	——
Spray-dried porcine plasma	3-10	3-6	——	——
Spray-dried blood meal	——	——	2-5	——

[a]Segregated early weaning.
[b]Soy protein concentrate, extruded soy protein concentrate or isolated soy protein.

The Phase 1 diet should be fed to pigs weaned at 17-24 days of age. This diet can also be used for creep feeding and for small, runt or problem pigs weaned at older ages. Phase 1 should be pelleted because bridging in feeders and clogging of the feeding system will occur with high levels of dried milk products and plasma. The Phase 1 diet should contain about 10% soybean meal so that pigs become accustomed to soybean protein. This practice should ease the transition to the simpler, corn-soybean meal-based Phase 2 diet. Phase 2 may or may not be pelleted depending on producer preference and cost. If pelleted, Phase 2 should contain 3-4% added fat. Growth promoting levels of antibiotic and copper sulfate (125 ppm copper) should also be included.

Because pigs usually perform quite well on the SEW and Phase 1 diets, a temptation is to allow them to eat it for longer than a week. This practice should be avoided because as the pigs get older, they will consume large amounts of this expensive diet. They will perform nearly as well on the Phase 2 diet at considerably less cost.

Feed intake for starter pigs can be measured by the **group method or the inventory method.** When using either of these methods, one must account for the frequent changes in diet being offered to pigs. These methods are discussed below in the section entitled "Feeding Grower-Finisher Pigs."

Table 7. Example Phase Feeding Program for Starter Pigs

	Lb			
Ingredient	**SEW**	**Phase 1**	**Phase 2**	**Phase 3**
Corn	734	927	1025	1120
Soybean meal (44% CP)	100	200	537	786
Dried whole whey	500	400	300	—
Dried skim milk	200	50	—	—
Spray dried porcine plasma	150	100	—	—
Vegetable fat	100	100	20[a]	20
Fish meal	200	200	—	—
Spray dried blood meal	—	—	60	—
Dicalcium phosphate	3	10	34	37
Limestone	—	—	15	20
Salt	—	—	—	8
Vitamin premix[a]	6	6	6	6
Trace mineral premix[b]	2	2	2	2
DL Methionine	3	3	—	—
L-lysine HCl	1.5	1.5	—	—
Copper sulfate (25% Cu)	1	1	1	1
Antibiotic premix[c]	+	+	+	+
	2000	2000	2000	2000
Calculated analysis:				
Crude protein	24.00	21.60	21.00	22.20
Lysine	1.70	1.50	1.25	1.25
Calcium	.90	.90	.90	.90
Phosphorus	.75	.75	.75	.75

[a]If Phase 2 diet is pelleted, increase fat to 80 lb at the expense of corn.
[b]See Table 10 for suggested vitamin and trace mineral premixes.
[c]Add at the expense of corn.

Feeding Grower-Finisher Pigs

Since 75% of total feed used in a farrow-finish operation is consumed in the grower-finisher phase, nutritional accuracy in this phase has a substantial economic impact. Due to the quantity of feed consumed, the impact of amino acids on lean growth, the cost of adding amino acid sources to the diet and increased demand for leaner pork, emphasis is being placed on more accurately defining amino acid requirements for grower-finisher pigs based on genotype, sex and stage of growth. However, ensuring an adequate quantity of energy intake is equally critical to optimize lean growth rate and efficiency.

Genotype

Research at Purdue University has indicated that lean growth potential is highly variable among genotypes commonly found in the pork industry. Faster growth rates, more efficient feed conversion and increased carcass leanness create economic advantages for producing high lean growth genotype pigs. Differences in lean growth potential result in differences in amino acid requirements, especially lysine. The lean growth rates of pigs of various genotypes can be identified and used to determine their protein and lysine requirements. A procedure to determine lean gain for pigs is presented in the **Appendix.**

Sex

Barrows eat more feed and grow faster than gilts. Gilts have less fat, more muscle, a higher carcass yield and better feed conversion than barrows at a similar body weight. Thus, gilts require higher dietary concentrations of amino acids to promote optimal lean gain than do barrows. When penned together, barrows and gilts are often fed a level of protein and lysine intermediate between the requirements of the two sexes. Consequently, excess protein is fed to barrows resulting in increased cost/lb of gain. Gilts are deprived of protein resulting in reduced growth rate and decreased carcass lean.

Customized diets can be formulated for the requirements of barrows and gilts, but they must be penned and fed separately. If feeding systems and facilities can be inexpensively modified to use separate diets for barrows and gilts, separate sex feeding will generally increase profitability when pigs are marketed on a lean value pricing scheme. New swine facilities should be constructed to accommodate separate sex feeding to allow producers to tailor diets for barrows and gilts. Differences between barrows and gilts in feed consumption and carcass composition begin to appear above 40 lb body weight and become significantly greater as pigs reach market weight. Sexes can be separated when moved into the nursery or grower facilities.

Boars gain faster, are more efficient and have less backfat than gilts and barrows at a given weight; consequently, growing boars have greater amino acid requirements than barrows and gilts. Developing boars should be full-fed up to about 240 lb to allow assessment of rate of gain and backfat depth for genetic selection programs. Boars can then be limit-fed as outlined in the section on feeding boars.

Stage of Growth

Rate of muscle growth decreases and maintenance requirement increases with increasing body weight. Thus, amino acid requirements also change with stage of growth. Altering dietary lysine levels to match changes in feed intake and nutrient requirements along the pig's growth curve improves the efficiency of amino acid use and can reduce production cost.

The frequency with which lysine levels are altered in the grower-finisher phase depends on knowledge of amino acid requirements and the ability to handle multiple diets in your feeding system. Some producers will have the information and feeding system flexibility to change diet formulations every time a feed bin is filled. This gives those producers a distinct competitive advantage.

Two critical pieces of information are necessary to fine-tune diets for grower-finisher pigs: growth rate and feed disappearance (intake). There are two general methods of recording this information. The inventory method is the simplest method but provides limited information. The group method is more complex and provides more detailed information.

Measuring growth rate. The **inventory method** requires producers to record the weight of all pigs as they enter the building, number and weight of dead pigs and dates and weights of pigs marketed.

ADG = [(wt. out – wt. in) + wt. gain of pigs remaining in building] ÷ Pig-days*

*Pig-days = no of pigs x no of days of monitoring (inventory) period

The disadvantage of using the inventory method for measuring ADG (average daily gain) is that in all-in all-out production systems it only provides an overall average of all pigs in the barn over the entire inventory or grow-finish period. It does not account for the gains of pigs in different stages of growth.

In the **group method** of measuring ADG, pens of pigs of the same age are randomly selected and weighed at intervals throughout the grow-finish period. Pigs should be identified and weighed individually to provide the most accurate measure of ADG. Multiple pens of pigs should be monitored in order to accurately and confidently determine a change in gain and feed intake.

Measuring feed disappearance. Measuring feed intake is a key component of determining protein and lysine levels in the grower-finisher phase. Because of the volume of feed consumed in this phase, minimizing feed wastage is especially critical.

The following formula can be used to calculate feed disappearance:

Avg. Daily Feed Disappearance = [total feed used, lb] ÷ Pig-days

One option when using the inventory method is to record the weight of the feed delivered to the bin and subtract the estimated amount of feed remaining at the end of the inventory period. Another way of using this method is to fill the bin and take inventory both when the bin is full and again when it is nearly empty. One major drawback of using this method is that it does not provide any information on how much feed has been consumed by each pen of pigs.

The group method of measuring feed disappearance is more accurate because one selects a representative number of pens and weighs the feed delivered to each feeder. After a period of time, feed left in the feeder is weighed and subtracted from the total amount offered to arrive at total feed used. In some feeding systems, the feeders themselves may be detachable and light enough to drag onto a scale. Other commercially available monitoring systems record feed disappearance using weigh hoppers above feeders or equipment that measures volume of feed flow. Some producers have equipped bulk feed tanks with electronic load cells. By recording the weight of the tank after filling and at set time intervals, one can calculate the weight of feed being consumed by a group of pigs.

When pen weights and feed disappearance are measured, it is best to randomly select the pens to be monitored to avoid biases created by location within the building. Two pens sharing one feeder are counted as one unit.

Estimates of lysine requirements for grower-finisher pigs and developing boars are presented in **Table 8.** For example, a 100 lb gilt of high lean growth genotype requires 23.0 g of lysine daily. If she consumes 3.0 lb of grower feed/day, the feed should contain 1.69% lysine. If this gilt consumes 5.0 lb feed/day, the diet should contain 1.01% lysine. These estimates were developed under ideal conditions and should be regarded as targets.

Steps in Formulating Diets for Growing-Finishing Pigs

Step 1. Measure feed disappearance as described above and lean growth rate as described in the **Appendix.** These assessments should be conducted several times each year to account for seasonal differences in pig performance.

Step 2. Determine the appropriate nutrient needs for the identified type of pigs. Estimates of daily lysine requirements are listed in **Table 8.** Lysine is the first limiting amino acid in most practical swine diets. In most cases, if diets are formulated to satisfy the pigs' lysine needs using common feed ingredients, then the pigs' needs for other essential amino acids will also be satisfied. However, diets formulated for high lean growth genotypes using synthetic amino acids may be limiting in other essential amino acids. In this situation, consult a nutritionist to ensure that all essential amino acids are in a proper ratio to each other.

Table 8. Estimated Dietary Lysine Needs for Grower-Finisher Pigs and Developing Boars*

Lean Growth Genotype	Sex	Weight, lb	Dietary Lysine, g/day	Feed intake, lb/day 3.0	4.0	5.0	6.0	7.0
				Dietary lysine, %				
High (>0.75 lb lean gain/day)	Mixed	45-130	22.0	1.62	1.21	0.97	0.81	
		130-200	21.8	1.60	1.20	0.96	0.80	0.69
		200-240	21.5		1.18	0.95	0.79	0.68
	Barrows	45-130	21.0	1.54	1.16	0.93	0.77	
		130-200	20.5	1.51	1.13	0.90	0.75	0.65
		200-240	20.5		1.13	0.90	0.75	0.65
	Gilts	45-130	23.0	1.69	1.27	1.01	0.85	
		130-200	23.0	1.69	1.27	1.01	0.85	0.72
		200-240	22.5		1.24	0.99	0.83	0.71
	Boars	45-110	25.2	1.85	1.39	1.11	0.93	
		110-175	24.6	1.81	1.36	1.08	0.90	0.77
		175-240	24.6		1.36	1.08	0.90	0.77
Medium (0.60-0.75 lb lean gain/day)	Mixed	45-110	20.8	1.52	1.14	0.91	0.76	
		110-175	21.0	1.54	1.16	0.93	0.77	0.66
		175-240	20.0		1.10	0.88	0.73	0.63
	Barrows	45-110	20.0	1.47	1.10	0.88	0.73	
		110-175	20.0	1.47	1.10	0.88	0.73	0.63
		175-240	19.0		1.05	0.84	0.70	0.60
	Gilts	45-110	21.5	1.58	1.18	0.95	0.79	
		110-175	22.0	1.62	1.21	0.97	0.81	0.69
		175-240	21.0		1.16	0.93	0.77	0.66
	Boars	45-110	24.0	1.76	1.32	1.06	0.88	
		110-175	24.0	1.76	1.32	1.06	0.88	0.76
		175-240	22.8		1.26	1.01	0.84	0.72

*Based on research at the University of Kentucky (Stahly, 1991; Williams, 1984)

In most situations, cereal grain and soybean meal will constitute the major portion of diets for growing-finishing pigs. This type of diet contains about 1450-1,500 kcal of metabolizable energy per pound of feed. In young growing pigs (up to 100 - 120 pounds depending on genotype), insufficient energy intake usually limits growth rate. Consequently, it is essential to maximize energy intake of pigs by maintaining high energy density of the diet. Use of feedstuffs that dilute energy density below 1450 kcal ME/lb should be avoided in diets for growing pigs. Energy density of diets can be increased by adding supplemental fat. Addition of supplemental fat up to 5% of the diet usually increases growth rate, reduces feed intake and improves feed efficiency. Unfortunately, supplemental fat also increases backfat depth of pigs, especially during the finisher phase for low-to-average lean growth genotypes.

Step 3. Formulate a diet based on the observed feed disappearance that will satisfy the pig's daily lysine needs. Macrominerals, vitamins and trace minerals should be incorporated according to the guidelines listed below in **Tables 9** and **10.** Subtherapeutic levels of antibiotics can be added if health conditions warrant.

Step 4. Feed newly formulated diets and continue to evaluate pig performance. If desired levels of performance are not achieved, re-evaluate diet formulation and management practices.

Vitamin and Mineral Requirements at Each Stage of Production

Although vitamins and minerals constitute a relatively small percentage of the swine diet, they are extremely important for normal growth and productive functions. Vitamins lose potency when exposed to minerals, heat, light or moisture or when stored for longer than three months. If basemixes or vitamin-trace mineral premixes are used, be sure to turn over inventory quickly to limit storage time. Vitamin and mineral recommendations in this publication contain safety margins over NRC levels and are designed for use with good storage conditions. Suggested macromineral levels are presented in **Table 9.** Vitamin and trace mineral allowances are presented in **Table 10.** In practical situations, the same vitamin and mineral premixes can be used for breeding stock and starter pigs.

A wide range of vitamin and mineral premixes is available to pork producers. Inclusion rates and nutrient concentration of these products are quite variable. There is no one correct inclusion rate or nutrient concentration. Pork producers must evaluate premixes based on the total amount and form of each nutrient that is provided to one ton of feed. For this reason, vitamin and trace mineral allowances in **Table 10** are presented as amount of nutrient provided per ton of final diet.

Table 9. Suggested Calcium, Phosphorus and Salt Levels for Swine Diets

Stage of Production	Ca (% of diet)	P (% of diet)	Salt (% of diet)
Gestation/Mature Boars[a]	0.90	0.80	0.50
Lactation[b]	0.90	0.80	0.50
Starter	0.90	0.75	0.30
Grower (45-100 lb)	0.75	0.65	0.40
Finisher (100-240 lb)	0.65	0.55	0.40
Developing boars	0.75	0.60	0.40
Replacement gilts (100-240 lb)	0.80	0.70	0.40

[a]Feed intake > 4.5 lb/day. [b]Feed intake > 11 lb/day.

Table 10. Suggested Vitamin and Trace Mineral Levels for Swine Diets

Ingredient	Stage of Production: Lactation Gestation/boars Replacement stock	Starter	Grower/Finisher	Suggested Source
	——Amount / ton of diet——			
Vitamin Premixes:				
Vitamin A, IU	6,000,000	6,000,000	4,000,000	Vitamin A palmitate-gelatin coated
Vitamin D3, IU	1,500,000	1,500,000	672,000	Vitamin D3-stabilized
Vitamin E, IU	30,000[a]	30,000[a]	21,000	dl-tocopheryl acetate
Vitamin K, mg	4,000	4,000	2,600	Menadione sodium bisulfite
Riboflavin, mg	6,000	6,000	4,000	Riboflavin
Niacin, mg	36,000	36,000	24,000	Nicotinamide
Pantothenic acid, mg	24,000	24,000	16,000	Calcium pantothenate
Vitamin B12, mg	30	30	18	Vitamin B12 in mannitol (.1%)
Pyridoxine, mg	800	800	0	Pyridoxine HCl
Thiamin, mg	1,000	1,000	0	Thiamin mononitrate
Folic acid, mg	1,000	0	0	Folic acid
Biotin, mg	200	0	0	D-Biotin
Choline, mg	530,000	0	0	Choline chloride (60%)
Trace Mineral Premixes:				
Copper, g	8	8	3.6	$CuSO_4 \cdot 5H_2O$
Iodine, g	0.2	0.2	0.2	KIO_4
Iron, g	90	90	54	$FeSO_4 \cdot 2H_2O$
Manganese, g	27	27	1.8	$MnSO_4 \cdot H_2O$
Selenium, mg	90	272[b]	90	$NaSeO_3$ or $NaSeO_4$
Zinc, g	90	90	54	ZnO (80% Zn)

[a]If fat is added to diet, increase to 40,000 IU/ton of diet.
[b]The final diet concentration of selenium will be .3 ppm, which is the legal limit for pigs up to 40 lbs. body weight at this writing.

In **Table 10,** one number appears for each nutrient in each stage of production. However, this should not be interpreted to mean that diets can only be supplemented with exactly the amount stated in **Table 10.** Varying storage and handling conditions, health status of the herd, genetic potential of pigs, voluntary feed intake and other factors may dictate a different level of supplementation. Our recommendations should satisfy the vitamin and trace mineral needs of most pigs under commercial conditions.

Non-Nutritive Feed Additives

Antibiotics. Antibiotics and antimicrobials have been used at subtherapeutic levels in swine diets for over 35 years. Antibiotics are quite effective growth promotants. Researchers believe that the primary reason low-level antibiotic feeding promotes growth is due to suppression of subclinical disease caused by bacteria. Other direct metabolic and nutrient-sparing effects have been observed with low-level antibiotic feeding. Typically, subtherapeutic levels of antibiotics increase growth rate about 15% and improve efficiency of feed conversion 5 to 7% **(Table 11).** Use of antibiotics may reduce mortality rate. As the pig gets older and heavier, the growth promoting benefits of antibiotics wane. There is some question as to the effectiveness of antibiotics in the diet of finishing pigs.

Critics suggest that long-term feeding of antibiotics will result in antibiotic-resistant bacteria making low-level antibiotic feeding ineffective. However, Zimmerman (1986) summarized the response to antibiotic feeding from experiments conducted over 35 years. He found that antibiotics were just as effective growth promotants from 1978 to 1985 as they were from 1950 to 1977 **(Table 11).** Response to antibiotics increases as disease load and environmental stresses on the pig increase. Consequently, one may expect response to antibiotics to be greater under commercial conditions than the responses observed in university trials. While response to antibiotics is greater in a "dirty" environment, antibiotics are not a substitute for cleanliness and good management. Low-level antibiotic feeding is another tool for use in efficient swine production.

Swine producers must be aware of the cost of feeding subtherapeutic levels of antibiotics. One must be certain that the increased feed cost due to antibiotic use is paid for by increased growth rate, improved feed efficiency and/or reduced mortality rate. The swine industry is striving to produce a high-quality product that is free of drug residues. Swine producers must observe withdrawal times to assure pigs are residue-free at slaughter. Withdrawal times are clearly marked on any feed or feed ingredient that contains a drug. Read labels thoroughly and observe withdrawal times.

Additives. In addition to antibiotics, there are numerous additives that are used to increase acceptability of the diet to pigs, preserve quality of the diet or improve digestion and utilization of the diet. Some of these additives include: probiotics, flavors, sweeteners, pellet binders, clays, antioxidants, mold inhibitors, enzymes, organic acids, yucca extract and electrolytes. It is not our intent to thoroughly discuss each of these additives in this publication. For more information on use and effectiveness of these and other feed additives, contact one of the authors or your consulting nutritionist.

Table 11. Percentage Improvement in Performance of Pigs Fed Antimicrobials for Specific Years[a]

		Improvement, %	
Years	Periods[b]	Daily gain	Feed efficiency
1950 to 1977	Starter	16.1	6.9
	Grower-Finisher	4.0	2.1
1978 to 1985	Starter	15.0	6.5
	Grower-Finisher	3.6	2.4

[a]Zimmerman, 1986
[b]Starter = 18 to 57 lb; Grower-finisher = 58 to 200 lb

Table 12. Equations Commonly Used in Swine Nutrition

Equation 1

$$\text{Feed intake} = \frac{\text{Feed consumed}}{\text{Number of pigs} \times \text{Number of days}}$$

Equation 1a

$$\text{Feed intake} = \frac{\text{Total feed consumed}}{\text{Lactation length (days)}}$$

Equation 2

$$\text{Nutrient intake} = \text{Nutrient concentration of diet} \times \text{Feed intake/day}$$

Equation 3

$$\text{Ave. daily litter weight gain} = \frac{\text{Litter weaning weight} - \text{Birth weight of live pigs}}{\text{Lactation length (days)}}$$

Equation 4

$$\text{Nutrient concentration} = \frac{\text{Desired nutrient intake}}{\text{Feed intake}}$$

Equation 5

$$\text{Percent of diet} = \text{Nutrient concentration} \times 100$$

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Appendix. Determining Lean Gain for Pigs

To determine lean gain for pigs, the following information is needed:

1) Pig identity (ear notch or tag)

2) Initial weight and date weighed (obtained at 40-70 lb)

3) Carcass data

   a) **When optical probe (e.g., Fat-O-Meater) information is available:**
      Hot carcass weight (HCW), lb
      Backfat depth (BF), in.
      Loin eye depth (LED), in.

      -or-

   b) **When carcasses are ribbed:**
      Adjusted hot carcass weight, lb
      Loin muscle area, sq. in.
      10th rib backfat depth, in.

      -or-

   c) **When carcasses are not ribbed:**
      Adjusted hot carcass weight, lb
      Carcass muscling score (1 = thin, 2 = medium, 3 = thick)
      Last rib backfat depth, in.
      Sex code (barrow = 0, gilt = 1)

4) Days on test from initial weight to market weight

Appendix continued on back cover

Calculate lean gain/day using the following equations (equations taken from NPPC, 1991):

$$\text{Lean gain/day} = \frac{\text{Carcass muscle} - \text{Initial muscle}}{\text{Days on test}}$$

Initial muscle, lb = (.418 x initial live weight, lb) – 3.65

For Fat-O-Meater information:

Carcass muscle, lb = 2.827 + (.469 x adj. hot carcass wt., lb)
+ (9.824 x loin muscle depth, in.)
– (18.470 x fat depth, in.)

If backfat and loin muscle depth are provided in centimeters by the packer, convert to inches (1 centimeter = .394 in).

For ribbed carcasses:

Carcass muscle, lb = 7.231 + (.437 x adj. hot carcass wt, lb)
+ (3.877 x 10th rib loin muscle area, sq. in.)
– (18.746 x 10th rib fat depth, in.)

For unribbed carcasses:

Carcass muscle, lb = 8.179 + (.427 x adj. hot carcass wt., lb)
+ (6.290 x carcass muscle score*)
+ (3.858 x sex code**)
– (15.596 x last rib fat depth, in.)

*Carcass muscle scores: 1 = thin, 2 = intermediate, 3 = thick
**Barrow = 0, Gilt = 1

For example, a pig has the following information:
Initial weight = 50 lb
Days on test = 109
Hot carcass weight = 180 lb
Fat-O-Meater measurements: LED = 3.15 in. BF = .8 in.

Initial muscle = (.418 x 50) – 3.65 = 17.25 lb

Carcass muscle = 2.827 + (.469 x 180) + (9.824 x 3.15) – (18.470 x .8) = 103.4 lb

$$\text{Lean gain/day} = \frac{103.4\text{ lb} - 17.25\text{ lb}}{109\text{ days}} = .79\text{ lb}$$

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