Iowa State University
LIFE CYCLE SWINE NUTRITION

Cover

Nutrient Requirements
Adjustments
Diet formulas
Mineral supplements
Trace Mineral Premixes
Vitamin Premixes
Feeding Systems
Feed Additives

Foreward (inside cover)

Swine feeding is a complex science. For maximum success the pork producer must follow a scientific feeding program based upon the nutritional needs incurred in each stage of the pig's life and how those needs are affected by the environment. These concepts require the producer to define status of the herd. For example, the lean gain potential, the existing climatic conditions, and the health status of the herd must be evaluated. Adjustments are then based on these factors when defining the specific requirements for each stage of the life cycle from the nursing pig through the breeding herd.

This seventeenth revision of Life Cycle Swine Nutrition contains the recommendations of the ISU Swine Nutrition, Growth and Behavior Section of the Iowa Agriculture and Home Economics Experiment Station and the Animal Science Extension Section of Iowa State University.

Prepared by:
Palmer Holden
Richard Ewan
Marshall Jurgens
Tim Stahly
Dean Zimmerman

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Objective

The objective of Life Cycle Swine Nutrition is to define nutritional regimens that allow the most economic conversion of nutrients into lean (muscle) tissue growth or milk production while maintaining animal well-being and the quality of the surrounding environment.

Biologic Basis for Establishing Nutrient Requirements

Animal growth and reproduction are the result of numerous biological processes regulated by genetic and production conditions. The genotype of the animal determines the maximum rate at which these processes occur. Conditions, such as thermal and social climates, dietary regimens and health status, determine the proportion of the genetic potential actually expressed. These biological processes require inputs of energy (carbohydrates and lipids), amino acids, minerals and vitamins. Thus the rates at which these processes occur are affected by the nutrient intake of the animals.

The major biological processes occurring in the pig are grouped into maintenance and growth. Maintenance includes repair or replacement of body tissues and fluids, energy for voluntary (e.g., walking) and involuntary (e.g., heart contractions) activities, generation of body heat for warmth, and regulation of body defense (e.g., immune) systems. Growth includes accretion of body tissues (e.g., muscle, bone), organs (e.g., mammary gland), fluids (e.g., milk) and fluid components (e.g., red blood cells).

The primary determinants of nutrient needs for maintenance are body weight (tissue mass) and to a lesser degree physical activity, body temperature regulation and body defense systems. The primary determinants of nutrient needs for growth are tissue (e.g., lean, fetal-placental) accretion rates and milk yield, or pig weight gain preweaning.

Nutrients consumed in excess of the amount needed to support these biological processes are stored in the body or degraded and excreted. Consequently, nutrients consumed in excess of those needed to maximize tissue growth may contribute to the nutrient content (e.g., vitamin, mineral and lipid) of edible pork products and to the physical properties (e.g., color, water-holding capacity) of these products. However, a high proportion of excess nutrients are excreted in the urine and feces.

Economic Basis for Establishing Nutrient Requirements

Economic returns in the pork industry are the value of the pork products produced minus the costs expended to produce them. The value of pork products is determined by consumer perception of the quality of the food products produced and the acceptability of production methods. Production costs per unit of quality pork produced normally is lowest in pigs provided the amounts and types of nutrients needed to allow each biological process to proceed at the maximum rate possible in pigs maintained under specific production conditions. Deficient or excess intakes of nutrients relative to the animals' biological demands will lower biological and economic efficiency of pork production. Dietary additions of nutrients resulting in only small enhancements in performance may not return the cost of the added nutrients. Currently, dietary regimens that result in the lowest feed cost per pound of muscle of acceptable quality produced yet maintain the well-being of the animal and the environment are recommended.

Pig Lean Growth Capacities and Standard Production Conditions

Nutrient requirements for pigs vary depending upon their genetic capacities for growth and the production conditions to which they are subjected. Table 1 defines the lean growth capacities upon which the Life Cycle Swine Nutrition nutrient requirements are based.

Table 1. Pig lean growth capacities from 40 to 245 pounds.

Lean growth capacity	Lean w/10% fat, lb/day	Fat free lean lb/day
High	0.75 to 0.90	0.65 to 0.77
Moderate	0.60 to 0.70	0.52 to 0.60
Low	0.40 to 0.55	0.34 to 0.47

Table 2 defines the standard production conditions upon which Life Cycle Swine Nutrition nutrient requirements are based. Approximately 15 to 25 percent of pig groups are maintained in these conditions. Growing pigs exposed to production conditions that deviate from these standard conditions must have their nutrient needs redefined using Tables 7a or 7b. Adjustments for sows and boars are in Tables 11, 12 and 13.

Table 2. Standard production conditions.

Herd Factors:	Standard conditions
Pig gender	1:1 ratio of barrows and gilts
Antigen exposure	Modest (Table 4)
Thermal climate	Thermoneutral (Figures 8 &10)
Social climate	
Pen and feeder space/pig	Adequate or above (Figure 9)
Pig weight variation	Less than 20% of mean weight
Dietary ingredients:	
Grain source	Corn
Protein source	
6-30 lb pigs	Soy and animal proteins
Over 30 lb pigs	Soybean meal, dehulled
Vitamins and trace minerals	Biologically available and stable
Antimicrobial agent	Subtherapeutic levels
Feeding regimen:	
Feed intake	Ad libitum
Feed form	Meal
Feed particle size	650 to 750 microns
Feed toxins	None
Growth modifiers	None
Breeding herd factors:	
Parity	Gilt (1st parity)
Initial breeding weight	290 lb
Feed particle size	750 to 900 microns
Sow weight gain	
Parities 1-3	81-91 lb
Parities 4-5	76 lb
Parities 6-8	44 lb
Lean growth capacity	Moderate (Table 1)
Sow body condition	Optimum
Lactation weight loss	None postfarrowing to weaning

Expected Performance of Pigs Raised Under Standard Conditions

Figure 1. Feed intake.

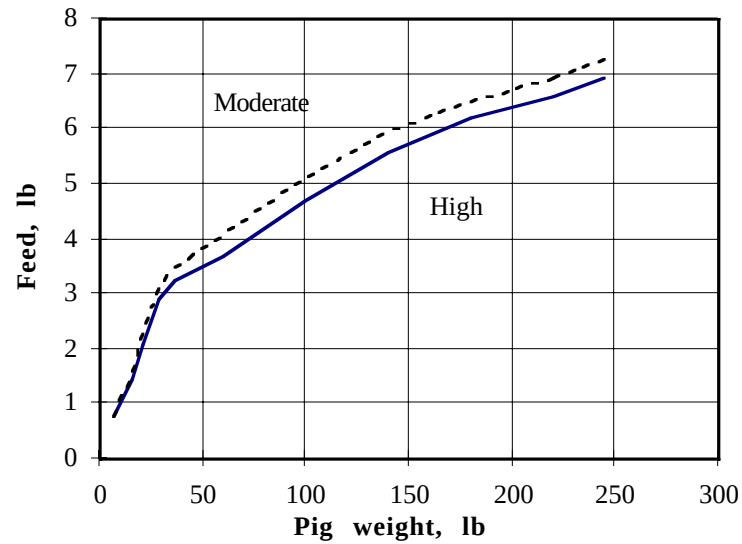


Figure 2. Daily weight and muscle gain.

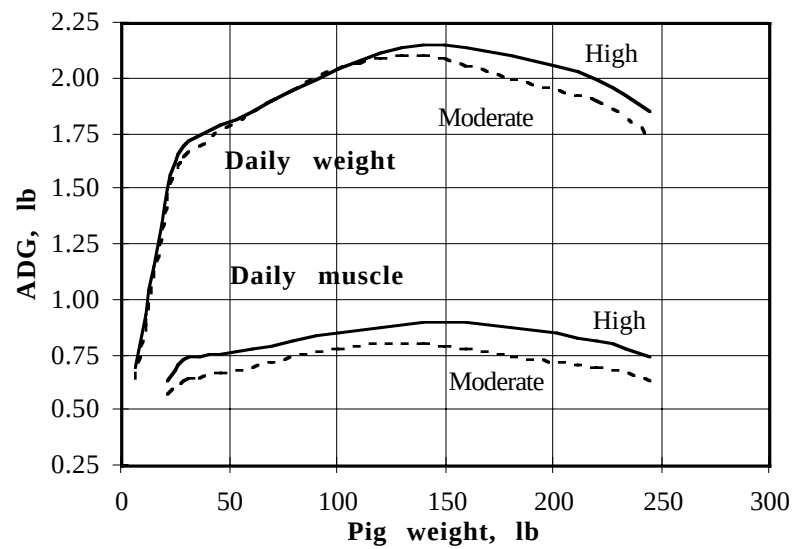


Figure 3. Feed required per unit of gain.

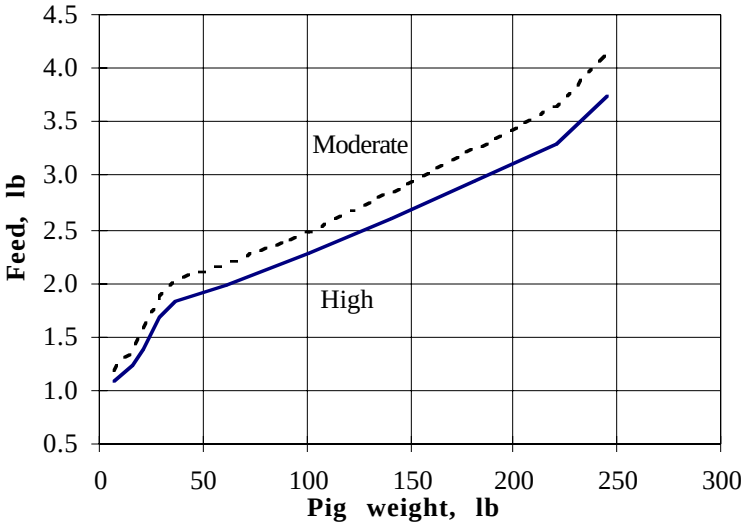


Figure 4. Body weight and age.

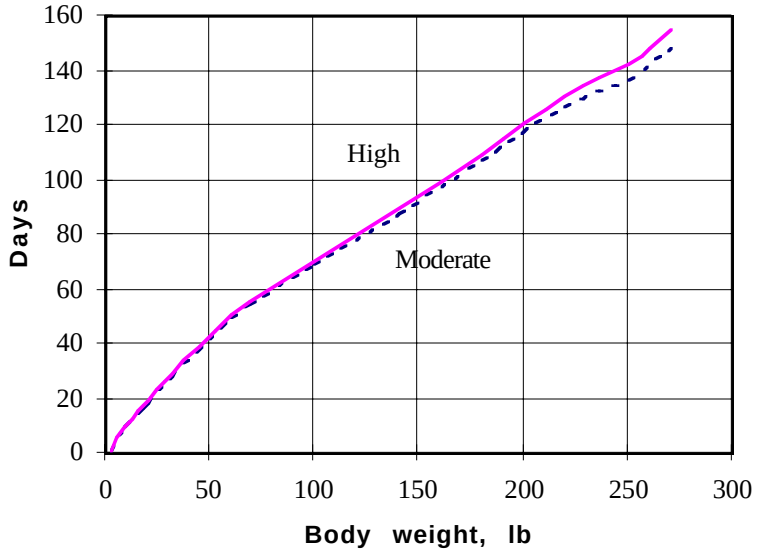
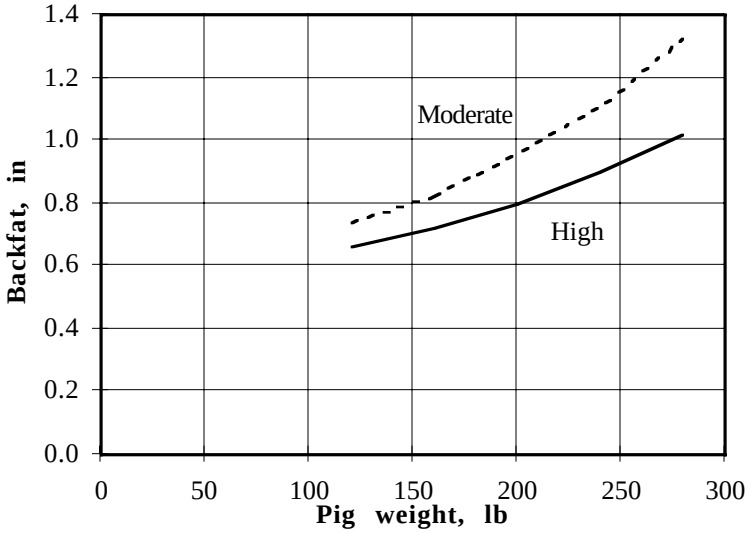


Figure 5. Carcass backfat, 10th rib.



Expected Performance of Sows Raised Under Standard Conditions

Figure 6. Sow weight changes by parity.

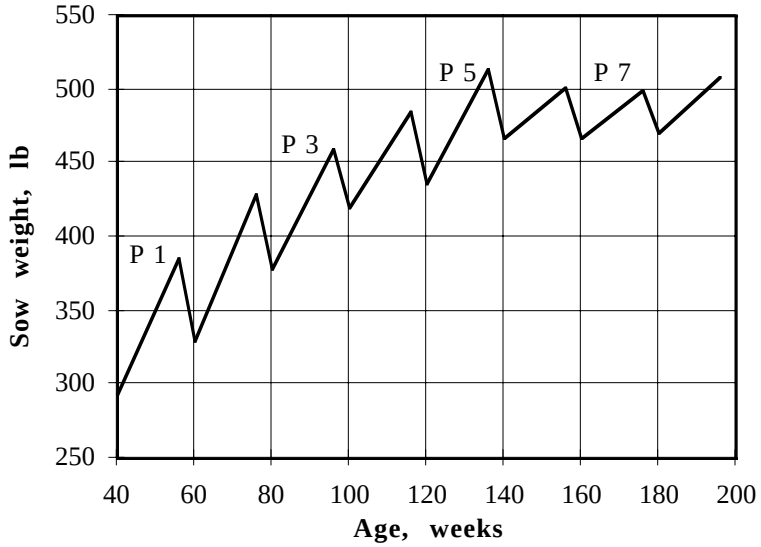
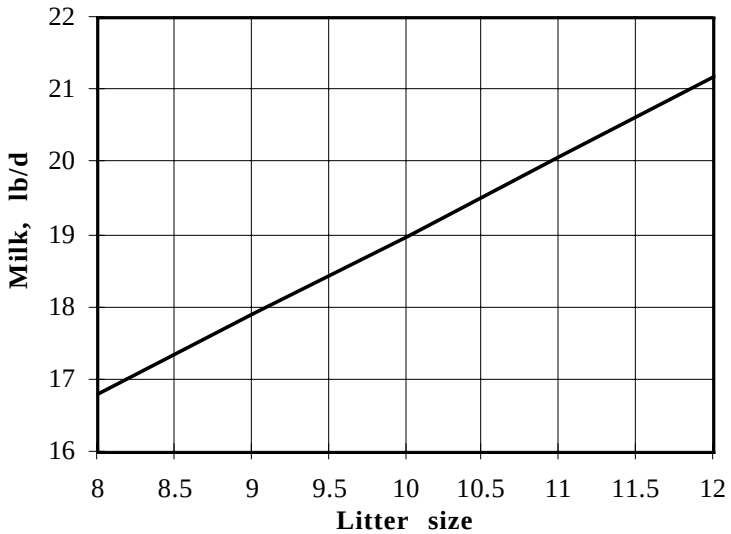


Figure 7. Litter size and milk production.



Feed Inputs and Expected Pork Product Outputs

Table 3. Expected feed inputs and product outputs per 245 pound pig produced under standard production conditions. [a]

Item	Lean growth capacity High	Lean growth capacity Moderate
Feed inputs, lb		
Pregestation, gestation	84	80
Lactation	28	28
Boar feed	6	6
Starter (12 to 50 lb)	51	63
Grow-finish (50 to 245 lb)	566	644
Total	735	820
Product outputs, lb		
Sow gain/pig produced	5	5
Pig	245	245
Total	250	250
Carcass muscle (w/10% fat)	102	95
Efficiency of production:		
Feed/lb pig weight produced	2.94	3.28
Feed/lb muscle produced	7.22	8.67

[a] These values are estimated allocations of sow and boar feed to each pig marketed plus the feed consumed by the market pig. The 1994 ISU Swine Enterprise Record Summary indicates an average whole herd efficiency of 3.69 pounds of feed/100 pounds of pork produced with a standard deviation of 0.38 pounds. Thus, a reasonable goal would be 3.30 pounds of feed/100 pounds of pork produced, or about one standard deviation better than average.

Pregestation and Gestation Diet

The estimated number of litters per sow per year is 2.0, including replacement gilts inventoried into the herd at 245 lb The number of pigs marketed per sow per year is 18.1 (9.4 weaned - 5% death loss post-weaning x 2.0 litters per sow per year). With a 21-day lactation period each sow would average 42 days per year on lactation feed and 323 days on the prebreeding and gestation diet (365 - 42). With an average daily feed intake of 4.7 lb/day for high lean sows and 4.5 lb/day for moderate lean sows of pregestation and gestation feed for 323 days, the annual feed usage would be 1,518 and 1,454 pounds, respectively. These pounds divided by 18.1 pigs produced per sow per year results in 84 or 80 pounds of pregestation and gestation diet charged to each pig.

Lactation Diet

A 21-day lactation period times 2.0 litters per sow per year results in an average of 42 lactating days per sow. If the average daily feed intake is 12 pounds, each sow consumes 504 pounds of lactation feed. These pounds divided by 18.1 pigs produced per year results in 28 pounds of lactation feed charged to each pig.

Boar Diet

The number of boars in the herd is estimated to be one for each 20 sows or 362 pigs marketed (20 x 18.1). This number may vary depending on the number of farrowings per year, as well as the method of mating, for example pen mating, handmating or artificial insemination. With an average intake of 6 pounds per day, each boar will consume 2,190 pounds of feed per year or 6 pounds per pig marketed (2190 ÷ 362).

Starter Diet (Stages 1 - 5)

Starter pig diet includes the feed consumed from weaning at 12 pounds to 50 pounds body weight. With a feed efficiency of 1.35 for high lean pigs and 1.65 for moderate lean growth pigs, they would consume 51 and 63 pounds of starter diet, respectively.

Grow-Finish Diet (Stages 6 - 14)

Lean growth capacity is an important factor in estimating the feed efficiency of pigs from 50 to 245 pounds body weight. Assuming a feed efficiency of 2.9 pounds of feed per pound of gain for high lean growth pigs results in a feed requirement of 566 pounds during this stage. Moderate lean growth pigs have a feed efficiency of 3.3 pounds of feed per pound of gain and require 644 pounds of grower-finisher diet.

Product Outputs

The feed inputs result in 5 pounds sow gain per pig marketed (90 lb gain per year ÷ 18.1 pigs) plus 245 pounds gain by the pig for a total gain of 250 pounds of pork per pig produced. High lean pigs yield 74% carcass weight containing 55% lean (w/10% fat) or about 102 pounds of muscle. Moderate lean pigs yield 74.2% carcass weight containing 51% lean (w/10% fat) or about 95 pounds of muscle.

Procedures for Defining the Nutrient Requirements of Growing Pigs

The first step in defining nutrient requirements of growing pigs is to determine the genetic capacity of the pigs for lean growth measured in pounds of lean growth per day. This may be done with the following methods:

1. Use published values for the genetic line involved;
2. Estimate the lean growth capacity of the pigs combining growth data from the swine enterprise and slaughter records using procedures described in the following section; or
3. Assume the pigs are of moderate lean growth capacity.

These estimations should be made on pigs reared under production conditions approximating those defined in Table 2. Use the estimated lean growth values from Table 1 to categorize the pigs into high, moderate or low lean growth capacities.

The second step is to identify the stage of development and associated nutrient requirements for a groups of pigs based on their lean growth capacity and body weight using Table 6.

The third step is to adjust the nutrient requirements for conditions under which the pigs are raised that differ from the standard production conditions. Use Table 7a for high lean growth pigs or Table 7b for moderate or low lean growth pigs to make the appropriate adjustments for specific production situations. If you prefer not to make these adjustments, refer to Table 5, Default Dietary Regimens, for feeding recommendations.

The final step is to select diets which meet the nutrient needs of the pigs. This may be done by purchasing commercial diets or preparing diets from available ingredients using the example diets (Tables 8 or 25), premix and corn-soybean meal (Table 25) or protein supplements and corn (Tables 26 and 27). Feed mixing guidelines are described in another section.

Estimation of Genetic Capacity for Lean Growth

Several procedures exist for determining the rate of lean growth. These provide estimates and should be periodically reevaluated. The information should be derived from groups of pigs of a common genetic capacity evaluated under standard production conditions similar to those described in Table 2. Lean growth estimates derived under other than the standard production conditions must be adjusted or even discarded. Evaluate the pigs' rate of lean growth from body weights of 40 ±5 pounds to 245 ±8 pounds for the best estimate of lean growth capacity.

Example calculations of lean growth

A. Example data.

Initial live wt	43 lb	Hot Carcass Wt (HCW)	180 lb
Initial lean, assume	40 %	Loin muscle area (LMA)	5.0 in^2
43 lb to market	110 days	Backfat, 10th rib	1 in[a]
Market weight	243 lb	Fat Free Lean Index (FFLI)	48.5 %
		Yield	74 %

[a] To convert packer last rib midline fat to 10th rib off-midline fat, subtract 0.15 from last rib midline measurement. If Loin Muscle Area (LMA) is not known, use 5.5 in^2.

B. Calculation of lean growth (with 10% fat)

1. Estimating pounds of carcass lean and percent lean (with 10% fat) if not provided on kill sheet

Lb lean = 2 + (0.45 x HCW) + (5 x LMA) - (11 x BF, 10th)
Lb lean = 2 + (0.45 x 180) + (5 x 5.5) - (11 x 1.0) = 99.5 lb
Percent lean (w/10% fat) = (lb lean ÷ Hot Carcass Wt.) x 100
Percent lean (w/10% fat) =(99.5 ÷ 180) x 100 = 55.3%

2. Estimating lean growth (with 10% fat)/day

Percent lean x HCW = lb lean in carcass
55.3% x 180 lb = 99.5 lb
Initial percent lean x initial weight = initial lb lean
40% x 43 lb = 17.2 lb
Final lb lean - initial lb lean = lean growth from initial wt to market,
99.5 lb - 17.2 lb = 82.3 lb lean gain
Lean growth, lb / days on test = lean growth/day, lb
82.3 lb / 110 days = 0.75 lb lean/day (High)

C. Calculating fat free lean (FFLI) growth/day

Lean growth, lb/ day = ADG x % Yield x % FFLI

$$\frac{200 \text{ lb gain}}{110 \text{ days}} \times 74\% \times 48.5\% = 0.65 \text{ lb lean/day (High)}$$

D. Quick lean growth estimate [a]

Av. daily gain, lb	10th rib fat thickness, in 0.7	0.8	0.9	1.0	1.1
	Daily lean growth (with 10% fat), lb				
1.6	0.63	0.62	0.60	0.59	0.57
1.8	0.71	0.70	0.68	0.66	0.64
2.0	0.75	0.73	0.72	0.70	0.68
2.2	0.87	0.85	0.83	0.81	0.79

[a] Assumes 74% dressing percentage.

Climate, social and antigen exposure

Climate and social

The thermoneutral climate for growing pigs is illustrated in Figure 8. They are assumed to be penned in groups of 10 to 30 pigs on slotted floors, in insulated buildings in the presence of drafts less than 50 feet/second and a relative humidity between 20 and 80%. Pigs housed on wet floors, in poorly insulated buildings and in drafts require the temperature to be increased 3 to 5, 3 to 5 and 5 to 7°F, respectively, to maintain thermoneutrality.

The recommended space allocations for growing pigs are illustrated in Figure 9.

Figure 8. Thermal climate for growing pigs.

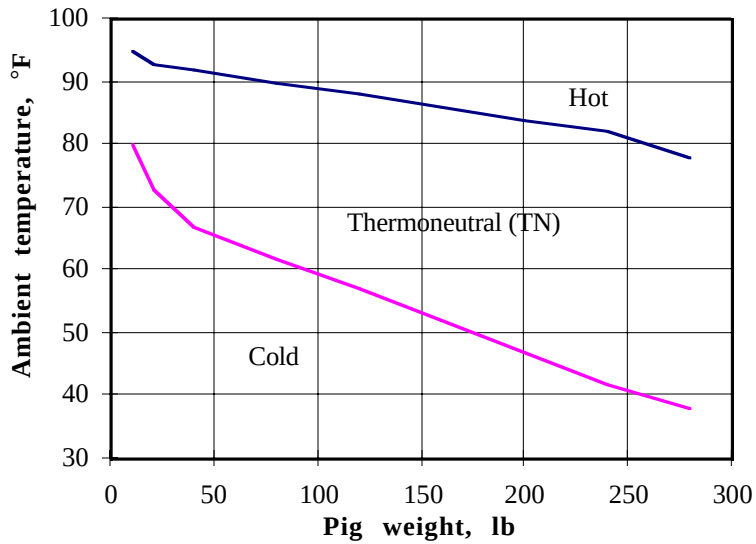
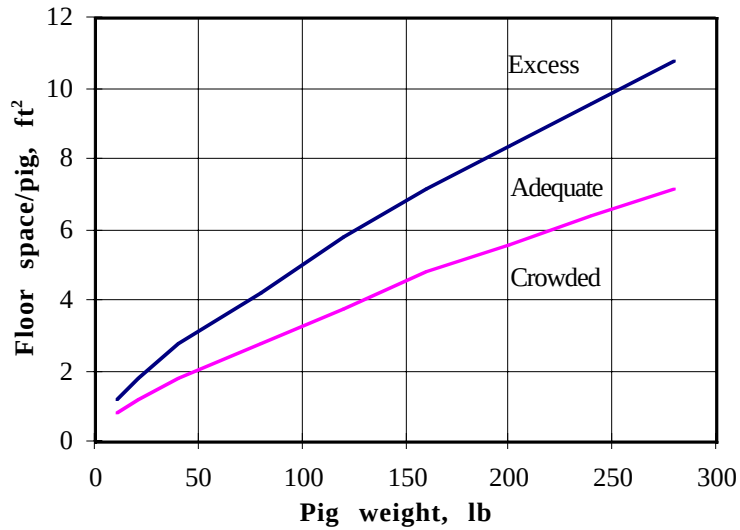


Figure 9. Social climate for growing pigs.



Determination of the Level of Antigen Exposure

Classify groups of pigs at each stage of development (e.g., breeding-gestation, lactation, nursery, grow-finish,) for their level of antigen exposure (Table 4). Assign a 1, 2, 3, 4 or 5 score, respectively, if the group has minimal, minor, modest, moderate or maximal exposure for each factor listed below. Total the numbers for the factors, divide by number of factors evaluated and round off to the nearest whole number. This number represents the pigs' level of antigen exposure to be used in adjusting their nutrient needs in Table 7a or 7b.

Table 4. Level of antigen exposure.

	Antigen Exposure [a]				
	Minimal	Modest	Moderate	Major	Maximal
Factor Score =	1	2	3	4	5
Facility all in/all out [b]	Always	Usually	Some	Rarely	Never
Multiple groups/room [c]	Never	Rarely	Some	Usually	Always
Facility sanitation [d]	Always	Usually	Some	Rarely	Never
Facility biosecurity [e]	High	Moderate	Low	Minimal	None
No. antigens present [f]					
Serum titers	0	1	2	3	>3
Visual symptoms	0	1	2	3	>3
Poor performance [g]	0-2%	2-3%	3-5%	5-7%	7-10%
Mortality [h]	0-1%	1-2%	2-3%	3-5%	4-10%

[a] An antigen is any substance that stimulates the production of antibodies.
[b] Facility completely emptied of pigs between pig groups.
[c] Two or more groups from different buildings, farms or sources placed in the same room.
[d] Facility high pressure sprayedand disinfected between groups; surfaces resealed as needed.
[e] Facility biosecurity: High = separate sites (minimum of 0.5 miles apart) and labor, shower in; Moderate = separate sites (less than 0.2 miles apart), same labor, shower in; Low = same site, separate labor, shower in; Minimal = same site and labor, clean coveralls and boots; None = same site and labor force, no precautions.
[f] Number of antigens present based on 1) serum antibody titers indicating the number of disease antigens that the pigs have been exposed to (e.g., mycoplasmal pneumonia, APP, PRV, PRRS, TGE) and 2) visual symptoms of illness (e.g., coughing, diarrhea, emaciation).
[g] Percentage of pigs in a group that grow 20 to 30 percent below average.
[h] The percentage death loss of pigs in a group.

Default Dietary Regimens

If diets are not to be adjusted to the pigs' needs when specific production conditions deviate from standard production conditions, dietary regimens 3, 6, 9, 12 and 14 are suggested for pigs fed over the weight ranges outlined in Table 5. Use the nutrient concentrations associated with these stages of developments (Table 6) to formulate diets.

Table 5. Default dietary regimens

Lean growth capacity	Pig weights at which diets should be fed, lb				
High	12-39	39-100	100-208	208-313	-
Moderate	8-26	26-69	69-150	150-283	-
Low	6-19	19-49	49-109	109-201	201-246
Stage of development	3	6	9	12	14

Table 6. Nutrient requirements of growing pigs reared under standard production conditions.

Lean growth capacity		Pig weights at which diets should be fed, lb													
High		6-12	12-18	18-27	27-39	39-55	55-75	75-100	100-130	130-166	166-208	208-257	257-313		
Moderate		6-8	8-13	13-18	18-26	26-37	37-51	51-69	69-91	91-118	118-150	150-188	188-233	233-283	
Low			6-9	9-14	14-19	19-26	26-36	36-49	49-65	65-85	85-109	109-138	138-162	162-201	201-246
Stage of development		1	2	3	4	5	6	7	8	9	10	11	12	13	14
Amino acids															
Lysine	%	1.90	1.71	1.54	1.39	1.25	1.13	1.02	0.92	0.83	0.75	0.67	0.60	0.54	0.49
Threonine	%	1.29	1.16	1.05	0.94	0.84	0.74	0.67	0.61	0.55	0.51	0.46	0.42	0.38	0.35
Tryptophan	%	0.38	0.34	0.31	0.28	0.25	0.22	0.20	0.18	0.17	0.15	0.13	0.12	0.11	0.10
Methionine + Cystine	%	1.06	0.96	0.86	0.78	0.70	0.63	0.57	0.52	0.47	0.44	0.39	0.35	0.32	0.29
Crude protein [a]	%	27.70	27.10	26.50	24.00	22.10	20.30	18.80	17.50	16.10	15.10	14.00	13.00	12.20	11.40
Metabolizable energy [a]	kcal/lb	1566	1469	1466	1480	1484	1486	1489	1493	1496	1498	1499	1502	1503	1504
Minerals															
Calcium	%	1.11	1.04	0.95	0.88	0.80	0.75	0.70	0.65	0.61	0.59	0.56	0.52	0.50	0.49
Phosphorus, total	%	0.93	0.86	0.78	0.72	0.66	0.60	0.56	0.52	0.49	0.47	0.45	0.42	0.40	0.39
Phosphorus, available	%	0.70	0.62	0.54	0.48	0.41	0.36	0.31	0.27	0.24	0.21	0.19	0.16	0.14	0.12
Sodium (Na) [b]	%	0.21	0.20	0.19	0.18	0.17	0.16	0.16	0.15	0.15	0.14	0.14	0.13	0.13	0.12
Chlorine (Cl) [b]	%	0.31	0.30	0.28	0.27	0.26	0.24	0.24	0.22	0.22	0.21	0.21	0.20	0.20	0.19
Trace minerals (added)															
Iron	ppm	174	160	147	135	124	114	105	97	89	82	75	69	64	58
Zinc	ppm	174	160	147	135	124	114	105	97	89	82	75	69	64	58
Copper	ppm	10.8	10.0	9.2	8.5	7.8	7.2	6.6	6.1	5.6	5.1	4.7	4.4	4.0	3.7
Manganese	ppm	5.4	5.0	4.6	4.3	3.9	3.6	3.3	3.1	2.8	2.6	2.4	2.2	2.0	1.9
Iodine	ppm	0.22	0.21	0.2	0.19	0.17	0.16	0.15	0.14	0.14	0.13	0.12	0.11	0.11	0.1
Selenium	ppm	0.30	0.30	0.30	0.30	0.28	0.25	0.23	0.21	0.2	0.18	0.17	0.15	0.14	0.13
Vitamins (added/lb of diet)															
Vitamin A	IU	2300	2200	2100	1900	1800	1700	1600	1500	1400	1300	1250	1200	1100	1000
Vitamin D_3	IU	230	220	210	190	180	170	160	150	140	130	125	120	110	100
Vitamin E	IU	16	15	14	13	12	12	11	10	10	9	9	8	8	7
Viamin K (menadione)	mg	0.69	0.65	0.61	0.57	0.54	0.51	0.48	0.45	0.42	0.40	0.37	0.35	0.33	0.31
Niacin	mg	31	28	25	23	20	18	16	14	12	10	9	8	7	6
Pantothenic acid	mg	20	18	16	15	13	12	11	10	9	8	7	6	5	5
Riboflavin	mg	7.1	6.4	5.8	5.3	4.8	4.2	3.7	3.2	2.9	2.5	2.2	1.9	1.7	1.5
Vitamin B_{12}	mcg	35	32	29	26	23	20	18	16	14	12	10	9	8	7
Biotin [c]	mg	0.013	0.012	0.011	0.010	0.009	0.007	0.005	0.002						
Folic acid [c]	mg	0.061	0.055	0.050	0.045	0.036	0.03	0.024	0.012						
Choline [c]	mg	90	80	70	62	55	48	32	16						

[a] The crude protein and metabolizable energy values are the results of formulating the example diets in Table 8. They are not minimum levels.
[b] Sodium and chlorine supplementation is provided by salt (NaCl).
[c] Biotin, folic acid and choline additions are not required for pigs with a moderate or low lean growth capacity and major or maximal antigen exposure.

Table 7a. High lean growth pig adjustments of nutrient requirements (Table 6) to specific production conditions.

Steps to utilize this table:

A. Identify the stage of development (pig weight) to be addressed.

B. Identify the production conditions for pigs in that stage of development that deviate from the standard production conditions defined in Table 2.

C. For the production conditions that deviate from standard conditions, total the appropriate numbers for the stage of development being addressed. Round the total to the nearest whole number. Add or subtract that number from the stage of development being addressed. Use the adjusted number to determine the dietary nutrient concentrations in Table 6 that most closely match the nutrient needs of pigs reared in these specific production condition.

Example calculation: Pigs with high lean growth capacities in "Stage 6" of development (55-75 lb) are maintained in a cold thermal climate (5°F below TN) and experience a moderate level of antigen exposure. Adjustments for these specific conditions total +0.90 (+ 0.35 + 0.55). This number, rounded to the nearest whole is +1.0. This number (1) added to "Stage 6" equals 7 and represents the stage of development in Table 6 that defines the nutrient needs of pigs reared under the**se** unique production conditions.

	Pig weights at which diets should be fed, lb [a]											
	6-12	12-18	18-27	27-39	39-55	55-75	75-100	100-130	130-166	166-207	207-257	257-313
Stage of development	1	2	3	4	5	6	7	8	9	10	11	12
Pig gender												
Boars	0	0	0	0	0	-0.15	-0.35	-0.70	-1.15	-1.60	-1.40	-1.10
Gilts	0	0	0	0	0	-0.10	-0.30	-0.60	-1.00	-1.40	-1.00	-0.70
Barrows	0	0	0	0	0	+0.10	+0.30	+0.60	+1.00	+1.40	+1.00	+0.70
Thermal climate (Figure 8)												
Cold -10 F below TN	+0.60	+0.60	+0.50	+0.40	+0.40	+0.70	+0.70	+0.70	+0.80	+0.90	+1.40	+2.00
- 5 F below TN	+0.30	+0.30	+0.25	+0.20	+0.20	+0.35	+0.35	+0.35	+0.40	+0.45	+0.70	+1.00
Hot + 5 F above TN	0	-0.05	-0.05	-0.10	-0.10	-0.15	-0.30	-0.50	-0.60	-0.70	-0.80	-0.90
+10 F above TN	0	+0.05	+0.10	+0.15	+0.20	+0.30	+0.45	+0.60	+0.70	+0.80	+0.90	+1.00
Social climate (Figure 9)												
Crowded by 20%	+0.15	+0.12	+0.10	+0.08	+0.06	+0.03	0	-0.05	-0.15	-0.30	-0.50	-0.70
Dietary form												
Particle > 900 microns	+0.30	+0.25	+0.20	+0.15	+0.12	+0.10	+0.08	+0.05	+0.02	-0.01	-0.04	-0.08
Pelleted [b]	-0.15	-0.15	-0.10	-0.10	-0.10	-0.10	-0.10	-0.12	-0.15	-0.25	-0.35	-0.45
Antigen exposure (Table 4)												
Minimal	-0.30	-0.40	-0.50	-0.50	-0.55	-0.55	-0.55	-0.55	-0.60	-0.60	-0.60	-0.60
Modest	0	0	0	0	0	0	0	0	0	0	0	0
Moderate	+0.30	+0.40	+0.50	+0.50	+0.55	+0.55	+0.55	+0.55	+0.60	+0.60	+0.60	+0.60
Major	+0.60	+0.80	+1.00	+1.00	+1.10	+1.10	+1.10	+1.10	+1.20	+1.20	+1.20	+1.20
Maximal	+0.90	+1.20	+1.50	+1.50	+1.65	+1.65	+1.65	+1.65	+1.80	+1.80	+1.80	+1.80
Dietary ingredients other than corn and soybean meal	- maintain same digestible nutrient/ME ratio as in Table 6 - if digestibilities of nutrients (especially amino acids and phosphorous) in alternative ingredients differ substantially from that of corn and soybean meal, raise and lower dietary nutrient/ME ratios accordingly											
Growth regulators	- adjust nutrient concentrations based on the impact of growth regulators on feed intake and lean tissue growth and nutrient digestibility.											

[a] Pigs receiving a diet are assumed to be uniform in body weight.

[b] Increase dietary vitamin concentrations by 20%.

Table 7b. Moderate lean growth pig adjustments of nutrient requirements (Table 6) to specific production conditions.

Steps to utilize this table:

A. Identify the stage of development (pig weight) to be addressed.

B. Identify the production conditions for pigs in that stage of development that deviate from the standard production conditions defined in Table 2.

C. For the production conditions that deviate from standard conditions, total the appropriate numbers for the stage of development being addressed. Round the total to the nearest whole number. Add or subtract that number from the stage of development being addressed. Use the adjusted number to determine the dietary nutrient concentrations in Table 6 that most closely match the nutrient needs of pigs reared in these specific production condition.

Example calculation: Pigs with moderate lean growth capacities in "Stage 6" of development (37-51 lb) are maintained in a cold thermal climate (5°F below TN) and experience a moderate level of antigen exposure. Adjustments for these specific conditions total +0.75 (+ 0.35 + 0.40). This number, rounded to the nearest whole is +1.0. This number (1) added to "Stage 6" equals 7 and represents the stage of development in Table 6 that defines the nutrient needs of pigs reared under these unique production conditions.

	Pig weights at which diets should be fed, lb [a]												
	6-8	8-13	13-18	18-26	26-37	37-51	51-69	69-91	91-118	118-150	150-188	188-233	233-283
Stage of development	1	2	3	4	5	6	7	8	9	10	11	12	13
Pig gender													
Boars	0	0	0	0	0	0	-0.15	-0.30	-0.60	-1.10	-1.60	-1.30	-0.80
Gilts	0	0	0	0	0	0	-0.10	-0.25	-0.50	-0.90	-1.30	-1.00	-0.50
Barrows	0	0	0	0	0	+0.10	+0.10	+0.25	+0.60	+0.90	+1.30	+0.90	+0.50
Thermal climate (Figure 8)													
Cold -10 F below TN	+0.60	+0.60	+0.50	+0.40	+0.40	+0.70	+0.70	+0.70	+0.80	+0.90	+1.40	+2.00	+2.60
- 5 F below TN	+0.30	+0.30	+0.25	+0.20	+0.20	+0.35	+0.35	+0.35	+0.40	+0.45	+0.70	+1.00	+1.40
Hot + 5 F above TN	0	-0.05	-0.05	-0.10	-0.10	-0.15	-0.30	-0.50	-0.60	-0.70	-0.80	-1.00	-1.15
+10 F above TN	0	+0.05	+0.10	+0.15	+0.20	+0.30	+0.45	+0.80	+0.90	+1.00	+1.10	+1.20	+1.35
Social climate (Figure 9)													
Crowded by 20%	+0.12	+0.10	+0.08	+0.05	+0.03	-0.05	-0.15	-0.25	-0.40	-0.60	-0.80	-1.00	-1.20
Dietary form													
Particle > 900 microns	+0.30	+0.25	+0.20	+0.15	+0.10	+0.07	+0.04	+0.01	0	0	0	0	0
Pelleted [b]	-0.15	-0.15	-0.10	-0.10	-0.10	-0.10	-0.10	-0.12	-0.15	-0.25	-0.35	-0.50	-0.65
Antigen exposure (Table 4)													
Minimal	-0.30	-0.35	-0.35	-0.40	-0.40	-0.40	-0.40	-0.40	-0.45	-0.45	-0.50	-0.50	-0.55
Modest	0	0	0	0	0	0	0	0	0	0	0	0	0
Moderate	+0.30	+0.35	+0.35	+0.40	+0.40	+0.40	+0.40	+0.40	+0.45	+0.45	+0.50	+.50	+.55
Major	+0.60	+0.70	+0.70	+0.80	+0.80	+0.85	+0.85	+0.85	+0.90	+0.90	+1.00	+1.05	+1.10
Maximal	+0.90	+1.05	+1.05	+1.25	+1.25	+1.30	+1.30	+1.30	+1.45	+1.45	+1.50	+1.60	+1.65
Dietary ingredients other than corn and soybean meal	- maintain same digestible nutrient/ME ratio as in Table 6 - if digestibilities of nutrients (especially amino acids and phosphorous) in alternative ingredients differ substantially from that of corn and soybean meal, raise and lower dietary nutrient/ME ratios accordingly												
Growth regulators	- adjust nutrient concentrations based on the impact of growth regulators on feed intake and lean tissue growth and nutrient digestibility.												

[a] Pigs receiving a diet are assumed to be uniform in body weight.

[b] Increase dietary vitamin concentrations by 20%.

Table 8. Example diets for growing pigs using ingredients defined under standard production conditions.

	Stage of development													
Ingredient, lb	1	2 [a]	3 [a]	4	5	6	7	8	9	10	11	12	13	14
Corn	347.50	339.60	357.60	546.40	600.60	648.40	691.00	728.70	765.80	791.85	823.05	849.90	871.00	891.90
Soybean meal, dehulled	140.00	435.00	460.00	415.00	365.00	320.00	280.00	245.00	210.00	185.00	155.00	130.00	110.00	90.00
Dried whey	175.00	150.00	150.00											
Skim milk, dried	125.00													
Plasma protein, spray dried	75.00	40.00												
Fish meal, menhaden	100.00													
Soybean oil or other fat	25.00													
Limestone	5.40	9.10	7.20	8.50	8.25	8.50	8.90	8.75	8.70	9.00	9.00	9.00	9.00	9.50
Dicalcium phosphate	1.20	20.55	19.75	21.00	17.60	15.25	12.75	11.00	9.50	8.50	7.50	6.00	5.00	4.00
Salt [b]				4.50	4.30	4.10	4.10	3.70	3.70	3.50	3.50	3.30	3.30	3.10
Trace mineral premix [c]	2.50	2.50	2.50	1.95	1.80	1.65	1.50	1.40	1.30	1.20	1.10	1.00	0.95	0.85
Fat soluble vitamin premix [c]	1.00	1.00	0.95	0.85	0.80	0.75	0.70	0.65	0.60	0.60	0.55	0.55	0.50	0.45
B-vitamin premix [c]	1.00	0.95	0.85	0.75	0.70	0.65	0.55	0.45	0.40	0.35	0.30	0.25	0.25	0.20
Biotin & folic acid premix [cd]	1.00	0.95	0.85	0.75	0.70	0.50	0.35	0.25						
Choline premix [cd]	0.40	0.35	0.30	0.30	0.25	0.20	0.15	0.10						
Feed additives [e]														
Total, lb	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00

[a] Piglets nursing the sow can be creep fed diets from stages 2 or 3.
[b] Added salt (source of sodium and chlorine) is not required in the diets containing dried whey and/or spray dried plasma protein.
[c] Example trace mineral, vitamin and choline premixes can be found in Tables 9 and 10.
[d] Biotin, folic acid and choline additions are not required for moderate or low genetic gain capacity and moderate or maximal antigen exposure.
[e] Feed additives may be added at various levels as approved by the Food and Drug Administration in Table 32.

Table 9. Example trace mineral premix for growing pigs. [a]

Trace mineral	% in premix	Premix/1000 lb complete diet 1.0 lb	1.5 lb	2.0 lb	2.5 lb
		Parts per million in complete diet:			
Iron	7.00	70	105	140	175
Zinc	7.00	70	105	140	175
Copper	0.44	4.50	6.75	9.00	11.25
Manganese	0.22	2.2	3.3	4.4	5.5
Iodine [b]	0.010	0.110	0.165	0.220	0.275
Selenium	0.012	0.12	0.18	0.24	0.30

[a] Several sources of trace minerals may be used. See Table 22 for concentrations and availability.
[b] Iodine may be eliminated if iodized salt is used.

Table 10. Example vitamin premixes for growing pigs.

Fat soluble vitamin premix	Amount/lb of premix	Premix/1000 lb complete diet 0.25 lb	0.50 lb	0.75 lb	1.00 lb
		Units added per pound of complete diet:			
A	2,300,000 IU	575	1150	1725	2300
D	230,000 IU	58	115	172	230
E	16,000 IU	4	8	12	16
K (menadione)	700 mg	0.175	0.350	0.525	0.700
B-vitamin premix		0.25 lb	0.50 lb	0.75 lb	1.00 lb
		Units added per pound of complete diet:			
Niacin	31,000 mg	7.75	15.50	23.25	31.00
Pantothenic acid	20,000 mg	5.00	10.00	15.00	20.00
Riboflavin	7000 mg	1.75	3.50	5.25	7.00
Vitamin B_{12}	35,000 mcg	8.75	17.50	26.25	35.00
Biotin & folic acid premix		0.25 lb	0.50 lb	0.75 lb	1.00 lb
		Units added per pound of complete diet:			
Biotin	13 mg	0.00325	0.0065	0.00975	0.013
Folic acid	60 mg	0.015	0.030	0.045	0.060
Choline premix		0.25 lb	0.50 lb	1.00 lb	1.50 lb
		Units added per pound of complete diet:			
Choline (60%)	236,000 mg	59	118	236	354

Procedures for Defining the Nutrient Requirements for the Breeding Herd

The first step in defining nutrient requirements of the breeding herd is to identify the gender (sow or boar) and stage of production (breeding, gestation, lactation) being addressed. Second, identify specific production conditions in which the breeding herd is being reared that differ from the standard production conditions (Table 2). Use Tables 11 to 14 as guidelines to define appropriate nutrient concentrations and diets for replacements, breeding/gestating sows, lactating sows and boars, respectively. The final step is to select diets matching their nutrient needs. This may be done by purchasing or preparing diets similar to those in Tables 15, 26 or 27.

When conditions vary from the standard production conditions, nutrient requirements G2 (gestation) and L5 (lactation) in Table 14 and diets G2 (gestation) and L5 (lactation) in Table 15 should be used as default feeding programs.

Replacement Gilts

Replacement gilts should be on full feed until they reach the heaviest stage of development in Table 6. For example, high lean growth gilts should be full fed until approximately 257 to 313 lb body weight. After removal from full feed, feed and nutrient intakes should be based on the adjustments for gestating sows in Table 11. Gilts may be flushed 14 to 21 days before breeding by increasing daily feed intake 50 to 100%. Reduce daily intake to 4 or 5 lb postmating.

Breeding and Gestating Sows

Nutrient recommendations for sows are based on the assumption that non-lactating and pregnant sows are maintained under the standard production conditions in Table 2 and a thermal neutral climate illustrated in Figure 10. Sows and boars are assumed to be penned individually on slotted floors, in insulated buildings and in the presence of minimal drafts. For sows housed on wet floors, in poorly insulated buildings or in the presence of drafts, the temperature must be increased 5, 5, and 8 degrees, respectively, to maintain thermoneutrality. For animals penned in groups on solid concrete floors or housed in dry straw, the temperature may be reduced by 4 and 10 degrees, respectively and still maintain thermoneutrality.

The standard sow is a first parity female, of moderate lean growth capacity and optimum body condition with an expected loss of less than 15 pounds from postfarrowing to weaning. Table 11 indicates the adjustments in feed intake and lysine recommendations for gestating sows maintained in production conditions that deviate from the standard production conditions.

For example, first parity sows (gilts) raised under standard production condition would be fed 4.0 lb of feed/day containing 0.51% lysine. However, third parity sows require 4.4 lb (4.0 + 0.4 lb) of feed/day containing 0.44% lysine (0.51%-0.07%). Use the estimated feed intake and lysine needs to identify the appropriate nutrient requirements in Table 14 for breeding and gestating sows.

Figure 10. Thermal climate for sows and boars.

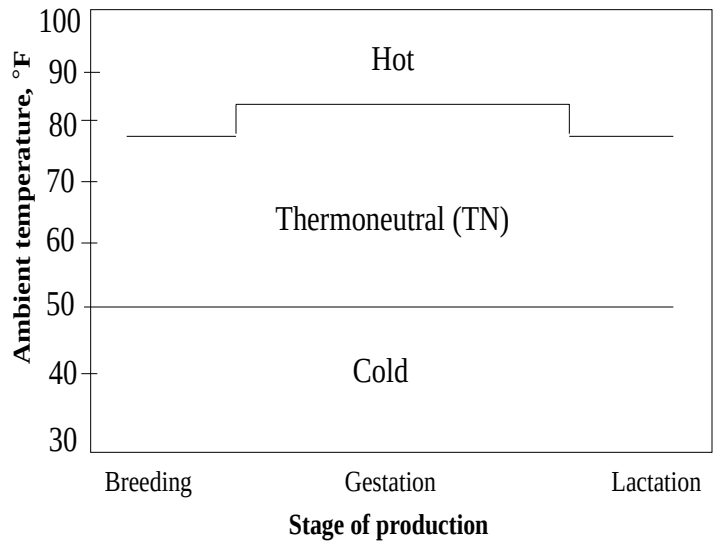


Table 11. Gestating sow adjustments of feed intake and lysine requirements to match specific production situations.[a]

		Feed, lb/day	Lysine, %
Standard production conditions [a]		4.0	0.51
Adjustments:			
Parity	2	+0.4	0
	3	+0.4	- 0.07
	4	+0.5	- 0.09
	5	+0.6	- 0.10
	6-8	+0.4	- 0.20
High lean growth		+0.2	0
10°F below thermoneutrality		+0.8	- 0.07
Over-condition		-0.5	+0.03
Weight loss, postfarrow to weaning, lb			
	15	+0.3	0
	30	+0.6	+0.01
	45	+0.8	+0.02
	60	+1.1	+0.03
	75	+1.4	+0.04

[a] See Table 2.

Lactating Sows

Appropriate diets for lactating sows can be estimated using Table 12. Because only one diet will likely be fed in a lactation room, the producer should determine the average number of pigs nursed per sow and the average lactation feed intake by season. Then select a diet that most closely matches that litter size and feed intake. Ad lib feeding is recommended during lactation and sows should be brought up to maximum feed intake as quickly as possible postfarrowing. Feed fresh diet twice per day and remove stale feed daily. Lactation requirements and example diets are in Tables 14 and 15.

Boars

Nutrient requirements for growing boars are in Table 6 and adjustments for non-standard conditions are in Tables 7a or 7b. The recommended feed intakes and diet composition for boars of different weights and frequency of matings is in Table 13.

Table 12. Lactating sow diet selections.

Pigs nursed per litter	Daily feed intake, lb [a]						
	10	11	12	13	14	15	16
	Diet number [bc]						
8	**L7**	**L6**	**L4**	**L3**	L2	L1	
9	**L8**	**L7**	**L6**	**L4**	L3	L2	L1
10	**L9**	**L7**	**L6**	**L5**	**L4**	L3	L2
11	**L10**	**L8**	**L7**	**L6**	**L5**	**L4**	L3
12	**L11**	**L9**	**L8**	**L7**	**L6**	**L5**	L4

[a] Average daily feed intake over a 21-day lactation.
[b] **Bold diet numbers** indicate that the associated feed intake is inadequate to supply sufficient energy for milk production. In these situations body energy stores will be used.
[c] Example: Sows have an average intake of 11 lb of feed per day over a 21-day lactation and a weaning average of 10 pigs/litter. Diet L7 most closely matches these nutrient requirements.

Table 13. Boar feeding regimens. [a]

Matings/ week	Boar weight, lb			
	270-350	350-450	450-550	550-650
	Feed, lb/day [b]			
1-2	5.3	5.6	5.8	6.2
2-4	5.5	5.8	6.0	6.4
Diet [bc]	L3	L2	L1	G3

[a] Requirements are based on the standard production conditions in Table 2. Boars housed in a colder thermal climate should have the daily feed allowance increased by 0.17 lb for each 5°F decrease in temperature below thermoneutrality (Figure 10).
[b] If diets differ from corn-soybean meal, adjustments in feed and nutrient allowances may be needed.
[c]. Diets represent lactation (L3, L2 and L1) and gestation (G3) diets in Table 15 that most closely match the nutrient requirements of boars.

Table 14. Nutrient requirements of the breeding herd.

		Stage of production													
		Breeding/Gestation			Lactation										
Diet number		G1	G2	G3	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11
Amino acids															
Lysine	%	0.44	0.51	0.56	0.72	0.76	0.81	0.85	0.88	0.94	1.00	1.06	1.11	1.15	1.20
Threonine	%	0.32	0.37	0.41	0.45	0.47	0.50	0.53	0.55	0.58	0.62	0.66	0.69	0.71	0.74
Tryptophan	%	0.10	0.11	0.12	0.14	0.15	0.16	0.17	0.18	0.19	0.20	0.21	0.22	0.23	0.24
Methionine + Cystine	%	0.36	0.41	0.45	0.35	0.37	0.40	0.42	0.43	0.46	0.49	0.52	0.54	0.56	0.59
Crude protein [a]	%	10.60	11.60	12.20	14.70	15.20	15.80	16.40	16.80	17.70	18.50	19.30	20.10	20.60	21.20
Metabolizable energy [a]	kcal/lb	1483	1478	1481	1496	1492	1490	1488	1485	1482	1479	1477	1474	1471	1469
Minerals															
Calcium	%	0.80	0.85	0.90	0.65	0.67	0.70	0.73	0.76	0.80	0.84	0.88	0.91	0.94	0.97
Phosphorus, total	%	0.63	0.68	0.73	0.59	0.61	0.64	0.66	0.69	0.73	0.76	0.80	0.83	0.85	0.88
Phosphorus, available	%	0.36	0.42	0.50	0.31	0.33	0.35	0.37	0.40	0.43	0.46	0.49	0.52	0.54	0.56
Sodium (Na) [b]	%	0.14	0.16	0.18	0.13	0.14	0.15	0.15	0.16	0.17	0.18	0.19	0.20	0.21	0.22
Chlorine (Cl) [b]	%	0.21	0.24	0.26	0.20	0.21	0.22	0.23	0.24	0.26	0.27	0.29	0.30	0.31	0.33
Trace minerals (added)															
Iron	ppm	86	100	110	82	86	92	96	100	107	114	120	126	131	136
Zinc	ppm	73	85	94	70	73	78	82	85	91	97	102	107	111	116
Copper	ppm	5.2	6.0	6.6	4.9	5.2	5.5	5.8	6.0	6.4	6.8	7.2	7.6	7.9	8.2
Manganese	ppm	10	12	13	10	10	11	12	12	13	14	14	15	16	16
Iodine	ppm	0.15	0.17	0.19	0.14	0.15	0.16	0.16	0.17	0.18	0.19	0.20	0.21	0.22	0.23
Selenium	ppm	0.15	0.18	0.20	0.15	0.15	0.17	0.17	0.18	0.19	0.21	0.22	0.23	0.24	0.24
Vitamins (added/lb of diet)															
Vitamin A	IU	1376	1600	1760	1312	1376	1472	1536	1600	1712	1824	1920	2016	2096	2176
Vitamin D_3	IU	138	160	176	131	138	147	154	160	171	182	192	202	210	218
Vitamin E	IU	15	18	20	15	15	17	17	18	19	21	22	23	24	24
Vitamin K (menadione)	mg	0.34	0.40	0.44	0.33	0.34	0.37	0.38	0.40	0.43	0.46	0.48	0.50	0.52	0.54
Niacin	mg	6.9	8.0	8.8	6.6	6.9	7.4	7.7	8.0	8.6	9.1	9.6	10.1	10.5	10.9
Pantothenic acid	mg	8.2	9.5	10.5	7.8	8.2	8.7	9.1	9.5	10.2	10.8	11.4	12.0	12.4	12.9
Riboflavin	mg	2.6	3.0	3.3	2.5	2.6	2.8	2.9	3.0	3.2	3.4	3.6	3.8	3.9	4.1
Vitamin B_{12}	mcg	10.3	12.0	13.2	9.8	10.3	11.0	11.5	12.0	12.8	13.7	14.4	15.1	15.7	16.3
Biotin	mg	0.12	0.14	0.15	0.11	0.12	0.13	0.13	0.14	0.15	0.16	0.17	0.18	0.18	0.19
Folic acid	mg	0.28	0.34	0.38	0.11	0.12	0.13	0.13	0.14	0.15	0.16	0.17	0.18	0.18	0.19
Choline	mg	301	350	385	287	301	322	336	350	375	399	420	441	459	476

[a] The crude protein and metabolizable energy values are the results of formulating the example diets in Table 15. They are not minimum levels.
[b] Sodium and chlorine supplementation is provided by salt (NaCl).

Table 15. Example diets for sows and boars under standard production conditions.

	Stage of production													
Ingredient, lb	G1	G2	G3	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11
Corn	891.15	862.50	843.70	799.30	781.50	765.10	748.85	737.00	709.95	687.90	665.95	943.95	627.45	611.15
Soybean meal, dehulled	75.00	100.00	115.00	175.00	190.00	205.00	220.00	230.00	255.00	275.00	295.00	315.00	330.00	345.00
Limestone	10.50	10.00	9.00	6.25	7.70	7.70	7.75	7.75	7.80	7.85	7.90	8.00	8.00	8.00
Dicalcium phosphate	16.80	20.00	24.00	13.50	14.50	15.50	16.50	18.00	19.50	21.00	22.50	24.00	25.00	26.00
Salt	3.50	4.00	4.50	3.25	3.50	3.75	3.75	4.00	4.25	4.50	4.75	5.00	5.25	5.50
Sow trace mineral premix [a]	0.90	1.00	1.10	0.85	0.85	0.90	0.95	1.00	1.10	1.15	1.20	1.25	1.30	1.35
Sow fat soluble vitamin premix [a]	0.30	0.35	0.35	0.30	0.30	0.30	0.35	0.35	0.35	0.40	0.40	0.40	0.45	0.45
Sow B-vitamin premix [a]	0.35	0.40	0.45	0.35	0.35	0.40	0.40	0.40	0.45	0.50	0.50	0.50	0.55	0.55
Sow Folic acid premix [a]	0.20	0.25	0.25											
Choline premix [a]	1.30	1.50	1.65	1.20	1.30	1.35	1.45	1.50	1.60	1.70	1.80	1.90	2.00	2.00
Feed additives [b]														
Total, lb	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00

[a] See Tables 16 and 17 for sow trace mineral and vitamin premixes.
[b] Feed additives may be added at various levels as approved by the Food and Drug Administration in Table 31.

Table 16. Example sow trace mineral premix. [a]

Trace mineral	% in premix	Premix/1000 lb complete diet			
		0.75 lb	1.00 lb	1.25 lb	1.50 lb
		Parts per million in complete diet:			
Iron	10	75	100	125	150
Zinc	8.5	64	85	106	128
Copper	0.6	4.5	6.0	7.5	9.0
Manganese	1.20	9.0	12.0	15.0	18.0
Iodine [b]	0.017	0.13	0.17	0.21	0.26
Selenium	0.018	0.14	0.18	0.23	0.27

[a] Several sources of trace minerals may be used. See Table 15 for concentrations and availability.
[b] Iodine may be eliminated if iodized salt is used.

Table 17. Example sow vitamin premixes.

Fat soluble vitamin premix	Amount/lb of premix	Premix/1000 lb complete diet			
		0.3 lb	0.4 lb	0.5 lb	0.6 lb
		Units added per pound of complete diet:			
A	5,000,000 IU	1500	2000	2500	3000
D	500,000 IU	150	200	250	300
E	57,000 IU	17.1	22.8	28.5	34.2
K (menadione)	1,200 mg	0.36	0.48	0.6	0.72
B-vitamin premix		0.3 lb	0.4 lb	0.5 lb	0.6 lb
		Units added per pound of complete diet:			
Niacin	20,000 mg	6.00	8.00	10.00	12.00
Pantothenic acid	25,000 mg	7.50	10.00	12.50	15.00
Riboflavin	7,500 mg	2.25	3.00	3.75	4.50
Vitamin B_{12}	30,000 mcg	9.00	12.00	15.00	18.00
Biotin	400 mg	0.12	0.16	0.20	0.24
Folic acid	300 mg	0.09	0.12	0.15	0.18
Folic acid premix		0.15 lb	0.20 lb	0.25 lb	0.30 lb
		Units added per pound of complete diet:			
Folic acid	1,000 mg	0.15	0.20	0.25	0.30
Choline premix		1.25 lb	1.5 lb	1.75 lb	2.00 lb
		Units added per pound of complete diet:			
Choline (60%)	236,000 mg	295	354	413	472

Table 18. Average analysis of ingredients (as fed). [a]

Ingredients	Dry matter %	Metabolizable energy kcal/lb	Net energy kcal/lb	Crude protein %	Calcium %	Phos-phorus %	Avail. phos. %	Crude fat %	Crude fiber %	Lysine %	Threonine %	Trypto-phan %	Methionine + Cystine %
Alfalfa meal, dehydrated	92	775	245	17.5	1.40	0.23	0.23	2.80	24.00	0.85	0.71	0.34	0.56
Animal fat, stabilized	100	3585	1900	-	-	-	-	99.50	-	-	-	-	-
Barley	89	1380	895	11.5	0.05	0.34	0.11	1.70	5.00	0.40	0.36	0.15	0.37
Beet pulp, dried	91	1180	710	8.8	0.62	0.09	0.03	0.50	18.20	0.60	0.40	0.10	0.02
Blood meal, spray dried	93	1260	1010	86.0	0.41	0.30	0.27	1.20	1.00	7.44	3.63	1.05	2.08
Canola meal, solvent	93	1230	510	38.0	0.68	1.17	0.25	3.80	11.10	2.27	1.71	0.44	1.15
Corn, yellow	88	1535	1020	8.0	0.03	0.28	0.04	3.60	2.30	0.25	0.36	0.09	0.40
Corn, yellow, high oil	87	1590	1055	8.8	0.03	0.28	0.04	7.45	2.30	0.29	0.29	0.06	0.34
Corn distillers dried grain w/sol.	91	1485	780	27.0	0.14	0.66	0.41	9.30	9.10	0.70	0.92	0.17	0.78
Corn gluten feed	91	1235	800	23.3	0.18	0.99	0.58	2.70	6.80	0.64	0.79	0.15	0.80
Corn gluten meal, 60% CP	90	1630	1046	61.2	0.02	0.44	0.15	1.80	1.80	1.03	2.25	0.30	2.79
Cottonseed meal, solvent	92	1160	720	41.7	0.17	1.17	0.17	1.80	10.80	1.70	1.23	0.48	1.06
Fish meal, menhaden	92	1550	1060	61.2	5.19	2.88	2.88	9.60	0.90	4.74	2.51	0.65	2.33
Fish solubles, condensed	51	740	515	31.5	0.17	0.57	0.57	6.10	0.50	1.85	0.90	0.33	1.09
Hominy feed	90	1505	940	10.6	0.06	0.52	0.07	5.70	5.00	0.36	0.40	0.13	0.28
Lactose	92	1500	1130	-	-	-	-	-	-	-	-	-	-
Meat and bone meal, 50% CP	94	1025	510	50.9	9.90	4.58	3.50	12.00	2.40	2.89	1.60	0.28	1.14
Molasses, cane	74	910	435	4.4	0.77	0.08	0.08	0.10	-	-	-	-	-
Oats	89	1245	700	11.8	0.08	0.34	0.10	4.70	10.70	0.40	0.38	0.15	0.37
Oat groats (dehulled oats)	87	1530	1010	15.8	0.08	0.43	0.13	6.10	2.50	0.53	0.44	0.18	0.41
Plasma protein, spray dried	92	1760	1126	78.0	0.15	1.70	1.70	2.00	0.30	6.80	4.80	1.40	3.50
Poultry byproduct meal	96	1240	800	66.4	3.20	1.70	1.70	13.10	2.30	4.14	2.52	0.46	2.19
Skim milk, dried	94	1660	1040	33.3	1.28	1.02	1.02	1.10	0.20	2.54	1.57	0.43	1.35
Sorghum, grain	89	1490	940	8.9	0.03	0.28	0.05	2.80	2.20	0.23	0.27	0.10	0.29
Soybean meal, dehulled, solvent	90	1540	800	47.5	0.26	0.64	0.16	0.90	3.50	3.04	1.90	0.69	1.41
Soybean meal, solvent	90	1465	760	44.0	0.30	0.65	0.23	1.10	7.30	2.90	1.70	0.64	1.18
Soybeans, full-fat, cooked	90	1650	1210	36.7	0.26	0.61	0.20	18.80	5.20	2.25	1.42	0.54	1.01
Soybean oil	100	3450	2500	-	-	-	-	97.00	-	-	-	-	-
Sugar (sucrose)	100	1670	1255	-	-	-	-	-	-	-	-	-	-
Sunflower meal, 28% CP	93	1205	735	28.0	0.35	0.90	0.03	1.00	24.00	1.10	1.00	0.30	1.55
Wheat, hard	88	1455	1010	12.6	0.04	0.37	0.18	1.60	2.60	0.40	0.37	0.17	0.52
Wheat bran	90	1020	600	15.5	0.13	1.16	0.41	4.00	10.00	0.56	0.41	0.25	0.43
Wheat midds	89	1375	690	16.5	0.13	0.89	0.40	4.30	7.80	0.68	0.57	0.19	0.41
Whey, dried	93	1405	930	13.3	0.86	0.76	0.58	0.80	-	0.94	0.89	0.18	0.49
Whey, dried, delactosed	93	1255	785	16.7	1.59	1.05	1.05	1.00	0.20	1.40	0.95	0.27	0.84
Yeast, dried brewers	93	1385	1020	43.8	0.14	1.36	0.45	0.90	3.00	3.23	2.06	0.51	1.18

[a] Energy values summarized from I.S.U. research and other comparable values.

Table 19. Ingredient inclusions that have produced satisfactory results and their relative values.

	Percentage of following diets				Relative value vs. [a]		
			Stage of development				
Ingredients	Gestation	Lactation	1 - 3	4 - 14	Corn	Soybean meal, dehulled	Remarks
Alfalfa meal, dehydrated	0-50	0-10	0	0-5	80-100	30	Low energy, high fiber, carotene
Animal fat, stabilized	0-8	0-8	0-8	0-8	140-160		High energy, more than 5% may bridge feed
Barley [b]	0-90	0-85	0-25	0-95	100-105		Energy source, moderate fiber
Beet pulp, dried	0-10	0-10	0	0	90-105		Bulky, high fiber, laxative
Blood meal, spray	0-5	0-5	0-5	0-5		205-220	High lysine, low isoleucine and tryptophan
Canola meal, solvent	0-5	0-5	0	0-5		72-74	High fiber
Corn, yellow [b]	0-90	0-85	0-45	0-95	100		Energy source, low lysine and tryptophan
Corn, yellow, high oil	0-90	0-85	0-45	0-85	105		Energy source, low lysine and tryptophan
Corn distillers dried grain w/solubles	0-10	0-5	0-5	0-5		45-50	B vitamin source, low lysine
Corn gluten feed	0-90	0	0	0	110-130	40-50	Low lysine and tryptophan availability
Corn gluten meal, 60% CP	0-5	0-5	0	0-5		55-65	Low lysine and tryptophan availability
Cottonseed meal, solvent	0-5	0-5	0	0-5		64-68	Gossypol toxicity, low lysine
Fish meal, menhaden	0-10	0-10	0-10	0-5		165-170	Potential rancidity
Fish solubles, condensed	0-5	0-5	0-5	0-3		65	Approximately 5% salt
Hominy feed	0-60	0-60	0	0-60	100-105		Energy source
Lactose	0	0	0-20	0	85-95		Energy source, palatable
Meat and bone meal	0-10	0-5	0-5	0-5		108-115	Low tryptophan, high calcium and phosphorus
Molasses, cane	0-5	0-5	0-5	0-5	34-38		Palatable
Oats	0-90	0-15	0	0-20	80-85		Energy source, high fiber
Oat groats (dehulled oats)	0-30	0-30	0-30	0-30	115-125		Energy source, palatable
Plasma protein, spray dried	0	0	0-8	0		205-215	Immunoglobulins, high salt content
Poultry byproduct meal	0-5	0-5	0	0-5		136-139	Potential of high ash content
Skim milk, dried	0	0	0-20	0		100-105	Excellent amino acid balance, palatable
Sorghum, grain [b]	0-90	0-85	0-45	0-95	92		Energy source, low lysine and tryptophan
Soybean meal, dehulled, solvent [b]	0-10	0-25	0-45	0-40		100	Good amino acid balance with corn
Soybean meal, solvent [b]	0-12	0-30	0-48	0-45		96	Good amino acid balance with corn
Soybeans, full-fat, cooked	0-15	0-32	0-60	0-50		90-100	High energy, soft pork
Soybean oil	0-8	0-8	0-8	0-8	190-215		High energy, more than 5% may bridge feed
Sugar (sucrose)	0	0	0-5	0	95-105		Added for palatability
Sunflower meal, 28% CP	0-10	0	0	0-10		45-55	High fiber, low lysine
Wheat, hard [b]	0-90	0-85	0-45	0-95	110-115		Energy source, low fiber
Wheat bran	0-30	0-10	0	0-5	95-105		High fiber, laxative
Wheat midds	0-30	0-20	0-5	0-5	95-115		Low energy, partial grain substitute
Whey, dried	0-5	0-5	0-30	0-5	130-160		Excellent amino acid balance,
Whey, dried, delactosed	0-5	0-5	0-30	0-5	140-200		palatable, high salt content
Yeast, dried brewers	0-3	0-3	0-3	0-3		112-115	Source of B-vitamins

[a] Relative value considers lysine content, net energy and available phosphorus. The cost of an ingredient can be evaluated by comparing its cost with the cost of corn or dehulled soybean meal times the particular coefficient for the relative value of the ingredient compared to corn or soybean meal. These values assume feeding levels within the suggested limits. High fiber feeds will decrease in value as their level in the feed is increased.

[b] Corn, barley, sorghum or wheat should be the basic energy source with other substitutions made within the ranges suggested. Soybean meal is assumed to be the basic protein source with other substitutions made within the ranges suggested.

Table 20. Calcium and phosphorus sources.

	Dry matter %	Calcium %	Phosphorus Total %	Phosphorus Available %
Limestone (calcium carbonate)	98	38.0	0	0
Dicalcium phosphate	96	21.3	18.7	18.7
Mono-calcium phosphate	98	20.0	21.0	21.0
Mono-dicalcium phosphate	97	16.0	21.0	21.0
Tricalcium phosphate	98	38.0	18.0	15.1
Mono-ammonium phosphate	98	0.3	23.0	21.9
Sodium phosphate, monobasic	96	0	25.8	25.8
Phosphoric acid, feed grade	75	0.08	23.7	23.7
Deflourinated phosphate	99	32.0	18.0	15.6
Bone meal, steamed	95	29.8	12.5	10.2

Table 21. Vitamin losses under various storage and processing conditions.

	Vitamin loss per month, % Premix			Pellet temp. Complete feed	
Vitamin	w/o Choline	w/Choline	Feed	~140°F	~220°F
A 650 (Beadlet)	5.0	8.0	9.5	5	21
D_3 325 (Beadlet)	4.0	6.0	7.5	3	11
D_3 400	6.0	9.5	12.0	5	23
E acetate	2.7	3.1	2.0	3	12
E alcohol	46.0	57.0	40.0	25	77
K (MSBC) [a]	25.0	38.0	17.0	20	56
K (MPB) [b]	22.0	34.0	15.0	18	50
Thiamine hydrochloride	12.0	17.0	11.0	7	37
Thiamine mononitrate	6.0	9.6	5.0	4	23
Riboflavin	5.0	8.2	3.0	5	22
Pyridoxine	5.6	8.8	4.0	6	25
B_{12}	1.4	2.2	1.4	1	6
d-Calcium pantothenate	5.3	8.4	2.4	5	22
Folic acid	8.0	12.2	5.0	5	23
d-Biotin	5.5	8.6	4.4	5	23
Niacin	5.3	8.4	4.6	4	20
Niacinamide	6.1	9.6	4.9	6	23
Choline	-	2.0	1.0	1	5

[a] Menadione sodium bisulfite complex.
[b] Menadione dimethyl pyrimidnol bisulfate.

Table 22. Trace mineral sources. [a]

Mineral	Source	Formula	Level [b]	Availability
Sodium	Salt	NaCl	39.3% Na	High
Chlorine	Salt	NaCl	60.7% Cl	High
Iron	Ferric oxide	Fe_2O_3	69.9% Fe	Unavailable
	Ferrous carbonate	$FeCO_3$	48.2% Fe	Varies
	Ferrous fumarate	$C_4H_2FeO_4$	32.9% Fe	High
	Ferrous sulfate	$FeSO_4 \cdot 7H_2O$	20.1% Fe	High
Zinc	Zinc chloride	$ZnCl_2$	48.0% Zn	High
	Zinc oxide	ZnO	80.3% Zn	High
	Zinc sulfate	$ZnSO_4 \cdot 7H_2O$	22.7% Zn	High
Copper	Copper carbonate	$CuCO_3$	67.9% Cu	High
	Copper chloride	$CuCl_2 \cdot 2H_2O$	37.3 % Cu	Medium
	Copper oxide	CuO	79.7% Cu	Medium
	Copper sulfate	$CuSO_4 \cdot 5H_2O$	25.4% Cu	High
Manganese	Manganese carbonate	$MnCO_3$	47.8% Mn	High
	Manganous oxide	MnO	77.4% Mn	High
	Manganese sulfate	$MnSO_4 \cdot 7H_2O$	22.8% Mn	High
Iodine	Calcium iodate	$Ca(IO_3)_2$	65.1% I	High
	EDDI [c]	$C_2H_8N_2 2HI$	80.0% I	High
	Potassium iodide	KI	76.4% I	High
Selenium	Sodium selenate	Na_2SeO_4	41.8% Se	High
	Sodium selenite	Na_2SeO_3	45.7% Se	High

[a] Source names taken from 1994 Feed Industry Red Book.
[b] Level in pure formula. Observe feed labels for variations in nutrient content.
[c] Ethylenediamine dihydroiodide.

Table 23. Crystalline amino acid sources. [a]

	Dry matter, %	Crude protei %	Amino acid content
L-lysine monohydrochloride	100	95.8	78% lysine
DL-methionine	100	58.6	99% methionine
DL-methionine hydroxy analog (MHA)	100	0	88% methionine ~79% available met
L-threonine	100	73.4	98.5% threonine
L-tryptophan	100	85.7	98.5% tryptophan
Lysine-tryptophan blend	98	119.0	47.4% lysine 10.0% tryptophan 2.25% methionine

[a] Crystalline amino acids can be considered 100% available while amino acids in feedstuffs a 70 to 90% available. Observe feed labels for variations in nutrient content.

Table 24. Ileal digestible amino acid content of selected ingredients.

	Lys, %	Thr, %	Trp, %	SAA, %
Alfalfa meal	0.43	0.33	-	0.20
Barley	0.27	0.23	0.10	0.28
Blood meal	7.07	3.09	0.97	1.71
Canola meal, solvent	1.66	1.15	0.31	1.15
Corn	0.17	0.25	0.06	0.34
Corn distillers dried grain w/sol.	0.30	0.50	0.09	0.51
Corn gluten feed	0.29	0.40	0.10	-
Corn gluten meal, 60% CP	0.81	1.82	0.25	2.32
Cottonseed meal	1.02	0.75	0.33	0.73
Fishmeal, menhaden	4.17	2.03	0.50	1.96
L-lysine monohydrochloride	78.00	-	-	-
Meat & bone meal	2.05	1.06	0.16	0.80
DL-methionine				99.00
Oats	0.28	0.21	-	0.26
Oat groats	0.42	0.33	0.15	0.32
Plasma protein, spray dried	4.00	3.11	1.33	-
Skim milk, dried	2.36	1.37	0.37	1.22
Sorghum, grain	0.15	0.18	0.08	-
Soybean meal, dehulled	2.65	1.44	0.56	1.14
Soybean meal, solvent	2.41	1.28	0.49	0.91
Soybeans, full-fat, cooked	2.23	1.24	0.47	0.90
Sunflower meal	1.24	1.17	0.43	1.26
L-threonine	-	98.50	-	-
L-tryptophan	-	-	98.50	-
Wheat, hard, red winter	0.29	0.26	0.13	0.43
Wheat bran	0.44	0.33	0.11	0.30
Wheat midds	0.42	0.30	0.11	0.29
Whey, dried	0.75	0.73	0.15	0.45

Table 25. Complete growing pig mineral-vitamin premix for corn-soybean meal based diets. [ab]

Ingredient, lb	1	2
Limestone	340.00	160.00
Dicalcium phosphate	406.00	
Deflourinated phospate		485.00
Salt [b]	150.00	150.00
Trace mineral premix	50.00	50.00
Fat soluble vitamin premix [c]	24.00	24.00
B-vitamin premix [c]	16.00	16.00
Biotin & folic acid premix [cd]	(8.00)	(8.00)
Choline premix [cd]	(6.00)	(6.00)
Carrier, wheat midds		101.00
Feed additive [e]		
Total, lb	1000.00	1000.00

Calculated analysis, minimum			
Calcium	21.57%	Vitamin A	55,200 IU/lb
Phosphorus, total	7.59%	Vitamin D_3	5,520 IU/lb
Phosphorus, available	7.59%	Vitamin E	384 IU/lb
Sodium (Na)	6.00%	Vitamin K	16.8 mg/lb
Chlorine (Cl)	9.00%	Niacin	496 mg/lb
Iron	0.350%	Pantothenic acid	320 mg/lb
Zinc	0.350%	Riboflavin	112 mg/lb
Copper	0.022%	Vitamin B_{12}	560 mcg/lb
Manganese	0.011%	Optional:	
Iodine	0.0005%	Biotin	0.10 mg/lb
Selenium	0.0006%	Folic acid	0.46 mg/lb
		Choline	1416 mg/lb

[a] Due to the instability of vitamins in the presence of trace minerals, this premix should be used within 30 days of preparation. Complete premixes are effective over a limited range of diets. Diets for stages lower than 6 will have excess calcium and deficient available phosphorus. Stages greater than 12 will be deficient in calcium and excessive in available phosphorus.

[b] Example mixing directions:

Stage	Growing pig premix	Corn, lb	Soybean meal, dehulled
6	35	645	320
8	27	725	245
9	25	765	210
10	22	793	185
12	21	849	130

[c] Trace mineral and vitamin premixes are in Tables 9 and 10.

[d] Biotin, folic acid and choline additions are optional. If they are not added, replace the pounds of each with carrrier. See Table 6 for requirements.

[e] Feed additives may be added at various levels as approved by the Food and Drug Administration in Table 32.

(Corrected B12 to 375)

Table 26. Complete gestation mineral-vitamin premix for corn-soybean meal based diets. [a b]

Ingredient, lb	1	2
Limestone	200.00	0.00
Dicalcium phosphate	535.00	0.00
Deflourinated phospate	0.00	640.00
Salt [b]	100.00	100.00
Trace mineral premix	25.00	25.00
Fat soluble vitamin premix [c]	8.00	8.00
B-vitamin premix [c]	10.00	10.00
Folic acid premix [c]	6.00	6.00
Choline premix [c]	37.00	37.00
Carrier, wheat midds	79.00	174.00
Feed additive [d]		
Total, lb	1000.00	1000.00

Calculated analysis, minimum			
Calcium	19.01%	Vitamin A	40,000 IU/lb
Phosphorus, total	10.07%	Vitamin D_3	4,000 IU/lb
Phosphorus, available	10.04%	Vitamin E	456 IU/lb
Sodium (Na)	4.00%	Vitamin K	9.6 mg/lb
Chlorine (Cl)	6.00%	Niacin	200 mg/lb
Iron	0.250%	Pantothenic acid	250 mg/lb
Zinc	0.2125%	Riboflavin	75 mg/lb
Copper	0.015%	Vitamin B_{12}	375 mcg/lb
Manganese	0.030%	Biotin	4.0 mg/lb
Iodine	0.00043%	Folic acid	9.0 mg/lb
Selenium	0.00045%	Choline	8732 mg/lb

[a] Due to the instability of vitamins in the presence of trace minerals, this premix should be used within 30 days of preparation.

[b] Example mixing directions:

Stage	Gestation Premix	Corn, lb	Soybean meal, dehulled
Gestation, G1	39	886	75
Gestation, G2	42	858	100
Gestation, G3	45	840	115

[c] Trace mineral and vitamin premixes for the breeding herd are in Tables 16 and 17.

[d] Feed additives may be added at various levels as approved by the Food and Drug Administration in Table 32.

Table 27. Complete lactation mineral-vitamin premix for corn-soybean meal based diets. [a b]

Ingredient, lb	1	2
Limestone	232.00	0.00
Dicalcium phosphate	544.50	0.00
Deflourinated phospate	0.00	650.00
Salt [b]	125.00	125.00
Trace mineral premix	31.00	31.00
Fat soluble vitamin premix [c]	10.00	10.00
B-vitamin premix [c]	12.50	12.50
Choline premix [c]	45.00	45.00
Carrier, wheat midds	0.00	126.50
Feed additive [d]		
Total, lb	1000.00	1000.00

Calculated analysis, minimum			
Calcium	20.41%	Vitamin A	50,000 IU/lb
Phosphorus, total	10.48%	Vitamin D_3	5,000 IU/lb
Phosphorus, available	10.18%	Vitamin E	570 IU/lb
Sodium (Na)	5.00%	Vitamin K	12.0 mg/lb
Chlorine (Cl)	7.50%	Niacin	250 mg/lb
Iron	0.310%	Pantothenic acid	312.5 mg/lb
Zinc	0.2643%	Riboflavin	93.75 mg/lb
Copper	0.0186%	Vitamin B_{12}	375 mcg/lb
Manganese	0.0372%	Biotin	5.0 mg/lb
Iodine	0.00053%	Folic acid	3.75 mg/lb
Selenium	0.00056%	Choline	10,620 mg/lb

[a] Due to the instability of vitamins in the presence of trace minerals, this premix should be used within 30 days of preparation.

[b] Example mixing directions:

Stage	Lactation premix	Corn, lb	Soybean meal, dehulled
Lactation, L1	29	801	170
Lactation, L3	30	765	205
Lactation, L5	33	737	230
Lactation, L7	38	687	275
Lactation, L9	44	641	315

[c] Trace mineral and vitamin premixes for the breeding herd are in Tables 16 and 17.

[d] Feed additives may be added at various levels as approved by the Food and Drug Administration in Table 32.

Table 28. Diets using alternative feedstuffs for growing pigs.

Lean growth capacity	Pig weights at which diets should be fed, lb													
High	6 - - 12	12 - - - - - - 18		18 - - - - - - 40		40 - - - - - - - - - - - 100			100 - - - - - - - - - - 210			210 - - - - - - - - - - 310		
Moderate	6 - - - 8	8 - - - - - - - -13		13 - - - - - - -25		25 - - - - - - - - - - - -70			70 - - - - - - - - - - - 150			150 - - - - - - - - - - 280		
Low		6 - - - - - - - 9		9 - - - - - - 20		20 - - - - - - - - - - - - 50			50 - - - - - - - - - - - 110			110 - - - - - - - - - - 210		
Stage of development	1	2 [a]	2	3 [a]	3	6	6	6	9	9	9	12	12	12
	Antigen status													
Ingredient, lb	Minimal	Minimal	Modest	Minimal	Modest									
Corn	241.35	226.50	381.00	433.00	497.00	712.05	532.55	647.10	809.40	739.00	761.65	913.90	865.60	863.15
Soybean meal, dehulled	165.00	392.50	300.00	430.00	460.00	217.50		270.00	127.50		162.50	40.00		65.00
Soybeans, full-fat, cooked [b]							435.00			235.00			112.50	
Meat and bone meal						55.00			56.00			35.00		
Wheat middlings								50.00			50.00			50.00
Dried whey	300.00	250.00	150.00	100.00										
Skim milk, dried	125.00	75.00	50.00											
Plasma protein, spray dried	75.00		60.00											
Fish meal, menhaden	50.00													
L-lysine HCl		0.50	0.50	0.50	0.50	1.75	1.50	1.50	1.00	1.75	1.50	2.00	2.00	2.00
D,L-methionine	0.75	1.00	0.50	0.50	0.50									
Soybean oil	25.00	25.00	25.00											
Limestone	7.00	6.50	10.25	7.50	8.25		9.00	9.20		9.15	9.25	4.00	9.20	9.50
Dicalcium phosphate	5.00	17.50	17.25	21.50	24.00	6.00	14.25	14.50		9.00	9.00		5.60	5.25
Salt [c]				2.00	4.75	4.00	4.00	4.00	3.75	3.75	3.75	3.30	3.30	3.30
Trace mineral premix [c]	2.50	2.30	2.30	2.10	2.10	1.65	1.65	1.65	1.30	1.30	1.30	1.00	1.00	1.00
Fat soluble vitamin premix [c]	1.00	1.00	1.00	0.95	0.95	0.75	0.75	0.75	0.65	0.65	0.65	0.55	0.55	0.55
B-vitamin premix [d]	1.00	0.90	0.90	0.80	0.80	0.60	0.60	0.60	0.40	0.40	0.40	0.25	0.25	0.25
Biotin & folic acid premix [de]	1.00	0.95	0.95	0.85	0.85	0.50	0.50	0.50						
Choline premix [de]	0.40	0.35	0.35	0.30	0.30	0.20	0.20	0.20						
Feed additives [f]	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total, lb	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00

[a] Piglets nursing the sow can be creep-fed these diets.
[b] Nutrient levels increased in relation to the added energy from full-fat soybeans.
[c] Added salt (source of sodium and chlorine) is not required in the diets containing dried whey or spray dried plasma protein.
[d] Example trace mineral, vitamin and choline premixes for growing pigs can be found in Tables 9 and 10.
[d] Biotin, folic acid and choline additions are not required for moderate or low genetic gain capacity and moderate or maximal antigen exposure.
[f] Feed additives may be added at various levels as approved by the Food and Drug Administration in Table 32.

Table 29. Example protein supplements for growing pigs. [a b]

Ingredient	Protein supplement, 2.25% lysine				Protein supplement, 2.55% lysine			
	1	2	3	4	5	6	7	8
Soybean meal, solvent	737.40	578.40	457.90	582.90				
Soybean meal, dehulled					824.40	638.15	504.90	633.40
Corn distillers dried gr., solubles			175.00				100.00	
Meat and bone meal		150.00	145.00	157.50		182.50	197.50	200.00
Wheat middlings	166.00	225.00	170.00	165.00	62.50	127.50	147.50	70.00
Fish meal, menhaden				50.00				50.00
L-lysine HCl			3.50				3.50	
Limestone	44.00	21.50	23.50	19.50	46.50	19.00	18.00	16.00
Dicalcium phosphate	27.50				38.00	4.25		2.00
Salt	15.00	15.00	15.00	15.00	17.50	17.50	17.50	17.50
Trace mineral premix [c]	4.50	4.50	4.50	4.50	5.00	5.00	5.00	5.00
Fat soluble vitamin premix [c]	2.00	2.00	2.00	2.00	2.25	2.25	2.25	2.25
B-vitamin premix [c]	1.50	1.50	1.50	1.50	1.75	1.75	1.75	1.75
Biotin & folic acid premix [c]	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
Choline premix [c]	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
Feed additives [d]	-	-	-	-	-	-	-	-
Total, lb	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00
Calculated analysis:								
Lysine, %	2.25	2.26	2.26	2.26	2.55	2.55	2.55	2.55
Threonine, %	1.35	1.35	1.27	1.34	1.60	1.58	1.45	1.56
Tryptophan, %	0.50	0.45	0.40	0.45	0.58	0.52	0.45	0.51
Methionine + cystine, %	0.94	0.95	0.91	0.94	1.19	1.16	1.08	1.15
Crude protein, %	35.18	36.80	35.41	36.39	40.19	41.71	39.52	41.42
Metabolizable energy, kcal/lb	1309	1310	1304	1242	1356	1345	1326	1277
Calcium, %	2.50	2.50	2.51	2.50	2.80	2.80	2.80	2.80
Phosphorus, total, %	1.14	1.26	1.23	1.25	1.29	1.44	1.42	1.42
Phosphorus, available, %	0.75	0.75	0.75	0.75	0.87	0.87	0.87	0.87

[a] Supplements 1 to 4 have added: Iron, 0.0315%; Zinc, 0.0315%; Copper, 0.00203%; Manganese, 0.00099%; Iodine, 0.00005%; Selenium, 0.000054%; Vit. A, 4600 IU/lb; Vit. E, 460 IU/lb; Vit. E, 32 IU/lb; Vit. K (menadione) 1.4 mg/lb; Niacin 47 mg/lb; Pantothenic acid, 30 mg/lb; Riboflavin, 10.5 mg/lb; Vit. B_{12}, 52.5 mcg/lb. Optional: Biotin, .02 mg/lb; Folic acid, 0.11 mg/lb; Choline, 142 mg/lb.

[b] Supplements 5 to 8 have added: Iron, 0.0350%; Zinc, 0.0350%; Copper, 0.00225%; Manganese, 0.0011%; Iodine, 0.000055%; Selenium, 0.00006%; Vit. A, 5175 IU/lb; Vit. E, 518 IU/lb; Vit. E, 36 IU/lb; Vit. K (menadione) 1.58 mg/lb; Niacin 54 mg/lb; Pantothenic acid, 35 mg/lb; Riboflavin, 12.3 mg/lb; Vit. B_{12}, 61.3 mcg/lb. Optional: Biotin, .02 mg/lb; Folic acid, 0.11 mg/lb; Choline, 142 mg/lb.

[c] Example trace mineral, vitamin and choline premixes can be found in Tables 9 and 10.

[d] Feed additives may be added at various levels as approved by the Food and Drug Administration in Table 32.

Table 30. Example diets using supplements in Table 29. [a]

Stage of development [b]	6		8		10		12		14	
Corn	550.0	616.5	665.0	710.0	750.0	780.0	818.5	845.0	873.0	740.5
Protein supplement, 2.25% lysine	450.0		335.0		250.0		180.0		122.5	
Protein supplement, 2.55% lysine		383.5		290.0		220.0		153.0		105.0
Limestone							1.5	2.0	4.5	4.5
Total, lb	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0
Calculated analysis:										
Lysine, %	1.15	1.13	0.92	0.92	0.75	0.76	0.61	0.60	0.49	0.49
Threonine, %	0.77	0.78	0.66	0.68	0.59	0.60	0.52	0.53	0.47	0.47
Tryptophan, %	0.23	0.23	0.19	0.19	0.17	0.17	0.14	0.14	0.13	0.13
Methionine + cystine, %	0.63	0.66	0.57	0.60	0.53	0.55	0.49	0.50	0.46	0.47
Crude protein, %	20.24	20.09	17.11	17.14	14.80	14.94	12.88	12.79	11.29	11.27
Metabolizable energy, kcal/lb	1403	1436	1437	1460	1462	1478	1480	1493	1492	1501
Calcium, %	1.14	1.09	0.86	0.83	0.65	0.64	0.53	0.53	0.50	0.49
Phosphorus, total, %	0.67	0.67	0.57	0.57	0.50	0.50	0.43	0.43	0.38	0.39
Phosphorus, available, %	0.36	0.36	0.28	0.28	0.22	0.22	0.17	0.17	0.13	0.13

[a] These supplements cannot be used for stages 1 to 5 as levels of calcium become excessive and other nutrients become imbalanced.
[b] See Table 6 to determine stage of development.

Table 31. Feeding value of full-fat soybeans for swine at various prices of corn and soybean meal, dehulled [a]

SBM, dehulled	Corn, $ per bushel (88% dry matter)											
$ per ton	$1.50	$1.75	$2.00	$2.25	$2.50	$2.75	$3.00	$3.25	$3.50	$3.75	$4.00	$4.25
	Feeding value of heat-treated soybeans, $ per bushel:											
$140	3.82	3.97	4.11	4.26	4.41	4.55	4.70	4.84	4.99	5.14	5.28	5.43
$160	4.24	4.39	4.53	4.68	4.82	4.97	5.12	5.26	5.41	5.55	5.70	5.84
$180	4.66	4.80	4.95	5.09	5.24	5.39	5.53	5.68	5.82	5.97	6.12	6.26
$200	5.07	5.22	5.37	5.51	5.66	5.80	5.95	6.10	6.24	6.39	6.53	6.68
$220	5.49	5.64	5.78	5.93	6.08	6.22	6.37	6.51	6.66	6.80	6.95	7.10
$240	5.91	6.06	6.20	6.35	6.49	6.64	6.78	6.93	7.08	7.22	7.37	7.51
$260	6.33	6.47	6.62	6.76	6.91	7.06	7.20	7.35	7.49	7.64	7.78	7.93
$280	6.74	6.89	7.04	7.18	7.33	7.47	7.62	7.76	7.91	8.06	8.20	8.35
$300	7.16	7.31	7.45	7.60	7.74	7.89	8.04	8.18	8.33	8.47	8.62	8.76
$320	7.58	7.72	7.87	8.02	8.16	8.31	8.45	8.60	8.74	8.89	9.04	9.18
$340	8.00	8.14	8.29	8.43	8.58	8.72	8.87	9.02	9.16	9.31	9.45	9.60
$360	8.41	8.56	8.70	8.85	9.00	9.14	9.29	9.43	9.58	9.72	9.87	10.02
$380	8.83	8.98	9.12	9.27	9.41	9.56	9.70	9.85	10.00	10.14	10.29	10.43
$400	9.25	9.39	9.54	9.68	9.83	9.98	10.12	10.27	10.41	10.56	10.70	10.85
$420	9.66	9.81	9.96	10.10	10.25	10.39	10.54	10.68	10.83	10.98	11.12	11.27

[a] If corn is $2.50 per bushel and dehulled soybean meal is $200 per ton (2000 lb), the feeding value of a bushel of soybeans is $5.66. To compare this value with the market price of soybeans it is necessary to deduct a processing charge of $0.50 to $1.50 per bushel. If the resulting value, $5.16 to $4.66, is less than the market price of soybeans, it would be more profitable to the whole farm enterprise to sell the soybeans and purchase soybean meal. It may not be necessary to process whole soybeans for sows.

Feed Mixing Guidelines

The goal of feed mixing is to produce a homogeneous blend of all ingredients. This process is accomplished most efficiently by using proper mixing equipment and appropriate methods.

In addition to mixers, the following equipment is needed:
1) typically, a minimum of two scales are required, one to weigh ingredients added at less than 100 lb and sensitive to the nearest tenth of a pound and one to weigh ingredients added at greater than 100 lb and sensitive to the nearest pound;
2) sufficient containers for storage of ingredients;
3) equipment for grinding; and
4) a safe, clean area for keeping accurate mixing records.

Various types of mixers are available. Horizontal mixers have a horizontal, rotating shaft with attached paddles or ribbons that mix the contents. These mixers are usually stationary. They come in many sizes, have high power requirements and require 4 to 8 minutes for complete mixing. Vertical mixers or blenders mix with single or double, vertical rotating auger(s). These mixers come in many sizes, have low power requirements and require 10 to 20 minutes for complete mixing. Portable mixers powered by farm tractors are of this type.

The sequence of additions to a mixer is important. In general, about half of the grain portion of a mix should be followed by the minor ingredients and then the balance of the grain and protein sources.

Mixers, augers, elevator legs, etc., need to be designed to be easily cleaned of residual feed. Cleaning and proper sequencing of batches is particularly important if feeds contain feed additives. The diet mixed immediately after one that contains a feed additive requiring a withdrawal before slaughter should not be fed to pigs about to be marketed.

In general, if an ingredient makes up less than 0.5% of the diet, it should be premixed before being added to the final mixture that will be fed. The following steps should be followed when preparing a premix. The example is for a premix prepared for a 1000 lb batch of final feed:
1. Determine microingredients and amounts to be incorporated in a 1000 lb batch.
2. Calculate the quantity of carrier required to dilute the microingredient to at least 5 lb (0.5% of diet). Carrier should be at least 70% of the premix.
3. Divide the weight of the premix used per 1000 lb of complete feed into the capacity or size of premix batch. This results in a <u>factor</u>. This <u>factor</u> is then multiplied by each component of the premix to arrive at the total weight of the ingredients in the batch of premix.

Example:

A premix is needed that will provide 1 lb of a vitamin supplement and 0.75 lb of an antibiotic supplement per 1000 lb of complete feed. Ground corn will be used as the carrier to make a premix added at 10 lb per 1000 lb of complete feed.
a) Weight of microingredients: 1 + 0.75 = 1.75 lb
b) Weight of ground corn in 10 lb premix: 10 - 1.75 = 8.25 lb
c) Premix <u>factor</u> representing number of batches of complete feed that one batch (1000 lb) of premix will service.

1000 lb mixer capacity ÷ 10 lb premix/ton = 100 batches

d) Use <u>factor</u> to calculate premix formula:

1.00 lb vitamin	x 100 =	100 lb
0.75 lb antibiotic	x 100 =	75 lb
8.25 lb corn	x 100 =	825 lb
		1000 lb total

Mixing procedure: Add 200-250 lb of corn to vertical mixer, followed by microingredients and remaining corn. Premixes should be mixed longer than complete diets, for example, 20-30 minutes in a vertical mixer or 5 to 10 minutes in a horizontal mixer. Recycle a portion of the mixture through the boot of the vertical mixer every 5 minutes.

Caution: If premixes are to be stored for more than one month, do not mix vitamins with trace minerals.

Sampling for Chemical Analysis

The goal is to obtain a sample that is representative of the mixture, load, or bin of feed or feedstuff. In general, a composite sample of bulk feeds may be prepared by combining 10 to 15 subsamples obtained using "grab" samples or by combining 4 to 5 subsamples using a grain probe. With bagged feed, take two grab samples from each of five to seven bags or one grain probe sample from each of 3 to 4 bags. If samples from bags are obtained at the time of mixing, do not sample the first and last bag from the batch. It is preferable to obtain the subsamples during delivery or removal from storage.

One to two pounds of the composite sample should be placed in an air-tight container and adequately identified before delivery to a laboratory for analysis. If samples contain significant concentrations of fat or moisture, they should be refrigerated.

Dietary Feeding Systems

The choice of the dietary feeding system and the choice of dietary ingredients and processing go hand in hand. A discussion of common feeding systems for pigs follows.

Simple Diet vs. Complex Diet

Modern diets for swine are usually of a simple format containing grain and soybean meal, fortified with vitamins and minerals. Piglets, pre-weaning or early-weaned, often benefit from complex diets with added dried milk products, spray-dried plasma protein, and other high quality protein sources. Because these sources are expensive, their use should be restricted to the young pig.

Swine diets may also be complex because of use of competitively priced sources of animal, poultry, dairy, marine, bakery and cereal byproduct feeds. This group includes products from meat, milk, or fish processing, distilling, brewing, and grain milling industries. In general, these byproducts may have higher concentrations of crude protein, fiber, minerals or vitamins than their parent products. When determining the economy of byproduct feeds, consideration should be given to the cost of the nutrients supplied; storage costs and losses; variation in nutrient content; palatability; possible presence of contaminants; effect upon the digestibility and utilization of the total diet; and labor costs in feeding. Reduced animal performance and less profit can result from improper feed substitution. Producers who grind and mix their own swine diets will usually prepare corn-soybean meal diets because of their availability, ease of preparation and cost of ingredients.

Complete Diet vs. Free-choice Diet

Complete diets are those in which all feedstuffs are combined into one feed mixture. They may be prepared by mixing a balanced supplement with grain; soybean meal and a commercial vitamin-mineral premix with grain; or by preparing a premix on the farm with vitamins and minerals to be mixed with soybean meal and grain. Complete self-fed diets for growing-finishing swine are recommended, because, in comparison with free-choice feeding, they (1) lend themselves to automation, (2) provide control of nutrient intake, and (3) result in faster gains.

A free-choice feeding program is one in which the pig is free to eat two or more feeds at will. Grain and protein supplement may be fed separately from different feeders or compartments within a feeder. Free-choice feeding may be the best feeding system for the small producer who does not have mixing equipment. The free-choice system requires more supervision, as the palatability of the grain or the protein supplement may vary and the pigs will then overeat or undereat the supplement or grain. If poorly supervised, poor feed efficiency and more expensive weight gains can occur.

Full-fed Diet vs. Limit-fed Diet

1. Growing-finishing Pigs

A full-fed diet is one that the pig to eats *ad libitum* (self-fed). This system results in the pig expressing its potential for weight gain when consuming unrestricted quantities of daily feed.

Limit feeding implies feeding animals less than they would voluntarily consume. The primary purpose is to restrict energy intake sufficiently to maintain lean tissue growth but not to allow excess body fat deposition. Usually, feed restriction is initiated when pigs weigh about 130 lb and feed is limited to about 85 to 95% of what pigs of comparable age consume when self-fed. This system exhibits greater benefits in pigs of low lean growth capacity than in pigs with genetic capacity for high lean growth. The slower growth rates, increased labor or mechanization required and increased supervision needed probably more than offset the small beneficial effect produced on carcass fat-to-lean ratio. Thus, unless sufficient premium is paid for the modestly leaner carcasses, limit-feeding may not be justified.

2. Gilts and Sows

Replacement gilts should be on full feed until they reach the heaviest stage of development for their lean growth capacity in Table 9. For example, gilts of high lean growth capacity should be full-fed until approximately 257 to 313 lb body weight and then placed on a reduced feed intake until breeding. All gestating gilts and sows should be limit-fed to prevent obesity and improve reproductive efficiency. Sows should be placed on a limit-fed regimen immediately after weaning. Limit feeding the breeding herd may be accomplished by any one of the following methods:

Individual feeding provides a measured quantity of feed to each sow. This requires sows to be fed in individual pens, crates, or tie stalls, or by electronic feeders. This system offers the best control of intake.

Group feeding provides a measured quantity of feed to several sows. It is hoped that each sow will eat her proper amount of feed. However, this system often results in the aggressive sows over consuming and the timid sows receiving inadequate feed. Sows in groups may be fed fibrous feeds such as silage, haylage, hay, dehydrated alfalfa meal, etc., to lower the energy content of the

diet. Such feeds should constitute one-third or more of the diet. This system requires more supervision to assure that the level of fibrous feed is sufficient to restrict energy intake and that feed costs are not excessive.

Interval feeding is another method of limit feeding gestating gilts and sows. For example, gilts or sows are allowed to eat every third day at a self-feeder for 2 to 6 hours or by providing the group a prescribed quantity of feed. This system reduces the labor requirement compared with daily hand feeding. The average daily intake can be regulated by limiting the time allowed at the self-feeder every third day or by the number of times they are hand-fed per week. Reproductive performance with interval feeding is essentially the same as with a daily limit-feeding method.

Dry vs. Liquid Feeding

Liquid feeding is accomplished by blending water with a dry meal feed (2 to 3 parts of water to 1 part dry feed). Various commercial feeding systems are available to provide liquid-feed mixtures for all phases of swine production.

Rate of gain is essentially the same between liquid full-fed pigs and dry full-fed pigs. Liquid feeding has some benefits for young weanling pig as they tend to eat wet feed more readily. Maintaining feed freshness is a problem. Starter diets high in milk products tend to develop off-flavors very quickly. However, if the feed delivery system is managed properly and if suitable antioxidants are included in the diet, these concerns can be largely overcome.

Feed Processing

Most swine feeds are processed before distribution and consumption. Methods used in preparation of swine diets include grinding or rolling, pelleting, and heat treating. The selection of one or more processes will depend on the ingredients employed, the age of the pig being fed and the cost/benefit relationship. Poorly processed feeds result in particle size variation, inadequate ingredient blending, particle sorting by the pig, impaired feed utilization, poor performance, and in some instances, serious health problems.

Grinding or Rolling

Grinding grain is the most common process used. It is simple, relatively inexpensive and has a definite cost/benefit relationship. Grinding reduces particle size and thereby exposes a larger area to the digestive enzymes in the alimentary tract. Both hammer mills and roller mills are used to grind grain.

Traditionally, the grinding of feedstuffs produces particle sizes described as fine, medium, or coarse. This terminology leaves much to be desired for definitive particle size measurement, because the terms mean different things to different people. Often particle size is expressed by stating the size opening in the hammer mill screen, such as "through a 3/16 inch opening". This method is one step better; however, many factors such as peripheral speed, hammer-screen clearance and moisture content of the grain affect the particle size.

The preferred method of describing particle size is by sieve screen analysis. This procedure uses a set of preselected screens with specific-sized openings. The ground sample is sieved through these screens and an average particle size is calculated and expressed in units of microns (one millionth of a meter).

Generally, when feedstuff particles pass through a 1/8 to 3/16-inch hammer mill screen, the feed is classified as finely ground and measures less than 700 microns (0.0276 in). Feed that passes through a 1/4 to 3/8-inch hammer mill screen is classified as medium ground and measures 800 to 1000 microns (0.0315 to 0.0394 in) and coarsely ground feed is that which passes through a 1/2-inch or larger hammer mill screen and measures over 1300 microns (0.0512 in).

Grinding ingredients to a uniform particle size prevents sorting by the pig and allows more uniform mixing. Feed efficiency is generally improved as feeds are ground more finely. Benefits are greatest in high fiber diets. However, grinding grain too fine can reduce palatability, cause bridging in self-feeders, increase dusty

conditions in confinement facilities and increase the incidence of gastric ulcers. The recommended particle size for growing pigs is 650 to 750 microns. If gastric ulcers are a problem, the breeding herd should be fed diets ground to 750 to 900 microns.

Pelleting

Pelleting is accomplished by agglomerating ground feed by compacting and forcing it through die openings with a combination of heat, moisture and pressure. Pellets can be made in varying lengths, diameters, and degrees of hardness.

Pelleting of swine diets improves growth rate and feed efficiency along with a reduction in feed consumption. Advantages also include reduced dustiness, reduced storage space, less feed wastage and reduced sorting of the diet by the pig. Pelleting temperatures in excess of 180 to 190°F destroy some feed-borne pathogens, e.g., salmonella.

The improved feed efficiency (5 to 7% results from improved nutrient digestibility, owing to partial gelatinization of starch (rupture of starch molecule) and reduced feed wastage. Improvements in performance are greater with fibrous feeds. Therefore, greater benefits from pelleting would be expected from barley-based than from corn-based diets.

Pigs prefer a pelleted diet over a meal diet, and nursing and newly weaned pigs prefer a small size pellet.

Disadvantages of pelleting swine diets include increased cost, increased incidence of gastric ulcers, partial vitamin destruction (Table 22), and difficulty in producing quality pellets in diets containing over 6% fat.

Heat Processing

Heat processing certain feedstuffs improves pig performance by increasing the bioavailability of nutrients, destroying enzyme inhibitors or eliminating toxins. Processing methods include heat; heat and moisture; or heat, moisture and pressure. Excessive heat, however, causes carbohydrates such as glucose to react with free amino groups to form a bond (Maillard or “browning” reaction) that is not hydrolyzed by digestive enzymes. Because digestive enzymes cannot release these bonded amino acids, such as lysine, they become unavailable to the pig. Consequently, the time and temperature of the heating process can increase or decrease the digestibility and availability of nutrients.

Some plant protein sources must be heat-treated to be effectively used by swine. Soybeans are an excellent example. The major objectives in the processing of soybeans for use by swine are to destroy the growth (trypsin) inhibitors and to inactivate the toxic hemagglutinin. Most soybeans are processed with a solvent to remove the oil and the resulting soybean meal is heated to improve its quality for livestock feed. Heating time, temperature and moisture level must be regulated closely to attain maximum product quality. If the soybean meal is undercooked, the antigrowth factors may not be destroyed or deactivated. Likewise, if soybean meal has been overcooked, the antigrowth factors are destroyed, but the availability of essential amino acids, particularly lysine, is reduced substantially. A urease test is used to determine proper heat treatment of soybeans.

Considering the cost of heat-treating corn and other grains and its small effect on pig performance, there has been little interest in this processing method.

Feed Ingredients for Swine Diets

Grains and Byproducts

A complete list of potential feedstuffs for swine is beyond the scope of this discussion. Grains and their byproducts are the major sources of carbohydrates (energy) for swine. Corn is the basis for most swine diets throughout the Americas. Other grains used as energy sources for swine include sorghum grain (milo), oats, barley, wheat and rye.

Animal and Plant Protein Sources

Next to energy, protein (amino acids) is the class of nutrients needed by swine in the largest amount. Protein supplements of animal origin and soybean meal generally supply proteins of high quality, whereas proteins of plant origin, other than soybean meal, generally supply proteins of lower quality. High quality proteins consist of highly digestible amino acids present in ratios that meet the animals' requirements for protein synthesis.

Whole Soybeans

Unprocessed whole soybeans have been successfully used as the protein supplement in both gestation and lactation diets without affecting dam and litter performance. However, growth retardation and reduced feed efficiency occur when raw soybeans replace soybean meal as a protein supplement in nursery or growing-finishing pig diets.

Proper heat application inactivates the antigrowth factors in raw soybeans, allowing them to serve as a protein source for growing-finishing swine. Heating also improves the palatability of soybeans for pigs. Heat treatment is accomplished in roasters or extruders.

Heat-treated soybeans are lower in protein and higher in fat and energy than solvent-extracted soybean meal. Because of this lower protein concentration, additional quantities of heat-treated soybeans must be added to swine diets to provide equivalent amounts of amino acids to those provided by soybean meal. Heat-treated soybeans contain over 18% fat compared with 1% fat in solvent-extracted soybean meal. Fat has 2.25 times the energy content of carbohydrate or protein. Because fat is used as a source of energy by pigs, the energy level of diets using heat-treated soybeans is higher than diets using commercial soybean meal. Because of this greater energy concentration, there is a 5% to 8% improvement in feed conversion when feeding heat-treated soybeans compared with soybean meal. An approximation of the feeding value of whole soybeans is in Table 31.

Pigs fed high energy diets will not consume as much daily feed. Hence, with higher levels of dietary energy provided from the heat-treated soybeans, additional protein must be supplied to keep the protein:calorie ratio at an optimal level. Therefore, diets containing heat-treated soybeans must contain one to two percentage points more protein than comparable diets using soybean meal.

Spray Dried Plasma Protein

Spray dried plasma protein is produced from the blood of swine and cattle. An anticoagulant is added to the blood and the cell fraction is removed by centrifugation. The resulting plasma is then spray dried. The dried product contains about 78% crude protein. If properly processed the proteins include immunoglobulins that retain functional activity as antibodies. When included at 4 to 7% of the pig diet for 7 to 10 days after weaning, spray dried plasma protein stimulates feed intake. Therefore, when included at more than 5% of the diet, salt additions are not required.

Dried Skim Milk and Dried Whey

Dried skim milk is the residue obtained by spray or roller drying low fat milk. It contains 8% maximum moisture and averages 32 to 35% crude protein. Dried whey is produced by spray or roller drying liquid whey, a byproduct of cheese manufacturing. It contains not less than 11% crude protein and not less than 61% lactose. Milk protein is a valuable component of milk replacers for pigs as well as an ingredient in the dry starter feeds. Young pigs readily digest milk protein and lactose in milk products. Dried skimmed milk or dried whey are typically included at 10 to 30% of pig diets the first 10 to 30 days post-weaning.

Fats or Oils

Common sources of feed grade fats and oils include animal (grease, tallow), vegetable (corn oil and soy oil) and restaurant and processing byproducts (blends of fats and oils). There is little difference in pig performance resulting from the type of fat used. Diet flowability problems preclude the use of over 7% added fat. Adding 0.5 to 1.0% fat reduces feed dust but has little effect on performance.

Growing pigs. Usually daily feed intake decreases, daily gain increases slightly and feed efficiency improves when fat is added to the diet. Each 1% added fat produces approximately a 2% improvement in feed efficiency. Adding fat at low levels (less than 2%) has little effect on backfat thickness. Higher levels (more than 3%) will slightly increase backfat thickness and reduce overall

carcass lean. The addition of unsaturated fats (oils) will increase the incidence of soft pork.

When fat is added, the caloric density of the diet increases. Therefore, dietary nutrient density should increase in proportion to the increase in caloric density to maximize pig performance. The growth response to fat is greater in warm than in cool temperatures.

Gestation and lactation. Benefits of adding fat to the sow diet before farrowing include increased fat content of colostrum and milk and improved baby pig survival (2 to 3%) in herds where survival rates are less than 80%. Added fat has little effect on litter size, birth weight or weaning weight. A minimum of 7.5% fat added to diets fed 10 to 14 days before farrowing is needed to obtain a response. Fat in the lactation diet in warm environments will help maintain caloric intake.

Vitamins and Minerals

Most energy and protein sources provide some minerals and vitamins, but often it is necessary to add specific mineral and vitamin sources to balance the diet. Calcium and phosphorus levels of feed ingredients can be found Table 20. Common vitamin and trace mineral sources are shown in Tables 21 and 22.

Feed Additives

Feed additives are nonnutritive substances added to swine feeds to improve the efficiency of feed utilization and feed acceptance, or to be beneficial to the health or metabolism of the animal in some way. The major ones used in swine diets are antimicrobial drugs, anthelmintics, probiotics, organic acids and copper sulfate. Antimicrobial drugs and anthelmintics have been extensively used in the United States since the 1950's. Used properly, these drugs increase U. S. meat production approximately 15% each year and enable swine producers to provide safe and wholesome pork to consumers at lower costs than would otherwise be possible.

Compounds with Food & Drug Administration approved claims

A. Antimicrobial drugs. Antibiotics and chemotherapeutics are medications added to swine feeds to improve health and performance. A list of compounds and use levels that can be used for specific purposes such as growth promotion, prevention of disease, and treatment of a specific disease is summarized in Table 32. A more detailed description of these drugs can be found by consulting the *Feed Additive Compendium* (The Miller Publishing Co., 12400 Whitewater Drive, Suite 160, Minnetonka, MN 55343, published annually).

Antibiotics are substances which are produced by living microorganisms (molds, bacteria, fungi, or green plants) that inhibit the growth of another microorganism. All antibiotics used commercially for swine growth promotion are produced by fermentation processes using fungi or bacteria. Chemotherapeutics are chemically synthesized compounds that inhibit the growth of certain microorganisms. They may be used alone or in conjunction with antibiotics. Evidence indicates that antibiotics and chemotherapeutics improve rate and efficiency of gain through one or more of the following actions:

1) Metabolic Effect. The metabolic effect implies that antibiotics directly influence the metabolic processes in the animal. This is not a reasonable explanation, however, for those antibiotics that are not absorbed from the intestinal tract.

2) Nutritional Effect. When antibiotics are fed, the populations of microorganisms in the animal's digestive tract change. This change may result in a greater availability of nutrients to the host animal, especially certain vitamins and amino acids. Antibiotics have been shown to reduce the thickness of the intestinal wall, resulting in a potential for greater absorption of nutrients. In addition, antibiotics reduce the total mass of the gut, so less nutrients are wasted on these rapidly metabolized body tissues.

3) Disease Control Effect. Antibiotics tend to suppress those microorganisms in the intestinal tract that might otherwise produce subclinical diseases in the animal. Although the effect of the microorganisms might be so mild that there would be no clinical symptoms of disease, it could still slow the animal's growth.

Subtherapeutic levels of antimicrobials in the feed increase an animal's ability to withstand stress and aid in control of postweaning diarrhea. The response to antimicrobial feeding is greatest in young, unthrifty, or stressed animals. The response is usually less when animals are housed in a new building; as microbial loads in the environment build up, the response to antimicrobials increases.

Although antimicrobials have been used as feed additives since the 1950's, their effectiveness has not diminished with time. The magnitude of the growth response is about the same now as when their use first began. This suggests that the development of microbial resistance to antibiotics, which is well documented, does not alter their growth-promoting activity.

Usage level of an antimicrobial or combination of antimicrobials must comply with FDA (Food and Drug Administration) approvals and the manufacturer's directions. The FDA classifies antimicrobials into those that have a high degree of human safety with no withdrawal time before slaughter and those with a higher potential risk for edible tissue residue. The latter have specific withdrawal times before slaughter (Table 32). Producers must responsibly use medications in their feeding program. They must know the approved use levels and withdrawal periods of the compounds they use. There is no extra-label usage (higher than approved FDA levels or unapproved combinations) with feed additives.

B. Anthelmintics. Anthelmintics are drugs used to control internal parasites (e.g., worms). Some anthelmintics are more effective than others for certain species of worms. Producers should become aware of the parasite spectrum and efficacy data of each anthelmintic. Anthelmintics may be added to swine feed for limited periods to kill (purge) worm accumulation including worm eggs in growing-finishing swine and the breeding herd. This type of deworming program usually removes the immediate worm burden but needs to be repeated (time period depends on specie of worm) for improved control. Continuous feeding of some anthelmintic products will block development of parasites during the specified feeding period. Swine anthelmintic agents and withdrawal periods are listed in Table 33.

Compounds pending Food & Drug Administration approved claims

Repartitioning agents. A new class of compounds that alter the lean:fat ratio in the carcass has recently surfaced in the swine industry. These compounds are called "repartitioning agents" in that they repartition or redirect nutrients toward muscle tissue accretion while reducing fat tissue deposition. More specifically, these compounds are ß-adrenergic agonists or ß-agonists. Ractopamine is an example of these compounds. Improvements in efficiency of feed utilization appear to accompany the improvements in carcass composition resulting from feeding these products. At this writing, no repartitioning agents have received FDA clearance for use in the United States.

Compounds without Food & Drug Administration approved claims

A. Generally Recognized As Safe (GRAS) status

1. Antioxidants have some value in reducing oxidation of dietary nutrients such as vitamin E and unsaturated fats. Synthetic antioxidants include ethoxyquin (Santoquin), butylated hydroxytoluene (BHT), and butylated hydroxyanisole (BHA). These synthetic antioxidants are very effective in preventing deterioration of stored feeds and are commonly used for this purpose. Besides protecting against peroxidation in feeds, synthetic antioxidants also prevent these reactions in animal tissues, thus having a sparing effect on vitamin E and selenium requirements.

2. Betaine and Carnitine are examples of feed additives currently under investigation. Betaine is a sugar-beet derivative shown under some circumstances to improve growth rate and carcass leanness. Carnitine has shown similar results but neither compound is FDA approved for use in swine diets. Research trials describing these products are few and the data is inconsistent.

3. Copper sulfate. Elemental copper is a required nutrient for normal pig growth and is routinely added to swine diets at the rate of 6 to 11 ppm to meet this requirement. At much higher levels (125 to 250 ppm), copper in the form of copper sulfate is a growth promoter for swine and has a similar mode of action as the antimicrobial agents. In young pigs, the combination of copper (1 to 2 pounds of copper sulfate per ton of complete feed) and antibiotics generally gives a greater growth response than the feeding of either alone.

Copper sulfate, when fed in excess of 250 to 500 ppm for an extended period of time, may be toxic. The severity of the toxicity is directly related to the level fed, and is increased if the diets are low in zinc and iron, and if the copper is fed for long periods of time. Therefore, producers should check with their feed manufacturer about the level of copper sulfate, iron, and zinc present in commercial feed before indiscriminately adding additional copper sulfate to feed. Drawbacks to

copper sulfate supplementation include increased corrosion of galvanized metal and decreased bacterial degradation of manure in lagoons.

4. Enzymes. Pigs produce adequate quantities of digestive enzymes for digestion of the proteins, carbohydrates, and lipids that they are capable of digesting. The main potential of enzyme addition to feed appears to be for digestion of substances that the pig is intrinsically incapable of digesting. Commercial sources of enzymes currently available as feed additives include ß-glucanase and phytase.

Barley (and to some extent oats) contains water-soluble carbohydrates, called ß-glucans, which are poorly digested and thus lower the digestible energy content. This is particularly true in poultry and to a lesser extent in swine. Enzyme preparations containing ß-glucanase and other complex-carbohydrate digesting enzymes may result in increased utilization of barley in swine and poultry feeding.

Phosphorus from plant feedstuffs (corn, soybean meal, etc.) is mainly present as phytate-phosphorus. Phosphorus in this form has a low availability for swine because they lack the digestive enzyme (phytase) required to cleave the phosphorus from the phytate molecule. The addition of a phytase enzyme to the swine diet increases the utilization of phytate-phosphorus. Increasing the availability of phytate-phosphorus enables a reduction in dietary total phosphorus contents without jeopardizing the animal's health or production performance. It also results in a lower phosphorus content in the swine manure, which is environmentally desireable.

5. Feed flavors are used to increase the acceptance of diets of low palatability, increase the intake of palatable diets, and increase the intake of diets during periods of stress such as weaning. A number of commercial feed flavors are available. Although published research data are not overly encouraging, they suggest that the effect is mainly on preference when a choice of rations is given rather than on total feed consumption. Thus the most probable useful role of feed flavors would be to stimulate adequate or normal intake of unpalatable but otherwise nutritious diets.

6. **Mold (fungi) inhibitors** are used to prevent mold growth in stored feed ingredients and mixed feeds. Molds reduce palatability and may produce mycotoxins. The toxin produced by *Aspergillus flavus* is known as aflatoxin. The primary condition conductive to the growth of *A. flavus*, and therefore, the production of aflatoxin, is moisture; hence, proper harvesting, drying, and storage will minimize mold growth and subsequent toxin production. Examples of effective antifungals include propionic acid (or its salts sodium or calcium propionate), sodium diacetate, sorbic acid, and gentian violet. The toxicity of aflatoxin-contaminated feed can be reduced when irradiated by ultraviolet light or exposed to anhydrous ammonia under pressure.

7. Organic acids. Pigs weaned less than 3-4 weeks of age have a relatively immature digestive system and do not digest the carbohydrates and proteins in plant-based diets as efficiently as the carbohydrate and proteins in milk. This is partially due to insufficient amounts of digestive enzyme secretion and hydrochloric acid production in the stomach.

Organic acids, commonly referred to as acidifiers or acidifying agents, have shown favorable effects when used as additives in diets for post-weaned pigs. Citric and fumaric acids have been the primary acidifiers tested. The exact mode of action is not known, but has been rationalized from several positions:

a) Acidification of the post-weaning pig diet may decrease stomach pH and increase pepsin activity (required for protein digestion).

b) A reduced stomach pH may decrease the rate of stomach emptying, thus increasing protein digestion time in the stomach.

c) A reduction in stomach pH may reduce the proliferation of coliforms and other pathogens in the upper gastrointestinal tract.

d) Organic acids may enhance energy metabolism, since both citric and fumaric acids are intermediates in the tricarboxylic acid cycle of cellular energy metabolism.

Research data have shown the effects of organic acid additions to diets on performance to be quite variable. This variability may be attributed to: 1) age of pigs; 2) the amount of milk by-products in the diet; and, 3) the presence or absence of antibiotics.

8. Pellet binders are products that enhance the firmness of pellets and reduce the tendency of pellets to crumble and break apart. Sodium bentonite, a clay, is probably the most widely used binder. Although bentonite has no nutritive value, several reports indicate that at the level of common usage (2 to 2.5% of the ration) it may even improve the growth and/or feed utilization of animals.

9. Probiotics are substances that contain desirable gastrointestinal microbial cultures and/or ingredients that may enhance the growth of desirable gastrointestinal microbes. They establish a desirable balance of gastrointestinal organisms and/or the substances which contribute toward the balance. The most common microorganisms included in probiotic products are *Lactobacillus* species, *Bacillus subtilis* and *Streptococcus faecium* and yeast (*Saccharomyces cerevisiae*) or mixtures of these substances.

It has been suggested that the beneficial actions of probiotics include: 1) change the enteric flora and reduction of *E. coli*; 2) synthesis of lactate with subsequent reduction in intestinal pH; 3) adhesion to or colonization in the digestive tract; 4) production of antibiotic substances; 5) reduction of toxic amines and ammonia levels in the gastrointestinal tract and blood.

Although probiotics have been commercialized and used extensively for at least 30 years, the documented evidence of their therapeutic and nutritional value is still quite variable. Some of the possible reasons for the variability of results are: viability of microbial cultures related to storage or processing method; strain differences; dose level and frequency of feeding; drug interactions; and lack of systematic investigation by researchers.

10. Zinc oxide supplemented to diets of newly weaned pigs has shown to enhance growth and improve stool consistency. Supplemental zinc has been suggested as a way to help reduce *E. coli* scours in nursery pigs. This may, in part, explain improved growth rate. Current research suggests the oxide form of zinc be supplemented at the rate of 3000 ppm.

B. Without Generally Recognized As Safe (GRAS) status

Chromium (chromium picolinate) has shown under some circumstances to improve growth rate and carcass leanness. At this printing, chromium is not FDA approved for use in swine diets.

Table 32. Swine feed additives with Food & Drug Administration approved claims. [a]

Chemical name	Trade name	Additive use level	Withdraw before slaughter	FDA approved claim [b]											
				A	B	C	D	E	F	G	H	I	J	K	L
Apramycin	Apralan	150 g/ton	28 days		B										
Arsanilic acid or sodium arsanilate	Pro-Gen	45-90 g/ton	5 days	A					F		H				
Arsanilic acid & bacitracin MD		10-30 g/ton & 0.005-0.01%	5 days	A				E							
Arsanilic acid & bacitracin zinc		45-90 g/ton & 10-50 g/ton	5 days	A							H				
Arsanilic acid & chlortetracycline		45-90 g/ton & 10-50 g/ton	5 days	A							H				
Arsanilic acid & oxy- or chlortetracycline		45-90 & not less 100 g/ton	5 days	A				E			H				
Arsanilic acid & penicillin		45-90 g/ton & 100 g/ton	5 days	A				E			H				
Bacitracin MD	BMD, Fortracin	10-30 g/ton	none	A											
Bacitracin MD	BMD, Fortracin	250 g/ton (sole ration)	none								H				
Bacitracin MD & chlortetracycline		10-30 g/ton& 400g/t (max 14 d	none	A				E					J		
Bacitracin zinc	Baciferm, Albac	10-50 g/ton	none	A											
Bacitracin zinc	Baciferm, Albac	250 g/ton	none								H				
Bambermycin	Flavomycin	2-4 g/ton	none	A											
Carbadox	Mecadox	10-25 g/ton	10 wk [d]	A											
Carbadox	Mecadox	50 g/ton	10 wk [d]	A					F		H				
Chlortetracycline	Aureomycin, Aureomix,	10-50 g/ton	none	A											
Chlortetracycline	Aureozol, PfiChlor, CLTC	50-100 g/ton	none				D							K	N
Chlortetracycline	CTC	400 g/ton for 14 days	none												M
Chlortetracycline	CTC	10 mg/lb bodyweight for 14 d	varies					E					J		
Chlortetracycline & Hygromycin B [c]		400 g/ton & 12 g/ton	15 days					E					J		
Chlortetracycline & sulfamethazine & penicillin	Aureo SP 250, PfiChlor 250	100 & 100 & 50 g/ton	15 days	A			D	E						K	N
Chlortetracycline & sulfathiazole & penicillin	CSP 250	100 & 100 & 50 g/ton	7 days	A			D	E						K	N
Colimix	Colimix	240 ml/ton	21 days		B										
Lincomycin	Lincomix	20 g/ton	6 days	A											
Lincomycin	Lincomix	40 g/ton	6 days								H				
Lincomycin	Lincomix	100 g/ton	6 days									I			
Lincomycin	Lincomix	200 g/ton	6 days										J		
Oxytetracycline	Terramycin, OXTC, OTC	7.5-10 g/ton or 25-50 g/ton	none	A											
Oxytetracycline	Terramycin, OXTC, OTC	50 g/ton	none				D								
Oxytetracycline	Terramycin, OXTC, OTC	100 g/ton	none					E							
Oxytetracycline	Terramycin, OXTC, OTC	50-150 g/ton	none												L
Oxytetracycline	Terramycin, OXTC, OTC	500 g/ton	5 days												M
Oxytetracycline & neomycin base [e]	Neo-terramycin, NEO/OXTC or/OXY	50-150 g/ton & 70-140 g/ton	7 days				D	E		G		I		K	
Penicillin	Penicillin P-100, Procaine Penicillin	10-50 g/ton	none	A											
Rabon	Rabon	0.05 g/100 lb body weight/d	none			C									
Roxarsone	Roxarsone, 3-Nitro	22.7-34 g/ton	5 days	A											
Roxarsone	Roxarsone, 3-Nitro	0.02% (feed for 5-6 days)	5 days									I			
Roxarsone & bacitracin MD		22.7-34.1 g/ton & 10-30 g/ton	5 days	A											
Roxarsone & bacitracin MD		22.7-34.1 g/ton & 250 g/ton	5 days	A							H				
Roxarsone & bacitracin MD		181.5 g/ton & 10-30 g/t (6 d)	5 days	A								I			
Roxarsone & bacitracin zinc		22.7-34 g/ton & 10-50 g/ton	5 days	A				E							
Roxarsone & chlortetracycline		0.02% & 10-50 g/ton	5 days	A								I			
Roxarsone & chlortetracycline		22.7-34.1 g/t & 400 g/t(14 d)	5 days	A				E					J		
Roxarsone & chlortetracycline		181.5 g/ton & 400 g/t (6 days)	5 days	A				E					J		
Roxarsone & penicillin		0.0025-0.0075% & 100 g/ton	5 days	A				E							

Chemical name	Trade name	Additive use level	Withdraw before slaughter	FDA approved claim [b]					
				A B C	D E F	G H I	J K L		
Tiamulin	DENAGARD	10 g/ton	none	A					
Tiamulin	DENAGARD	35 g/ton (sole ration)	2 days			H			
Tiamulin	DENAGARD	200 g/ton (2 wks, then 35 g/t)	7 days			I			
Tiamulin & chlortetracycline		35 g/ton & 400 g/ton (14 days)	2 days		E	H	J		
Tilmicosin	Pulmotil	181-363 g/ton	7 days					O	
Tylosin	TYLAN	10-20 or 20-40 or 20-100 g/t	none	A					
Tylosin	TYLAN	100g/ton for 3 wk, then 40 g/t	none			G			
Tylosin	TYLAN	100 g/ton	none				K		
Tylosin & Hygromycin B [c]		10-100 g/ton & 12 g/ton	15 days	A					
Tylosin & pyrantel tartrate [c]		100 g/ton for 3 wks & 96 g/ton				G			
Tylosin/sulfamethazine	TYLAN/Sulfa	100 g/ton	15 days			G	J K L		
Virginiamycin	Stafac	5-10 g/ton	none	A					
Virginiamycin	Stafac	25 g/ton	none			H			
Virginiamycin	Stafac	100 g/ton for 2 wk, then 50 g/t	none			H I			

[a] This is a partial list of feed additives and combinations approved by the FDA. This list does not contain the complete use levels approved for each additive. Users are advised to read the product label and adhere to use recommendations of the additive manufacturer. The regulations governing the use of these additives are subject to change and may do so during the life of this publication. Information in this table is from the May, 1997 Feed Additive Compendium published by The Miller Publishing Co., 12400 Whitewater Drive, Suite 160, Minnetonka, MN 55343.

[b] The claims, use levels and limitations are those for which FDA clearance was obtained. Iowa State University disclaims all responsibility for any results that may occur from use of this table. It is essential that the rules and regulations governing the use of feed additives be followed. The following claims are indicated for the appropriate additive:

A. Increase rate of gain and improve feed efficiency.
B. Prevention of post weaning colibacillosis.
C. Control of fecal flies in manure of treated swine.
D. Prevention of bacterial enteritis (scours).
E. Treatment of bacterial enteritis (scours).
F. Control of bacterial enteritis (scours).
G. Prevention of swine dysentery (bloody scours).
H. Control of swine dysentery (bloody scours).
I. Treatment of swine dysentery (bloody scours).
J. Control of swine pneumonias caused by bacterial pathogens (P. multocida and/or C. pyogenes).
K. Maintenance of weight gain in presence of atrophic rhinitis.
L. Lower incidence and severity of Bordetella bronchiseptica rhinitis.
M. Aid in treatment and reducing spreading of leptospirosis.
N. Reduce cervical abscesses.
O. Control of swine respiratory disease (Actinobacillus pleuropneumomiae and P. multocida.)

[c] See Table 33 for Hygromycin B and pyrantel tartrate claims.

[d] Do not feed Carbadox to swine weighing more than 75 lb body weight. Do not use in complete feeds containing less than 15% crude protein.

[e] Neomycin use levels are expressed as neomycin base, which is equivalent to 70% of the neomycin sulfate level (i.e. 140 g neomycin base is equal to 200 g of neomycin sulfate). When fed at the level of 1.4 g Neomycin base plus 2 g Oxytetracycline per head daily, requires withdrawal from feed 7 days before slaughter. No withdrawal is required at lower levels. All use levels in milk replacers require a 30-day withdrawal before slaughter.

Table 33. Swine anthelmintics (dewormers) with Food and Drug Administration approved claims. [a]

Chemical name	Trade name	Additive use level	Withdraw before slaughter	FDA approved claim [b]								
				A	B	C	D	E	F	G	H	I
Dichlorvos	Atgard C	348 g/ton; pigs <70 lb; fed consecutively 2 days	none			C		E		G	H	
Dichlorvos	Atgard C	348 g/ton; pigs 70 lb-mkt; sole ration fed continuously	none			C		E		G	H	
Dichlorvos	Atgard C	348 g/ton; boars, gilts, sows; 4.2 lb ration, fed cons. 2 days	none			C		E		G	H	
Dichlorvos	Atgard C	479 g/ton; boars, gilts, sows, 6.0 lb ration; 1 feeding	none			C		E		G	H	
Dichlorvos	Atgard C	334-500 g/ton; last 30d gestation; 1000 mg/head/day	none			C		E		G	H	I
Fenbendazole	Safe-Guard	9 mg/kg body wt. fed over a period of 3-12 days	none		B	C	D	E	F		H	
Hygromycin B	Hygromix-8	12 g/ton	15 days [c]			C		E			H	
Ivermectin [d]	Ivomec	1.8 g/ton (2 ppm); pigs <220 lb; fed 7 consecutive days	5 days [c]		B	C	D	E	F	G		
Ivermectin [d]	Ivomec	1.8-11.8 g/ton; adult swine; for 7 consecutive days	5 days [c]		B	C	D	E	F	G		
Levamisole hydrochloride	Tramisol	0.08% (0.36 g/lb)	72 hr [c]	A	B	C	D	E				
Pyrantel tartrate	Banminth	96 g/ton; sole ration fed continuously	24 hr [c]			C		E				
Pyrantel tartrate	Banminth	96 g/ton; fed 3d consecutively				C						
Pyrantel tartrate	Banminth	800 g/ton; fed as single treatment in complete feed at 2.5% of body wt. up to maximum of 5 lb/day	24 hr [c]			C		E				
Thiabendazole	TBZ	0.005-0.1% in complete feed	30 days [c]			C						

[a] Users are advised to read the product label and adhere to use recommendations of the additive manufacturer. The regulations governing use of these anthelmintics are subject to changes and may do so during the life of this publication. Information in this table was taken from the May, 1997 Feed Additive Compendium published by The Miller Publishing Co., 12400 Whitewater Drive, Suite 160, Minnetonka, MN 55343.

[b] The claims, use levels and limitations are those for which FDA clearance was obtained. Iowa State University disclaims all responsibility for any results that may occur from use of this table. It is essential that the rules and regulations governing the use of anthelmintics be followed. The following claims are indicated for the appropriate additive:

A. Treating swine infected with intestinal threadworms (Strongyloides...)
B. Removal or control of kidney worms (Stephanurus...)
C. Removal or control of large roundworms (Ascaris...)
D. Removal or control of lungworms (Metastrongylus...)
E. Removal or control of nodular worms (Oesophagostomum...)
F. Removal or control of small stomach worms (Hyostrongylus...)
G. Removal or control of thick stomach worms (Ascarops...)
H. Removal or control of whipworms (Tricharis...)
I. Improves litter production efficiency

[c] Warning or caution statement required on the feed label.

[d] Ivermectin also controls lice and mange mites.