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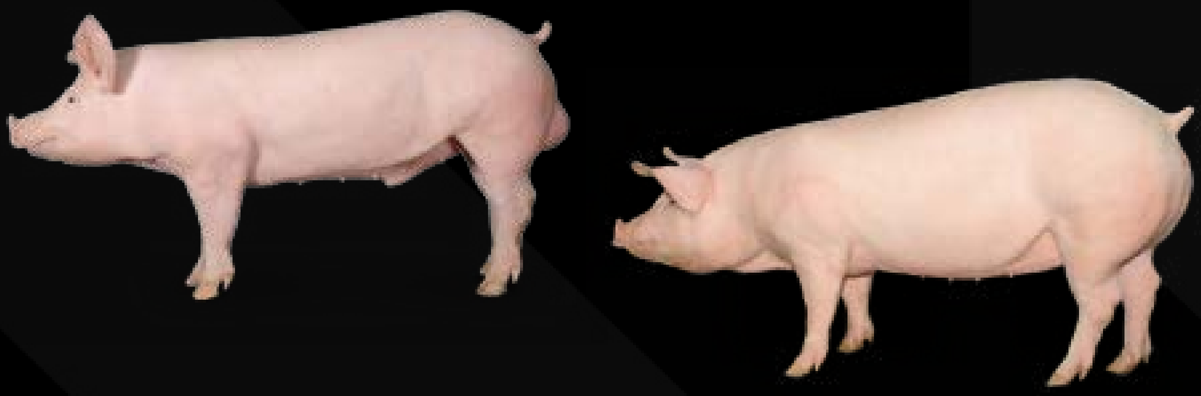
PIC® 2016

NUTRIENT SPECIFICATIONS MANUAL

WELCOME TO THE 2016 EDITION OF THE PIC NUTRIENT SPECIFICATIONS MANUAL



This manual is build up in three sections that lays out the fundamentals of our nutrition recommendation: first, it summarizes the principles of diet formulation; secondly, it lays out how different nutritional components can help fulfill those dietary formulation principles; and then it details how the basic diets vary for pigs depending on phase of production.

After these sections that lay out the fundamentals of our nutrition recommendation, we have included some tools and deep dives in specific topics that will help you optimize the diets for your pigs.

Finally, you find the nutrient specification tables that you can use to optimize your diets for successful nutrition of PIC pigs. Recommendations are based on published research, PIC internal research, research from universities, and commercial large scale designed experiments. The nutrient specifications have been validated in commercial environments. The National Swine Nutrition Guide (2010) and National Research Council (2012) publications serve as the basis for certain information. Concepts and the basis for recommendations are discussed in greater detail in other technical memos.

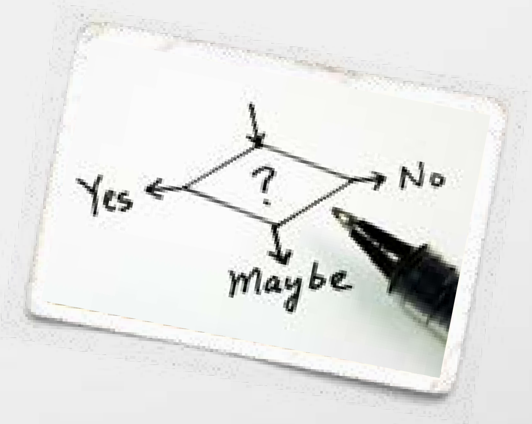
This is a dynamic manual. PIC will continue to update this manual as new research becomes available and share them with you through nutrition updates and the PIC website. Access http://na.picgenus.com/enewsletter_sign_up.aspx to sign up.

PRINCIPLES AND DECISION MAKING IN DIET FORMULATION

Once the principles of diet formulation are understood, there are multiple strategies that can be taken for diet formulation. Production systems around the world will typically decide between a combination of maximizing animal performance, minimize cost of production, and maximize profitability.

From a macro level, once growth and feed intake in the specific production system are known, the first step in diet formulation is to define the most economical net energy (NE) level. The second step is determining the standardized ileal digestible (SID) lysine (Lys) dietary concentration based on the SID Lys:NE ratio. Next, the other SID amino acids (AA) are defined as a ratio to SID Lys. Finally, the levels of macro minerals, trace minerals and vitamins are defined to achieve the requirement in amount of nutrients (i.e., grams, milligrams, or International Units) per pig per day.

THE ECONOMIC IMPLICATIONS OF FIXED TIME VS. FIXED WEIGHT

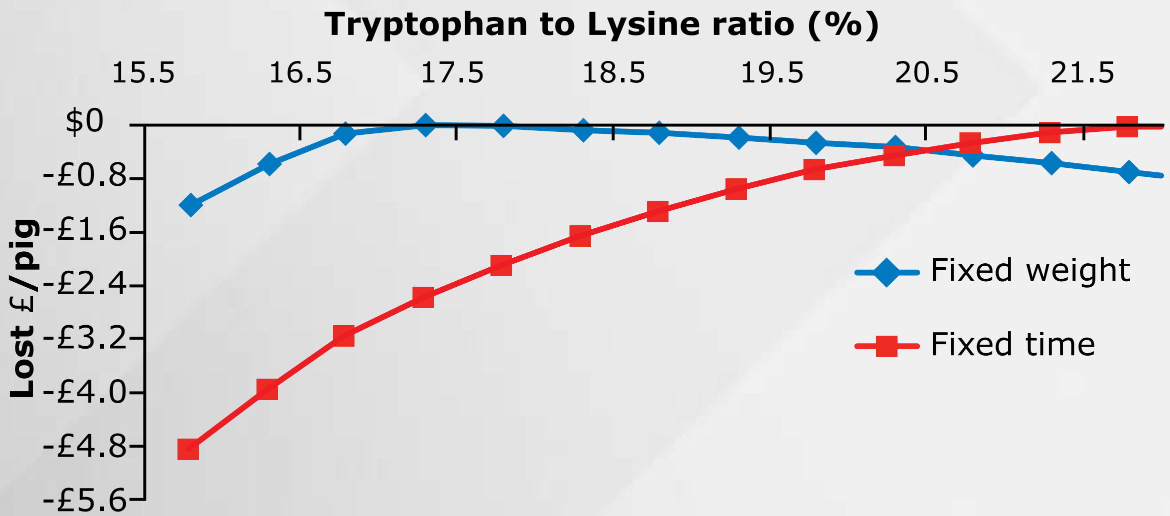


A key concept to consider when formulating diets for a specific production system is to understand if the system is marketing pigs on a fixed time or a fixed weight basis. Fixed time means that the system does not have extra or flexible space in the production flow. For example, when a finishing barn reaches 120 days of placement, the pigs are marketed and the barn is emptied for the next group of pigs. Fixed time can also be explained as being space short and fixed weight as space long. Fixed weight program, however, means that the system has some flexible amount of space available in the production flow and, thus, pigs can be left in the barn until they reach a target weight optimum for the given carcass value payment structure of the processing plant. The difference between these two scenarios is important because it changes the relative value of growth rate. The value of weight gain in a fixed time system is more valuable given the fixed constraint on number of growing days available; however, in the fixed weight system, pigs can stay in the barn at a fixed space cost (i.e., $0.11/pig/day) and, therefore, the economic value of weight gain by a given nutritional or management strategy is smaller compared to a fixed time scenario. Production systems will often be on a fixed weight basis during winter when pigs are growing at a faster rate and on a fixed time basis during summer when pigs are growing at a slower rate. The important point is that these two scenarios represent the range of economic optimums and evaluating both scenarios can be an effective tool for evaluating economic sensitivity of dietary changes.

The concept of optimum nutrient levels to maximize profitability in a fixed time program relative to fixed weight scenario is illustrated in Figure 1A. Tryptophan (Trp) to Lys ratio can have a significant impact on growth rate. In this specific scenario, varying tryptophan to Lys ratio has a much larger economic impact on a fixed time system than a fixed weight system simply because weight gain offers a greater marginal economic return compared to the fixed weight scenario. For additional information on the value of alternative Trp to Lys ratios, please visit http://www.lysine.com/en/tech-info/TrpLys.aspx to download a free dynamic economic calculator for the most economic Trp to Lys ratio specific to a production system.

FIGURE A1. STANDARDIZED ILEAL DIGESTIBLE TRYPTOPHAN TO LYSINE RATIO, %

Standardized ileal digestible (SID) tryptophan:lysine ratio for maximum profit on a fixed time and fixed weight basis (PIC 337 × 1050; Kansas State University and Ajinomoto Heartland, 2016).



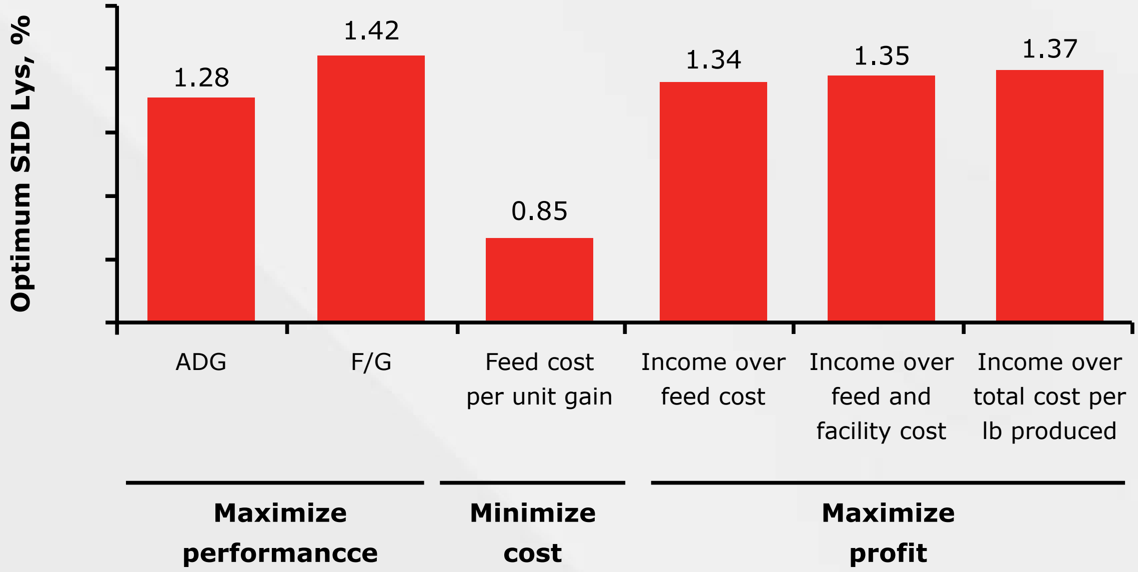
STRATEGIES FOR DIET FORMULATION

There are multiple strategies, or targets, that are commonly used for diet formulation. Some of the commonly used approaches are:

- Growth performance basis
  - Maximize average daily gain (ADG)
  - Minimize feed efficiency (F/G)
- Cost reduction basis
  - Minimize cost per kg of diet
  - Minimize feed cost per kg of gain
- Profit maximization basis
  - Maximize income over feed cost (IOFC)
  - Maximize income over feed and facility costs (IOFFC)
  - Maximize income over total cost (live or carcass)

A summary showing how these targets can impact formulation strategies and the resulting diets is shown in Figure 1B. These results show the levels of SID Lys to optimize the different strategies listed above. Note that the SID Lys level to maximize profit is greater than that to minimize cost. The economic optimum SID Lys level is dynamic and depends on the market prices. Each of these concepts, and some of the relative risks and rewards, are explained below in more detail.

FIGURE A2. EXAMPLE OF LEVELS OF STANDARDIZED ILEAL DIGESTIBLE (SID) LYSINE TO OPTIMIZE DIFFERENT OUTCOMES FOR PIC PIGS (20- TO 25-KG PIG; PIC INTERNAL DATA).



FORMULATING FOR MAXIMUM PERFORMANCE

The SID Lysine level to improve F/G is generally greater than that to maximize ADG. However, formulation targeting maximum performance does not take into account any economic measurement but only considers the impact on the biological response.

FORMULATING FOR MINIMUM COST

To minimize the diet cost, the nutritionists set the nutrient levels needed and use a least cost formulation software to achieve the minimum diet cost possible but still meet the needed requirements.

Thus, diet cost is technically an economic variable; however, it does not account for any changes in performance. Feed cost per kg of gain is calculated by multiplying F/G by the cost per kg of feed and, therefore, feed cost per kg of gain takes into account F/G. However, this approach does not take into account any changes in ADG, pig price, or the cost of each extra day in the barn.

Feed cost per kg gain = (Feed:gain x $ per kg of feed)

FORMULATING FOR MAXIMUM PROFIT

Income over feed cost (IOFC), on the other hand, takes into account the market price and the value of weight gain under a fixed time scenario:

IOFC = (market price per kg live weight × weight gain) - (feed cost per kg gain × weight gain)

Income over feed and facility costs (IOFFC) is similar to IOFC, however it is suitable for a fixed weight scenario:

IOFFC = (market price per kg live weight × weight gain) - (feed cost per kg gain × weight gain) - (cost per pig space × days in the phase)

PUTTING IT ALL TOGETHER

The formulation concept of feed cost per kg of gain generally leads to the conclusion of cheaper diets; however, often that is not necessarily the optimum level to maximize net profit. Income over total cost (IOTC) takes into account the dilution effect of the extra gain over each kg of live or carcass produced. For example, let's assume that the cost of the weaned pig was $40. Therefore, a production system with 121 kg of gain from weaning to market results in a cost of $0.3306 per kg that will be related to the cost from the weaned pig. However, if a given nutritional or management strategy increases the weight gain to 123 kg, the cost per kg related to that initial weaned pig cost will change to $0.325 or 1.7% reduction in cost.

To calculate income per kg of live weight produced:

$IOTC_L$ = [market price per kg - ((1/market weight) x (feed cost per pig + other costs per pig + feeder pig cost))]

Or to calculate income per kg of carcass weight produced:

$IOTC_C$ = [market price per kg - ((1/market weight/% yield) x (feed cost per pig + other costs per pig + feeder pig cost))]

The following examples use these principles for comparison of a few specific scenarios and the impact on income over feed cost and income over total cost on a carcass basis:

COMPARISON OF MINIMIZING COST VS. MAXIMIZING PROFIT PER PIG

TABLE A1. SCENARIOS AND ASSUMPTIONS.

	SCENARIO 1	SCENARIO 2[a]
Assumptions	Fixed time/no added fat diet	Fixed time/3% added fat diet
ADG, kg	0.816	0.841
F:G	2.800	2.632
Days on feed	90	90
Diet cost, £/kg[b]	0.183	0.196

[a]Assuming each 1% added fat improves gain by 1% and F:G by 2%. This response can vary from system to system and by season.
[b]Assuming costs of soybean meal, corn, and choice white grease at £280/ton, £2.88/bu (25.5 kg), and £0.54/kg, respectively.

Diet cost should have manufacturing and delivery included and not just ingredient cost because this is a more accurate reflection of the total cost of the feed consumed and the value of the performance differences.

CALCULATIONS

SScenario 1 (no added fat): 112 days x 0.816 ADG = 91.4 kg gain in the finishing
Feed cost per pig = 91.4 kg gain x 2.80 F/G x $0.229 feed cost/kg = $58.60

Scenario 2 (3% added fat): 112 days x 0.841 ADG = 94.2 kg gain in the finishing
Feed cost per pig = 94.2 kg gain x 2.632 F/G x $0.245 feed cost/kg = $60.74

In conclusion, the feed cost per pig in scenario 2 is $2.14 greater than scenario 1.
Thus, scenario 1 has the lowest feed per cost per pig;

However, in scenario 2 there are more kg produced per pig. Thus, this needs to be taken into consideration:

Considering the market pig price equal $1.21/kg and recalculating using IOFC:

Scenario 1:
IOFC (Sc1) = ($1.21 pig price/kg x 91.4 kg gain) – ($58.60 feed cost per pig) = $51.99 per pig
IOFC (Sc2) = ($1.21 pig price/kg x 94.2 kg gain) – ($60.74 feed cost per pig) = $53.24 per pig

In conclusion, the income over feed cost per pig in the scenario 2 is $ 1.25 better than scenario 1, thus, adding fat in this scenario is more profitable.

INCOME OVER TOTAL COST

Assumptions:

- Carcass yield = 74%
- Carcass price = $1.65/kg
- Feeder pig cost (22.7 kg) = $55
- Other costs (facilities/transport/medicines/vaccines/slaughter) = $14.56 per pig

Calculations on a live basis

$$IOTC_{L\ sc1} = [1.21£/kg\ (live) - ((1/(30\ kg+73.44\ kg)) \times (£37.63+£11.64+£55.45))] = £0.1976 \text{ per kg live weight produced}$$

$$IOTC_{L\ sc2} = [1.21£/kg\ (live) - ((1/(30\ kg+75.69\ kg)) \times (£39.04+£11.64+£55.45))] = £0.205 \text{ per kg live weight produced}$$

Scenario 2 (3% added fat) is 9.9% ($8.6/ton of live weight) more profitable than 1 (no added fat) in this market situation on a live basis.

Calculations on a carcass basis
Thus, scenario 2 (3% added fat) is 8.8% ($11.62/ton of carcass weight) more profitable than 1 (no added fat) in this simulation.

$$IOTC_{L\ sc1} = [1.5£/kg\ dead - ((1/(30\ kg+73.44\ kg)/0.74) \times (£37.63+£11.64+£55.45))] = £0.131 \text{ per kg carcass weight produced}$$

$$IOTC_{L\ sc2} = [1.5£/kg\ dead - ((1/(30\ kg+75.69\ kg)/0.74) \times (£39.04+£11.64+£55.45))] = £0.143 \text{ per kg carcass weight produced}$$

A summary of absolute and relative economic differences between scenarios are presented in Table A2.

TABLE A2. ABSOLUTE AND RELATIVE ECONOMIC DIFFERENCES BETWEEN SCENARIOS 1 AND 2.

	DIFFERENCES (SCENARIO 2 - SCENARIO 1)	
	ABSOLUTE	RELATIVE (%)
Diet cost, $/kg	0.016	+ 7.0%
Feed cost per pig, $/kg	2.14	+ 3.6%
Feed cost per kg produced, $/kg	0.004	+ 0.6%
IOFC, $/pig	1.25	+ 2.3%
$IOTC_{Live\ weight\ based}$, $/ton	8.60	+ 9.9%
$IOTC_{Carcass\ based}$, $/ton	11.62	+ 8.8%

In conclusion, there are multiple strategies and approaches for diet formulation. It is important to use an approach that takes into account the value of performance (i.e., ADG, F/G, yield) but also the fixed time or fixed weight nature of the system. Therefore, using approaches such as income over feed (and facility) costs or income over total cost on a carcass basis are suitable solutions to robustly maximize the profitability of swine operations.

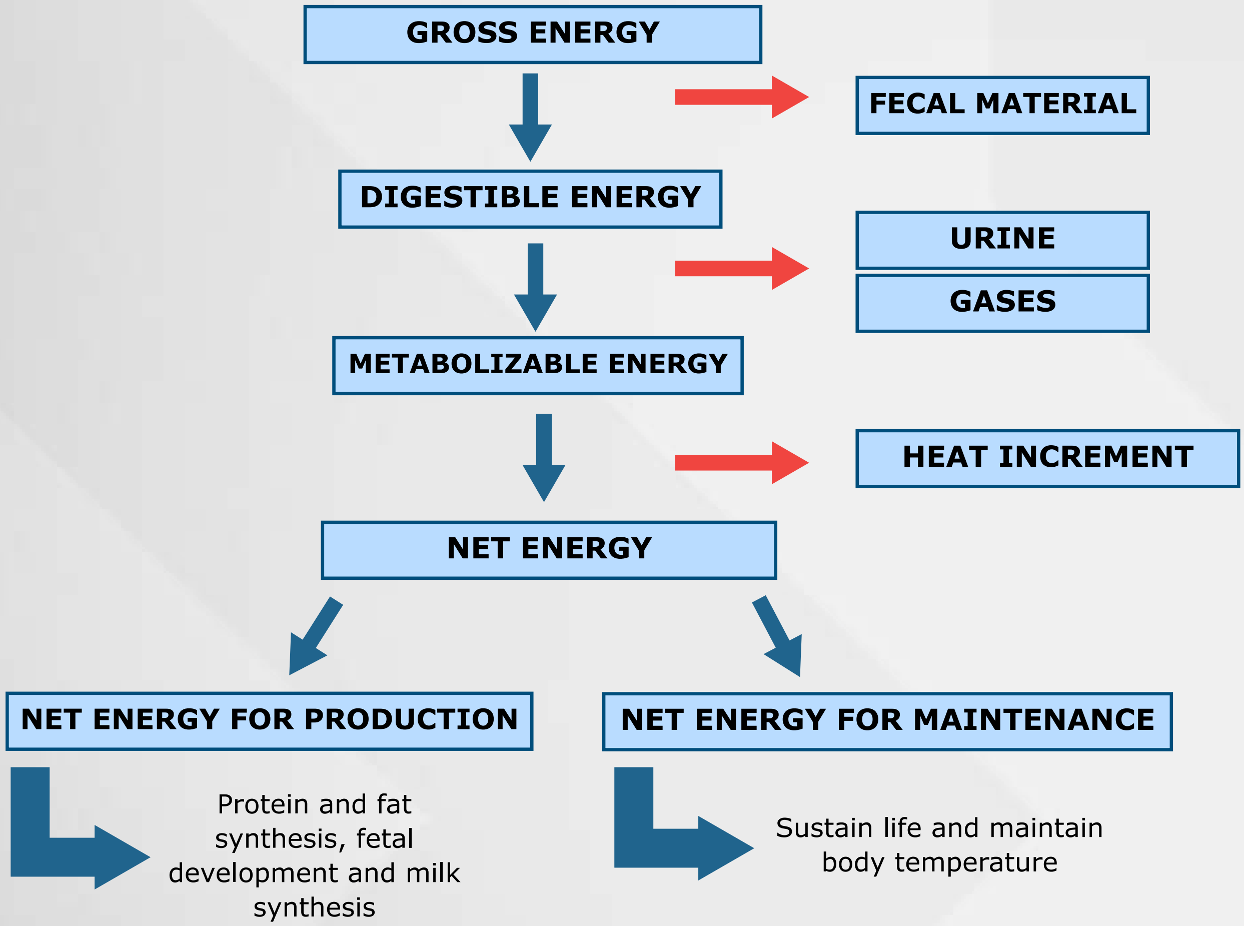
Section B:

ENERGY

Energy is the most expensive component of the diet, representing about 50% of the total diet cost. Thus, an understanding of its roles on metabolic processes throughout the different phases of production as well as its performance and economic implications is important.

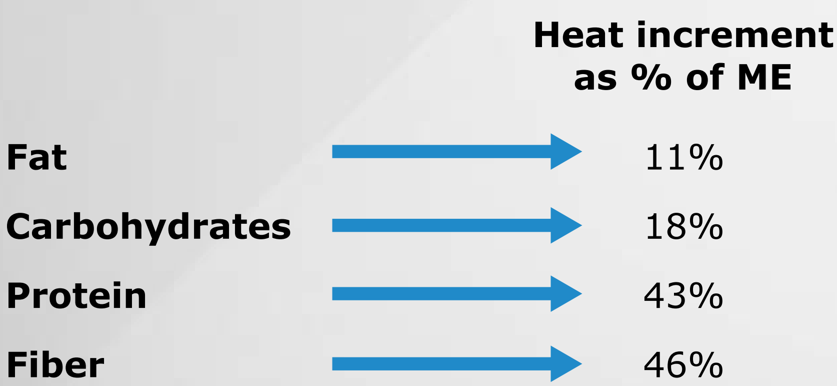
The utilization of dietary energy by pigs is illustrated in Figure 2A. Digestible energy (DE) is gross energy (GE) minus the heat of combustion of fecal material. Metabolizable energy (ME) is DE minus the heat of combustion of urine and gas production. Gas production in pigs is below 1% and is generally neglected. Net energy (NE) is ME minus the heat increment (HI), which is the heat of digestion and nutrient metabolism. Net energy is divided into NE for maintenance (NE_m) and NE for production (NE_p). Net energy for maintenance is the energy needed to sustain life and maintain homeostasis (i.e., body temperature). Net energy for production is the energy used in synthesis of protein, fat, fetal development, and milk synthesis. Thus, NE is the most accurate system to predict growth performance (Nitikanchana et al., 2015).

FIGURE B1. UTILIZATION OF DIETARY ENERGY BY PIGS.



Ingredients with high-fiber (i.e., DDGS, Midds) and/or high-protein (i.e., SBM) generate greater heat increment during digestion (Figure 2B), thus having a greater difference between DE or ME and NE compared with ingredients with moderate levels of fiber and protein. However, it is important to take into consideration that heat increment can be used by the pigs as a source of heat when they are below their thermoneutral zone. Thus, high-fiber and high-protein diets are not as detrimental during the winter season or in other situations where environmental controls can keep the growing pigs in their thermoneutral zone.

FIGURE B2. HEAT INCREMENT AS A PERCENTAGE OF METABOLIZABLE ENERGY (ME) FOR PIGS.



Adapted from Noblet & van Milgen (2004) and Rijnen et al. (2003).

THE IMPORTANCE OF ENERGY AND INGREDIENT LOADING VALUES

The ingredient loading values used in diet formulation are of extreme importance. There are many energy systems and it is important to be consistent in the system used in your database. Table 2A shows ME, NE, and SID Lysine (Lys) levels for the same diet using two different ingredients databases: National Research Council (NRC, 2012) and Central Bureau for Livestock Feeding (CVB, 2008). There is a 3.3, 4.2, and 2.2% difference in ME, NE, and SID Lys. These values show the importance of using an ingredient database that accurately describes the specific region but also the importance of knowing locally the energy and nutrient content of the ingredients used in diet formulation. It is also important to know the ingredient loading values used in determining the pigs' requirements. For example, different lysine loading values used in dose-response experiments will yield different requirements. Finally, it is important to know the moisture of the ingredients when determining energy and nutrient levels.

TABLE B1. SAME DIETS FORMULATED WITH TWO DIFFERENT INGREDIENTS DATABASES (NRC 2012 VS. CVB 2008).

DIET	PERCENTAGE, %	
Corn, yellow	70.99	
Soybean meal, solv. extr., CF<4%, CP<48%	25.19	
Corn oil	1.00	
Calcium carbonate	0.95	
Monocalcium phosphate	0.78	
Salt (NaCl)	0.37	
L-Lysine HCl	0.17	
DL-Methionine	0.04	
L-Threonine	0.02	
Vitamin and trace mineral premix	0.50	
Total, %	100	
	NRC, 2012	CVB, 2008
ME, kcal/kg	3342	3232
NE, kcal/kg	2515	2414
Standardized Ileal Digestible (SID) Lysine, %	0.93	0.91

Table 2B shows a corn-soybean meal based diet and a high-fiber ingredient based diet formulated to have the same level of ME. Note that even though the diets have same ME, the high fiber ingredient diet has 2.5% less NE. These could result in 2.5% worse F/G (Nitikanchana et al., 2015). Therefore, scenarios where high fiber ingredients are pricing into the diet, the differences in NE should be taken into account when conducting the economic calculations.

TABLE B2. DIETS WITH SAME METABOLIZABLE ENERGY (ME) BUT DIFFERENT NET ENERGY (NE) WITH NRC (2012) INGREDIENT VALUES.

	CORN AND SOYBEAN MEAL DIET	HIGH FIBER INGREDIENT DIET
Corn, yellow	70.99	37.48
Corn DDGS, <4% oil	---	30.00
Wheat middlings	---	19.00
Soybean meal, solv. extr., CF<4%, CP<48%	25.19	7.11
Corn oil	1.00	3.52
Calcium carbonate	0.95	1.28
Monocalcium phosphate	0.78	---
Salt (NaCl)	0.37	0.39
L-Lysine HCI	0.17	0.57
L-Threonine	0.02	0.10
L-Tryptophan	---	0.04
DL-Methionine	0.04	0.03
Vitamin and trace mineral premix	0.50	0.50
Total, %	100	100
ME, kcal/kg	3342	3342
NE, kcal/kg	2515	2452
Standardized Ileal Digestible (SID) Lysine, %	0.93	0.93

RESPONSE TO ENERGY LEVELS IN FINISHING DIETS

Table B3 is a summary of growth trials from PIC280, PIC327 and PIC337 sire lines. All sires were bred to PIC Camborough® sows.

Pigs were assigned to a series of high-energy diets (corn, soybean meal, 6% DDGS with 4.5% added fat, NRC ME ranged from 3408-3454 kcal/kg, from 27 kg to market) or a series of low-energy diets (corn, soybean meal, 6% DDGS, no fat, 16% wheat midds, NRC ME ranged from 3150-3209 kcal/kg from 27 kg to market, respectively. Diets were balanced on a SID Lysine:Mcal ME basis according to PIC recommendations. Minimum SID AA ratios of AA were maintained in all diets. Diets are shown in the Appendix A.

TABLE B3. RESPONSE TO HIGH- AND LOW-ENERGY DIETS[a].

ITEM	HIGH DIETARY ENERGY	LOW DIETARY ENERGY	PROBABILITY, *P* <
Target Market Weight of 123 kg			
Initial weight, kg	26.90	26.95	P = 0.86
Final weight, kg[b]	124.72	125.31	P = 0.27
ADG, kg/d	0.940	0.909	P = 0.0001
ADFI, kg/d	2.313	2.504	P = 0.0001
F/G	2.46	2.76	P = 0.0001
Target market weight of 132 kg			
Entry weight, kg	26.90	26.90	P = 0.82
Market weight, kg[b]	134.68	133.72	P = 0.09
ADG, kg/d	0.945	0.909	P = 0.0001
ADFI, kg/d	2.363	2.545	P = 0.0001
F/G	2.51	2.81	P = 0.0001

[a]PIC Executive Summary 49, 50, 51, 52, 53, 54, 55 (available on request).
[b]Pigs fed the lower eergy diet took about 6 days longer to achieve similar market weight.

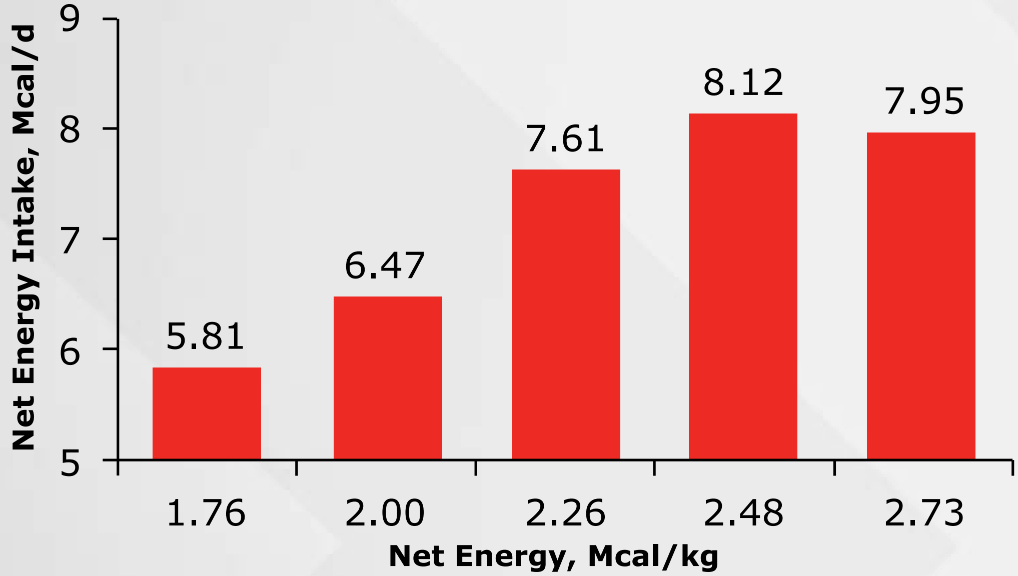
In this trial, feeding a series of high-energy diets resulted in a faster ADG by 3.5% (P < 0.0001), a lower ADFI (P < 0.0001) and improved feed conversion by 11% (P < 0.0001). Lifetime daily carcass gain was increased (P<0.05) in pigs fed high energy vs low energy diets.

However, the caloric efficiency was similar (P > 0.5) among the high-energy (8774 kcal ME/kg gain) and low-energy (8840 kcal ME/kg gain) diet series. This information demonstrates that the same daily calories were consumed and the same amount of calories was used to deposit the same amount of weight gain. Though the feed conversion was different, the pigs on the lower energy diets were not necessarily less efficient in energy utilization. There was no sire line x dietary energy interactions in this trial.

The results indicate PIC pigs perform well across a wide range of energy intakes and adjust well to dietary energy level. Results also indicate that PIC pigs also remain very efficient going to heavy market weights as indicated by the growth curve results. The growth curves for each sire can be requested to your account manager.

It is important to note that low energy diets will cause an increase in feed intake up to point where gut capacity becomes a constraint (Figure 2C) and energy intake per day is reduced. Additionally, when using low energy diets, it must be communicated to all production personnel so that they can allow for proper feeder/pen space and feeder adjustments to insure the growing pigs can reach these intake levels. Restricting feed intake below this point will reduce pig performance. More information on feeder space can be found in the PIC Wean to Finish Manual at http://na.picgenus.com/resources.aspx.

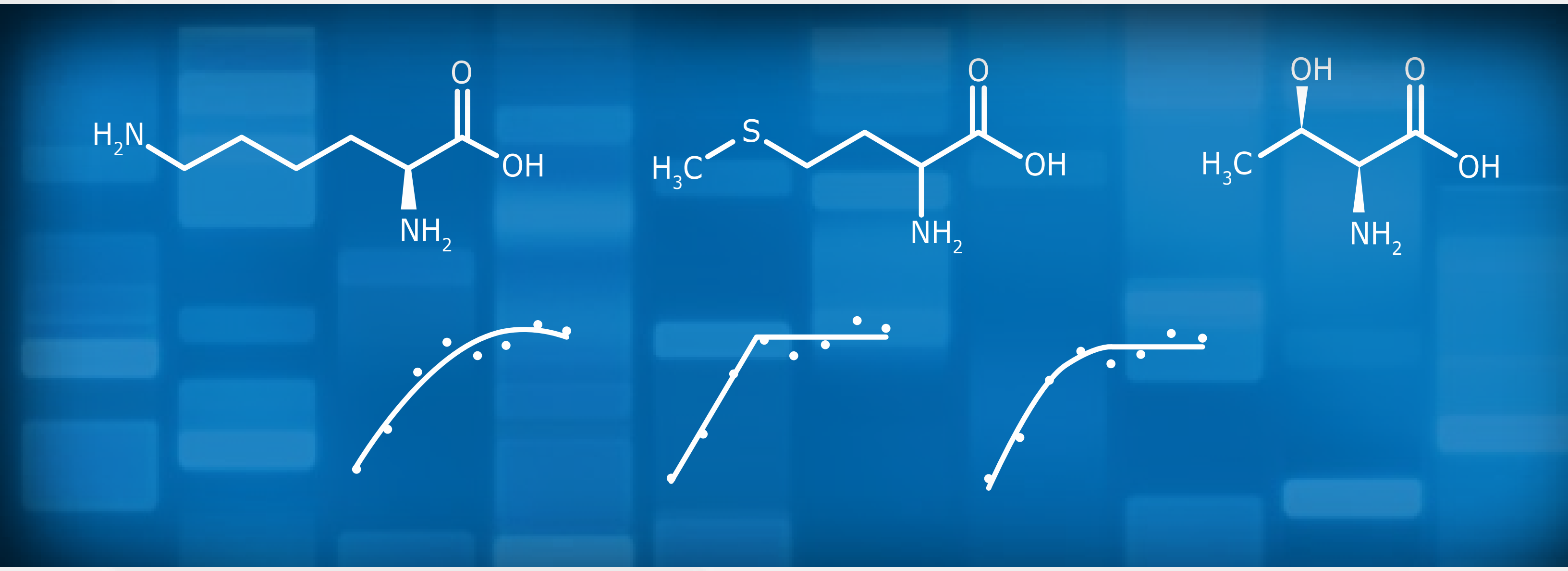
FIGURE B3. EFFECTS OF NET ENERGY INTAKE PER DAY BASED ON DIFFERENT NET ENERGY PER KG OF DIET (ADAPTED FROM STEIN AND EASTER, 1996) .



To decide on the most economical NE level for a specific production system one needs to consider the changes in performance expected by the changes in NE level and the cost related to those dietary energy changes. It is important to emphasize that a large amount of the value of growth response to energy depends on having adequate levels of amino acids.

Section C:

PROTEIN AND AMINO ACIDS



Amino acids are the building blocks of proteins that allow for highly efficient lean growth. PIC pigs have high potential for lean deposition, even at heavy market weights. Thus, an understanding of the impacts of each amino acid in protein deposition as well as other metabolic processes is important to maximize the success with PIC pigs.

Once the most economic energy level is defined, the SID Lysine (Lys) level is specified based on the Lys to Calorie ratio requirement of the pig. To obtain optimum performance, all amino acids must meet the requirement.

EXPRESSING AA REQUIREMENTS

Amino acids can be expressed in multiple ways (total AA basis, apparent AA basis, etc). However, since ingredient amino acids differ in their digestibility, standardized ileal digestible (SID) amino acid values are preferred to accurately formulate diets.

FORMULATING TO AN IDEAL AMINO ACID PATTERN

The NRC (2012) has defined essential amino acid recommendations for each physiological phase. NRC served as the basis for PIC recommendations when access to data was limited, but recent research-based modifications have been made based on the research work of PIC, Ajinomoto Heartland, production systems, and universities. Requirements for amino acids other than Lys are normally expressed in relation to the level of lys since it is most likely to be first limiting in the diet. This guide specifies the SID Lys requirement using NRC (2012) ingredient loading values. The suggested ratio of dietary amino acids for each phase is presented in the nutrient specification tables at the end of this manual.

Section D:

MACRO MINERALS

Macro minerals are involved in many processes ranging from structural framework of DNA and RNA to bone development, electrolyte balance, and growth performance. Thus, fine tuning the macro minerals levels in diet formulation is a key aspect of a well-formulated diet.

Macro minerals such as calcium (Ca) and phosphorus (P) are mainly involved in structural functions such as bone development and metabolism but also are involved in other metabolic functions. Typically, the minimum P levels of the diet are defined, and then the Ca level is defined as a ratio to P. It is generally recommended that the total Ca to total P ratio be between 1 to 1.5. The NRC (2012) concluded that a wider ratio lowers P absorption, especially if P is marginal in the diet.

PHOSPHORUS CAN BE EXPRESSED IN MANY WAYS:

- Total phosphorus: Total P represents all P that the ingredient contains (including the non-available P);
- Bioavailable phosphorus
  - Available phosphorus is estimated by using a method called "slope-ratio assay" and estimates the digestible plus post-absorptive utilization of P at the tissue level; however, this method is more expensive and assumes that an inorganic standard is 100% available.
  - Digestible phosphorus
    - Apparent Total Tract Digestible (ATTD) P: estimates the total tract digestibility of P and does not correct for basal endogenous P losses;
    - Standardized Total Tract Digestible (STTD) P: estimates the total tract digestibility of P and corrects for basal endogenous P losses;

PIC

The STTD P way of expressing phosphorus is becoming more common among researchers and nutritionists around the world. This manual provides requirements in an available P and STTD P basis.

Calcium has been mainly expressed in a total basis until this point. Recent work has been focusing on defining digestible calcium levels from different feed ingredients and this may be used in diet formulation in the years to follow. However, at this point, this manual will focus on total calcium. Another consideration with calcium is that some ingredients and feed additives may contain calcium sources as densifiers or diluents. Many times these sources are not accounted for in diet formulation and may have significant impact on the Ca to P ratio.

Sodium is important for maintaining homeostasis of water and electrolytes and can be easily supplemented by adding salt to the diets. Inadequate water supply can induce “salt poisoning”. Sodium deficiency can reduce feed intake, average daily gain, and worsen feed efficiency. Fraser et al. (1987) have reported that salt deficiency can induce tail biting. Finally, it is important to monitor sodium levels in feed ingredients to ensure that the expected formulated levels are achieved.

Section E:

TRACE MINERALS AND VITAMINS

Adequate supplementation of trace minerals and vitamins is important due to its variety of roles in regulatory functions. Their roles can range from maintaining a strong feet to maximizing reproduction efficiency.

PIC recommendations were established after being extensively compared to the recommendations of universities and major nutrition groups. A systematic allowance was made in relation to the NRC recognizing that this information is based on studies under nearly ideal conditions. The values are micronutrient additions and give no credit for ingredient content.

There are inorganic and organic forms of trace minerals such as zinc, manganese, iron, copper and selenium available in the market with different forms (i.e., chelates, proteinates, etc. for organic and sulfates, oxides, etc. for inorganic forms). These forms may have different bioavailability and this should be taken into account. Vitamin requirements are presented at the nutrient specifications table at the end of this manual. For an in-depth review on vitamins please refer to Matte and Lauridsen (2013) and for a review in minerals please refer to Hill (2013).

Section F:

WATER

Water is arguably the most important nutrient for pigs. Limited water availability will reduce feed intake and, thus, have negative effects on growth performance.

Two key aspects for successful production are water availability (Table F1) and water quality (Tables F2 and F3). Total dissolved solids is not an exact measure of water quality but can be used to estimate water quality. Sulfates are laxative agents and can cause diarrhea, especially in young pigs (NRC, 2012). Different countries may have different water quality standards for pigs. For an extensive review of water in swine nutrition refer to Thacker (2001) and PIC Sow and Gilt management manual at http://na.picgenus.com/resources.aspx.

TABLE F1. MINIMUM WATER INTAKE TARGET BY PHASE OF PRODUCTION[a].

CATEGORY	MINIMUM WATER INTAKE TARGET, liters/day
Nursery pigs	3
Finishing pigs	10
Gestating sows	17
Lactating sows	19
Weaned sows	19
Boars	17

[a]Adapted from Thacker, 2001.

TABLE F2. WATER GUIDELINES FOR PIGS[a].

ITEM	PPM (PARTS PER MILLION) LIMITS
Calcium	1000
Chloride	400
Copper	5
Fluoride	2-3
Hardness (Calcium Carbonate)	< 60 soft >200 hard
Iron	0.5
Lead	0.1
Magnesium	400
Manganese	0.1
Mercury	0.003
Nitrites	10
Nitrates	100
Phosphorus	7.8
Potassium	3
Sodium	150
Selenium	0.05
Solids dissolved	1000
Sulfate	1000
Zinc	40
Total viable bacterial count (TVC) per ml	Low but more important no fluctuation between samples.
37°C	$<2 \times 10^2$
22°C	$<1 \times 10^4$
Coliforms/100 ml	Zero

[a]Adapted from NRC (2012) and Task Force on Water Quality Guidelines, 1987.
Canadian Water Quality Guidelines, Inland Waters Directorate, Ottawa, Ontario.

TABLE F3. EVALUATION OF WATER QUALITY FOR PIGS BASED ON TOTAL DISSOLVED SOLIDS (NRC, 2012).

TOTAL DISSOLVED SOLIDS (mg/L)	RATING	COMMENTS
<1,000	Safe	No risk to pigs.
1,000 - 2,999	Satisfactory	Mild diarrhea in pigs not adapted to it.
3,000 - 4,999	Satisfactory	May cause temporary refusal of water.
5,000 - 6,999	Reasonable	Higher levels for breeding stock should be avoided.
> 7,000	Unfit	Risky for breeding stock and pigs exposed to heat stress.

FEED ADDITIVES

Technology advancements and large-scale research under commercial conditions is constantly allowing for the development and evaluation of different feed additives.

PHYTASE

Exogenous phytase is used as a feed additive to hydrolyze phytic acid (phytate) and increase phosphorus availability in feed ingredients. There are multiple phytase suppliers and a comparison between phytase sources, phytase stability, as well as the effects of superdosing phytases were reviewed by Gonçalves et al. (2016a). It is important that the nutritionist be confident in the release levels associated to phytase in order to avoid Ca and P deficiencies, especially in herds with low feed intake. Heat stable sources are preferred due to increased phytase stability over time and especially in pelleted diets (Sulabo et al., 2011). Additionally, high levels of phytase may need to be used when high levels of zinc oxide are used. There is increasing evidence that increased levels of phytase in nursery diets to those beyond P and Ca release may enhance growth performance (Kies et al., 2006; Walk et al., 2012; Langbein et al., 2013; Koehler et al., 2015). However, the mechanism for such an enhancement in performance remains unclear and the magnitude of impact is dependent on the levels of P, amino acids, and other nutrients in the diet (Adeola and Cowieson, 2011). At this point, there are mixed peer-reviewed research results regarding the impact of phytase on the release of nutrients beyond phosphorus and calcium (Johnston and Southern, 2000; Holloway et al., 2015).

RACTOPAMINE

Ractopamine is a feed additive with proven results in finishing pigs when diets are formulated correctly. Please keep in mind that ractopamine should not be fed to replacement gilts or boars. The nutrient specifications tables at the end of this manual provide guidelines for feeding ractopamine for less than 21 days and for feeding more than 21 days prior to market. Because the SID lysine in the ractopamine diet is high, there is a risk of adding too much soybean meal and causing a yield reduction (Gaines et al., 2004 and 2007). Synthetic amino acids should be used to reduce the amount of soybean meal in diets with ractopamine. Different countries have different regulations regarding ractopamine use.

ZINC AND COPPER

A review by Jacela et al. (2010a) suggests that the use of high levels of zinc oxide from weaning to 11.5 kg of body weight improve performance and reduce diarrhea rates. Similarly, using a copper source (i.e., 100 to 250 ppm) has been reported to increase growth performance. However, the data regarding an additive response to feeding high levels of zinc and copper simultaneously is conflicting. These high levels of zinc should not be fed for more than 20 to 25 days. Thus, current recommendation is to feed 3000 ppm of zinc from weaning to 7.5 kg, 2000 ppm of zinc from 7.5 to 11.5 kg, and 125 to 250 ppm of copper from 11.5 to 23 kg. Different countries have different regulations regarding the use of zinc and copper as growth promoter.

L-CARNITINE

Eder et al. (2001) supplemented 125 mg per day for sows from weaning to farrowing and observed an improvement of 8% and 7% in litter birth weight of gilts and mature sows, respectively. These results were further supported by later research (Ramanau et al., 2002; Ramanau et al., 2008). More research is needed to validate these effects in large litter sizes.

XYLANASE

There seems to be a reduction in mortality in finishing pigs with the use of commercially available xylanase in high-fiber diets (15% Corn DDGS and 10% wheat middlings). This has been reviewed by Boyd et al. (2015) and further research is warranted.

Section H:

UPPER LIMITS OF USAGE FOR FEED INGREDIENTS

There is a variety of feed ingredients used around the globe and, with expert advice, successfully meeting the requirements of PIC pigs.

Different feed ingredients can be used up to their upper limit and as long as diets are balanced (Table H1). In certain economic scenarios, it may be more economic going above the upper limits of usage, but this needs to be made with caution, ingredient knowledge, and with expert nutrition advice.

Additionally, it is important that nutritionists understand the impact that high-fiber ingredients may have on carcass yield and revenue when included in the diet. Diet cost savings must outweigh the revenue loss associated with marketing a lighter weight carcass. This topic is discussed in more detail in the carcass quality section.

TABLE H1. RECOMMENDED UPPER LIMITS OF USAGE (% OF THE DIET) FOR FEED INGREDIENTS IN SWINE DIETS (NATIONAL SWINE NUTRITION GUIDE, 2010).

PHASE	NURSERY	NURSERY	GROWER	FINISHER	GESTATION	LACTATION
Body weight, kg	<10	10-20	20-60	60-145		
Bakery meal	15	25	*	*	*	*
Barley	*	*	*	*	*	*
Beet pulp	0	5	10	15	50	10
Corn DDGS	10	20	30	20	40	20
Peas	15	30	40	50	15	25
Rapeseed (canola) meal[a]	0	5	15	20	15	15
Soy hulls	5	5	10	10	25	5
Sorghum, grain (milo)	*	*	*	*	*	*
Sunflower meal, 42% CP	0	5	*	*	*	*
Triticale (ergot free)	20	30	*	*	*	40
Wheat	*	*	*	*	*	*
Wheat middlings[b]	5	10	25	35	*	10

An * denotes no nutritional limitations in a balances diet. Higher levels may be fed although growth and reproductive performance and carcass composition and quality may be negatively impacted. Economic considerations should influence actual inclusion rates.

[a]It is important that the nutritionist understand the levels of glucosinolate content of the rapeseed (canola) meal to avoid negative effects on feed intake.

[b]If used in sow diets it is important to test for ergot alkaloids, as ergot has severe negative impact on sow reproductive performance. Maximum levels in final feed is 200 ppb of ergot alkaloids.

Careful attention must be used when using by-products. By-product ingredients tend to be highly variable in nutrient content and could possibly contain high levels of mycotoxins. Ingredient samples must be taken and analyzed to determine nutrient levels. A robust monitoring system should be in place to ensure consistency and when dealing with alternative ingredients, producers must keep in mind feed mill storage capability, feed flowability, and carcass traits.

Section I:

THE BASIC NUTRITION PROGRAM

This section will cover basic concepts for feeding PIC pigs during the different phases of production. The nutrient specification tables at the end of this manual provide specific recommendations about nutrient levels of the diets.

MATURE BOARS

The goal of boar feeding is to promote adequate growth and to maximize semen output and semen quality, while avoiding locomotor problems and reduce culling rate.

Underfeeding boars can have negative consequences in sperm production (PIC Technical Memo 142). The energy needed to support body condition without compromising sperm output has been calculated and validated in AI studs (Table I1; see PIC Technical Memo 142, available on request).

TABLE I1. FEED LEVEL IN RELATION TO BODY WEIGHT[a].

BODY WEIGHT, kg	MCAL ME/d	MCAL NE/d	FEED, kg/d
<159	7.2	5.3	2.3
159	7.9	5.9	2.5
205	8.6	6.4	2.7
250	9.5	7.0	3.0
295	10.4	7.7	3.3
341	11.2	8.3	3.5

[a]Adapted from PIC Technical Memo 142. Assumes ambient temperature of 17-18°C. Based on a dietary energy density of 2350 kcal NRC EN/kg.

Feed intake levels will depend on the body weight of the boars in the stud. With the nutrient levels provided on the specification table at the end of this manual, the typical feed intake is 2.5-2.7 kg. Thin boars are normally fed 2.7 kg/d, ideally conditioned boars are fed 2.5 kg/d, and fat boars are normally fed 2.3 kg/d.

Very little information exists on which to base nutrient specifications. Those presented at the Nutrition Specification tables are used by PIC and given for reference only. Energy and amino acid levels are based on limited university research.

There is some evidence that 0.3 ppm of organic selenium may help maintain sperm motility after consecutive collections, may help ameliorate the negative effects of semen storage on semen motility, and lastly, improve in vitro fertilization rates (Speight et al., 2012).

It has been reported an increase of 11% in total sperm per ejaculate after boars being fed for 16 weeks with 0,295 kg/d of a top-dressed supplement containing 31% omega-3 fatty acids (Estienne et al., 2008). A recent study has reported an 11% increase in semen doses produced when feeding 2000 FTU of Quantum® Blue/kg of diet (Stewart et al., 2016). Another recent study has reported a marginally significant increase in total sperm production of 6% for boars fed 16.3 g/d of a product with 96% betaine during summer months (Cabezón et al., 2016a). More research is warranted to further validate these findings.

GILT DEVELOPMENT

Gilt nutrition during development has a significant impact on the early and lifetime performance of females. The goal of this phase is to meet nutrient demands for: 1) adequate protein growth, 2) adequate bone development, 3) adequate reproductive tract development, and 4) a sound foot and leg structure.

Gilt development and management begins in the early stages of a gilts life and ends when the gilt completes her first lactation (Boyd et al., 2002).

The goal is to have an average daily gain from birth to first service of 0.61 to 0.77 kg/day.

The minimum individual weight at breeding is 135 kg. Thus, the average group weight will be, approximately, 145 to 160 kg. Breeding weight above 160 kg should be avoided. Below 135 kg there is a reduction in prolificacy and above 160 kg there is an increase in cost for energetic maintenance, increased weight loss during lactation due to low feed intake, increased chances of locomotor problems, and increased rate of early culling.

For further information about the management of the developing gilt, please refer to the Gilt and Sow Manual published by PIC at http://na.picgenus.com/resources.aspx.

As a summary, key differences between a gilt development diet and a market gilt diet are:

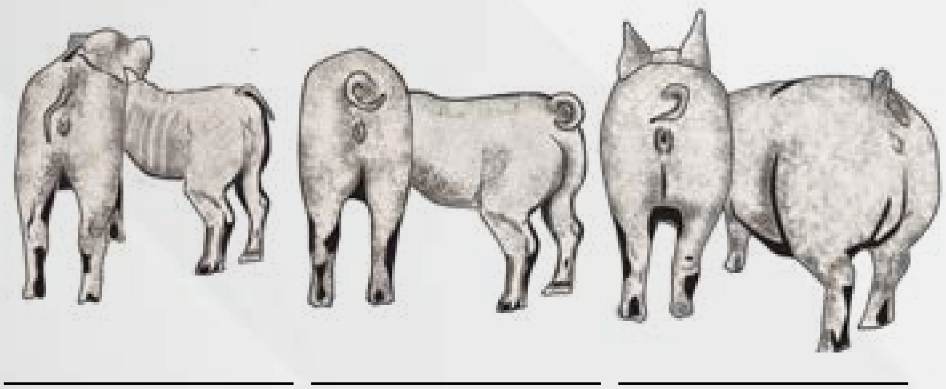
1) Vitamins specific for reproduction purposes (i.e., folic acid, biotin, etc)
2) Vitamin and trace mineral recommendations are higher than commercial recommendations in order to not limit the gilt for reproductive function (see requirement tables).
3) Higher Ca and P levels compared to market gilts.

GESTATING GILT AND SOW

The main goal during gestation is to manage body condition to allow for adequate embryonic/fetal and placental development to maximize litter size while not making sows too thin or too fat.

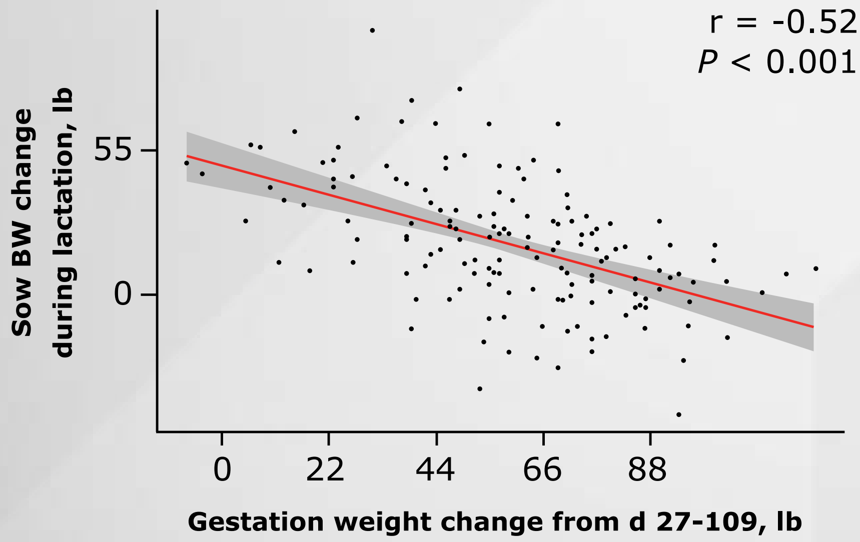
Managing body condition (Figure I1) is a key aspect of a high performance sow farm. An ideally conditioned sow is the one that the back, hip, and rib bones cannot be seen but can be felt when touching the sow. If these bones cannot be felt by touching the sow, then she is over conditioned. The target is to have 90% of the sows in ideal condition.

FIGURE I1. BODY CONDITION SCORE (ADAPTED FROM DISEASE OF SWINE, 2006).



Fat sows at farrowing will likely have low feed intake during lactation, lose more weight (Figure I2), produce less milk, and consequently, may wean lighter piglets. This negative energy balance will then likely influence a reduction in the subsequent litter size.

FIGURE I2. GESTATION AND LACTATION SOW BODYWEIGHT (BW) CHANGES ARE INVERSELY CORRELATED (REN ET AL., 2015).



A recent descriptive summary of experiments (Table 9B) evaluating increased feed intake during late gestation has shown that sow BW is increased by approximately 6.9 kg when bump fed an extra 0.9 kg/d during late gestation. Similarly, the overall effect of bump feeding on piglet birth weight was modest (1 oz or 28 g). This effect is greater and more consistent in gilts (1.1 oz or 31 g) compared to sows (0.4 oz or 11 g). In fact, multiple studies have shown negative effects of bump feeding in sows (Shelton et al., 2009; Soto et al., 2011; Greiner et al., 2016).

TABLE I2. DESCRIPTIVE SUMMARY OF EXPERIMENTS EVALUATING INCREASED FEED INTAKE DURING LATE GESTATION (GONÇALVES, 2015).

EXP.	TYPE	START, DAY OF GESTATION	LITTERS PER TREATMENT	TOTAL BORN	CONTROL, Mcal ME/d	CONTROL, g SID Lys/d	INCREASED FEED INTAKE, Mcal ME/d	INCREASED FEED INTAKE, g SID Lys/d	INCREASED BY TREATMENT	
									FEMALE BW GAIN, KG/KG OF EXTRA DAILY FEED[a]	PIGLET BIRTH WEIGHT, g
1	Both	90	540	10.6	5.8	10.6	10.2	18.4	5.7	40
2	Gilts	90	21	14.3	6.8	11.9	9.8	17.1	5.7	86
2	Sows	90	32	12.4	7.9	11.9	11.4	19.9	5.4	-109
3	Gilts	90	371	14.2	5.9	10.7	8.9	10.7	5.6	24
3	Gilts	90	371	14.2	5.9	20.0	8.9	20.0	9.1	28
3	Sows	90	181	15.1	5.9	10.7	8.9	10.7	9.0	47
3	Sows	90	181	15.3	5.9	20.0	8.9	20.0	10.8	19
4	Both	100	57	11.2	7.5	10.8	12.7	18.3	4.8	10
5	Gilts	100	24	12.5	7.0	9.8	12.9	18.2	---	126
5	Sows	100	51	12.9	7.9	11.2	13.9	19.5	---	-69
Average[b]	---	90.6	---	12.6	6.0	13.5	9.6	16.6	6.9±0.8	28±20.4

[a]Assuming a corn-soybean meal based diet with 2,405 kcal NE/kg, is the amount in kg of BW gain per kg of extra daily feed above the basal level. For example, increasing the amount of daily feed from 1.8 to 2.7 kg in late gestation, the gilt or sow will be, approximately, 6.9 kg heavier at farrowing. (1) Cromwell et al., 1989, (2) Shelton et al., 2009, (3) Gonçalves et al., 2016b, (4) Miller et al., 2000, (5) Soto et al., 2011.
[b]Weighted based on the number of sows in each study.

Additionally, a recent study using 1,102 PIC females (14.2 and 15.2 total piglets born for gilts and sows, respectively) where 15,979 piglets were weighed individually at birth in commercial research conditions suggests that the effect on birth weight is driven by energy (Figure I3) from starch rather than amino acid intake (Gonçalves et al., 2016b). In the same study, bump fed sows had an increase of 2.1% stillborn compared to sows that were not bump fed (Figure I4). This negative effect was not observed in gilts.

FIGURE I3. ENERGY WAS THE DRIVER OF THE MODEST INCREASE IN BIRTH WEIGHT OF PIC PIGLETS RATHER THAN AMINO ACID INTAKE (1,102 PIC FEMALES AND 15,979 PIGLETS WEIGHED AT BIRTH; GONÇALVES ET AL., 2016B).

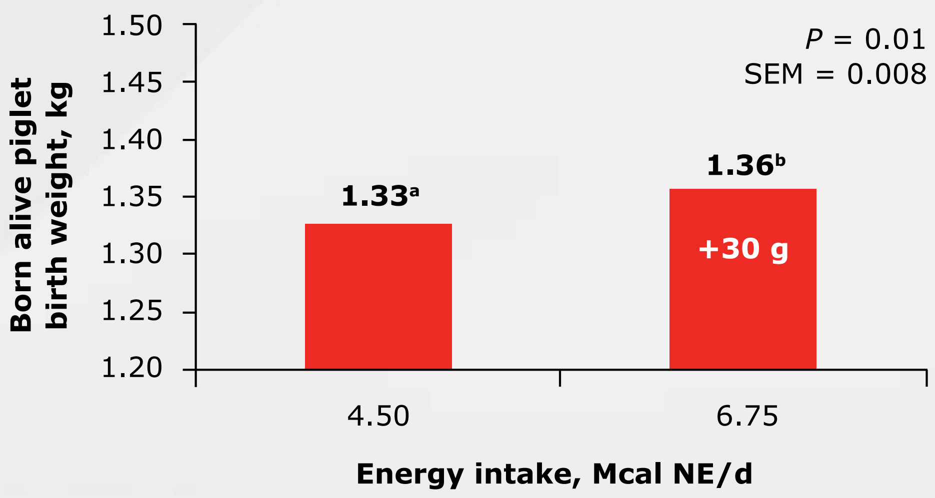
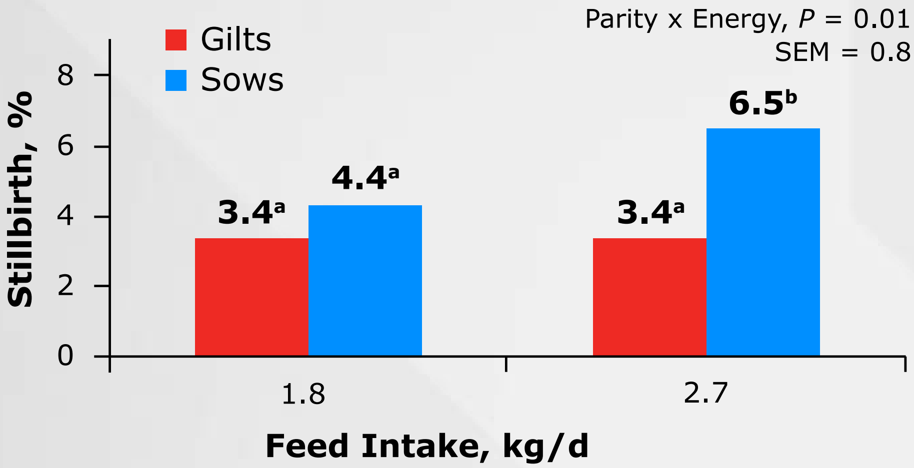
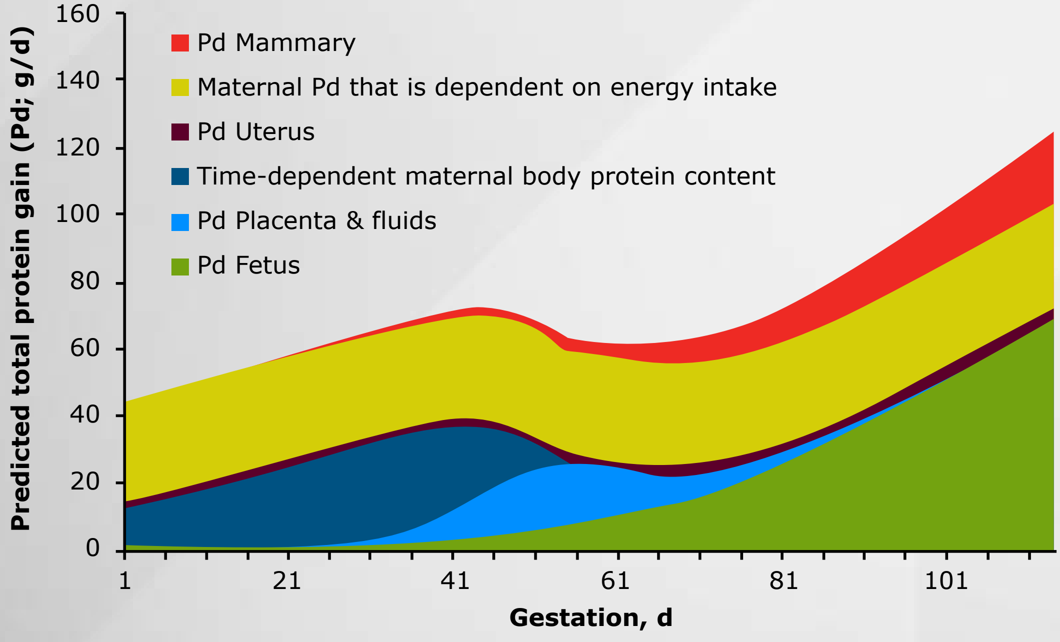


FIGURE 14. BUMP FEEDING CAN INCREASE 2.1% STILLBORNS IN SOWS, BUT NOT IN GILTS (DIET WITH 3307 KCAL ME/kg; GONÇALVES ET AL., 2016B).



The NRC (2012) suggests that requirements during gestation are higher with large litter sizes. However, daily requirements are not only for fetal needs but a high proportion is for maintenance and growth of the breeding female (Figure 15). Thus, nutrient requirements have not changed greatly enough to have a dramatic requirement update for gestating sows. This has been confirmed by multiple studies that were unable to increase sow reproductive performance by increasing energy and amino acid intake (Ampaire and Levesque, 2016; Buis et al., 2016; Gonçalves et al., 2016b; Greiner et al., 2016). It seems that sows prioritize the fetuses in late gestation at the expense of body weight gain (Theil et al., 2014; Gonçalves et al., 2016b). The PIC Global nutrition team along with the top universities and production systems around the globe will continue to monitor requirement changes as litter size and litter weight changes and updated information will be sent through PIC nutrition updates. At this point, bump feeding is only recommended for ideally conditioned gilts and thin sows.

FIGURE 15. PREDICTED TOTAL PROTEIN GAIN FOR DIFFERENT PROTEIN POOLS THROUGHOUT GESTATION (NRC, 2012).



Feeding management during the pre-farrowing period has been an area of increased interest by researchers (Cools et al., 2014; Decaluwe et al., 2014). Cools et al. (2014) showed that providing ad libitum feed prior to farrowing for fat sows reduced weaning weight and piglet growth rate, but no negative effects on sows that were thin or in ideal condition. Anecdotal evidences have made some veterinarians and nutritionists theorize that providing ad libitum feed prior to farrowing, especially in herds with too many fat sows and that induce farrowing may increase the risk of uterine and rectal prolapses. Current views have theorized that long term ad libitum feeding prior to farrowing may have negative effects on the lactating sow and that fat sows may have weakened uterine muscle tone and increased dystocia (Almond et al., 2006). At this point, there is no strong evidence to recommend more than 7.63 Mcal ME or 5.65 Mcal NE per day prior to farrowing to well-conditioned gilts and sows.

LACTATING SOW

The goal during lactation is to maximize sow feed intake to sustain milk production while minimizing body reserves depletion. Thus, sows need to be fed ad libitum (full feeding) from the day of farrowing on.

The positive effects of maximizing feed intake in PIC lactating females have been shown in multiples studies to maximize feed intake, milk yield, and piglet weaning weight (Figure I6) while minimizing sow weight loss (JBS United, 2009; Sulabo et al., 2010). Lactation feed intake (Figure I7) and energy intake (Figure I8) curves for different parities are presented below. Additionally, ensuring that the feeder is correctly adjusted and have fresh feed is extremely important (Figures I9 and I10).

The factors that can affect lactation feed intake are:

- Environment
  - Air velocity
  - Ambient temperature
  - Evaporative cooling
  - Humidity
  - Ventilation rates
- Facilities equipment
  - Feeder design
  - Automated vs. hand feeding
  - Floor surface
  - Crate design
  - Water flow
- Gestation feed intake
  - Body condition at farrowing
- Sow factors
  - Lactation length
  - Litter size
  - Genetics
  - Parity
  - Disease
- Management
  - Feeding frequency
  - Feed allowance
  - Feed freshness
  - Feeder adjustment
  - Water availability

The farm-specific Lys level for lactation depends on the actual litter growth rate and average lactation feed intake by sows. The daily Lys requirement is driven strictly by rate of litter growth and this can vary with health and thermal stress. This needs to be matched with the level of feed consumed. Table I3 could be used to derive farm-specific lysine needs. Start-up farms may need higher Lys level to maximize second litter size (Boyd et al., 2000). In the absence of other information, a typical starting point would be 1.05 to 1.10% SID Lys for stable herds and 1.15 to 1.25% SID Lys for gilts in start-up farms depending on feed intake. Finally, Table I4 shows that high lactation intake reduces sow body weight loss, increases piglet ADG, and reduces wean-to-estrus interval.

FIGURE 16. SOWS PROVIDED AD LIBITUM FEED DURING LACTATION HAVE INCREASED PIGLET WEANING WEIGHT (SULABO ET AL., 2010).

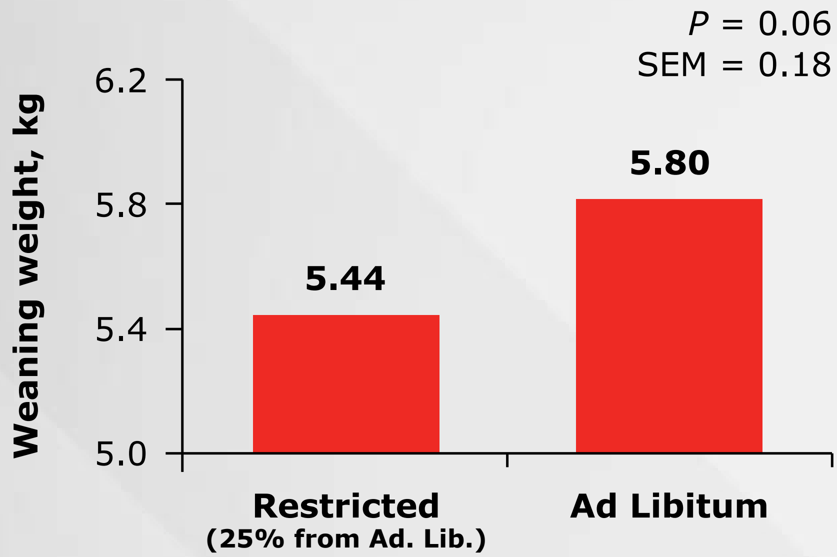


FIGURE 17. FEED INTAKE DURING LACTATION FOR PIC FEMALES WITH DIFFERENT PARITIES (2.50 MCAL NRC NE/kg DIET; CABEZÓN ET AL., 2016B).

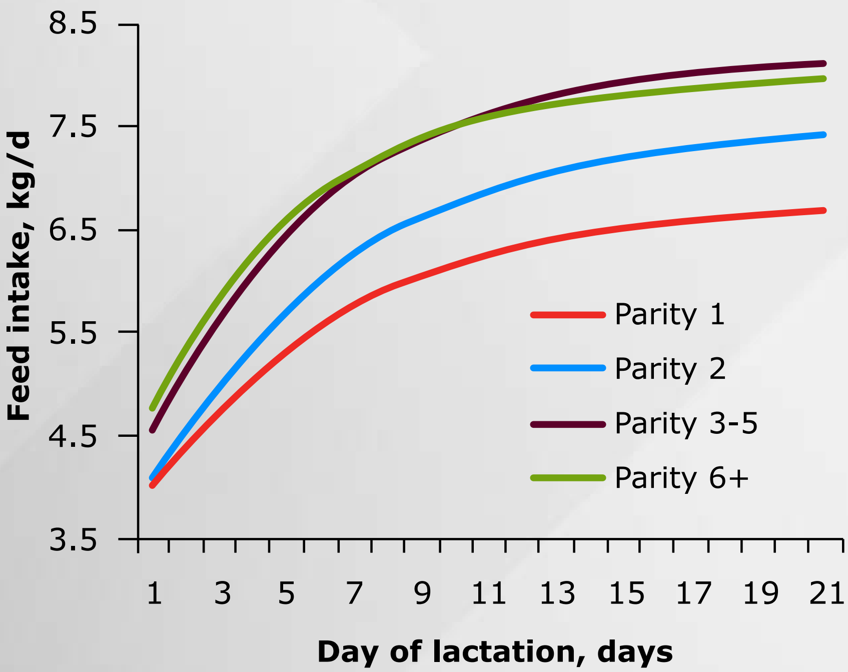


FIGURE I8. NET ENERGY INTAKE DURING LACTATION FOR PIC FEMALES WITH DIFFERENT PARITIES (ADAPTED FROM CABEZÓN ET AL., 2016B).

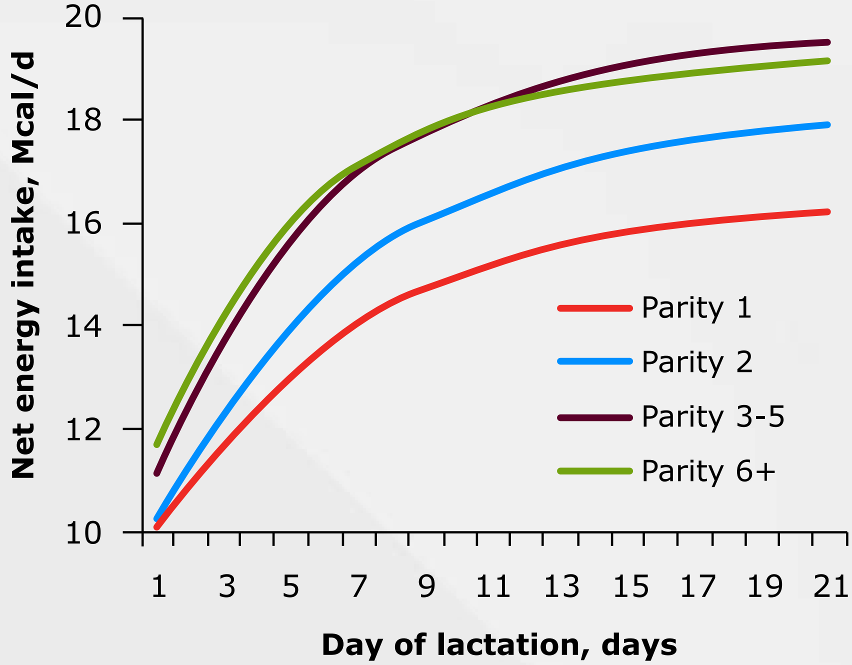


FIGURE I9. CORRECTLY ADJUSTED LACTATION FEEDER WITH FRESH FEED.

FIGURE I10. INCORRECTLY ADJUSTED LACTATION FEEDER WITH MOLDY FEED.

TABLE 13. LACTATION LYSINE LEVELS BASED ON LITTER GROWTH RATE AND SOW FEED INTAKE[a].

LITTER GROWTH RATE, kg/d	AVERAGE FEED INTAKE, kg/d (SID LYSINE, %)						SID LYSINE, g/d
	4.1	4.5	5.0	5.5	5.9	6.4	
2.1	1.19	1.07	0.97	0.89	0.82	0.77	49
2.3	1.34	1.20	1.09	1.00	0.93	0.86	55
2.6	---	1.34	1.22	1.11	1.03	0.96	61
2.8	---	---	1.34	1.23	1.13	1.05	67

[a]Assumes 21 d of lactation. Based on updated Pettigrew equation (Boyd, et al., 2000) and assumes that lysine need is not strictly related to energy intake. The equation is based on a linear relationship between litter growth rate and lysine needs (g/d) to support milk production. SID lysine is based on 86% of total lysine.

TABLE 14. EFFECTS OF FEED INTAKE DURING LACTATION ON WEAN-TO-ESTRUS INTERVAL, BODY WEIGHT LOSS, AND PIGLET AVERAGE DAILY GAIN (GREINER ET AL., UNPUBLISHED).

ADFI, kg	SID LYS, g/d	SOW BW DIFFERENCE, kg	SOW BW DIFFERENCE, %	PIGLET ADG, kg	WEAN-TO-ESTRUS INTERVAL, d
3.2	31.5	-12.0	-5.1	0.22	6.3
4.1	42	-10.4	-4.81	0.23	5.0
5.0	52.5	-2.6	-1.04	0.25	4.4
5.9	63	4.0	2.06	0.25	4.4
6.8	73.5	11.3	5.41	0.25	4.2
8.2	84	13.5	6.57	0.26	4.4
9.1	94.5	12.1	5.57	0.27	4.3

WEANED SOW

The goal of the feeding management of the weaned sow is to start the recovery of the body reserves lost during lactation, to maximize ovulation rate, and ensure high litter size in the subsequent farrowing.

Feeding management of the weaned sow requires a balance between providing enough fresh feed and avoiding wastage (Figures I11 to I13). Where possible, the weaned sow should be fed 2 to 3 times per day. To maximize feed intake, typically, the wean row would have a water nipple for every sow or shared between two sows.

An internal PIC observational study with 670 sows observed that increasing feeding level from 2.6 to 4.2 kg/d during the wean to service period reduced wean to estrus interval from 5.3 to 4.4 d, increased percentage of sows bred by d 7 from 92.8 to 97.5%, and increased subsequent litter size by a full pig from 12.9 to 13.9. Graham et al. (2015) used 637 sows and fed 2.7, 3.6, or 5.4 kg/d of a diet containing approximately 2.44 Mcal NE/kg from weaning to estrus. They achieved NE intakes of 6.5, 8.6, and 12.6 Mcal per day. They found no statistical difference in wean to estrus interval (5.1, 5.0, or 5.0 d), conception rate (95.6, 95.6, or 94.7%), farrowing rate (85.4, 87.0, and 82.3%), or born alive (13.1, 12.9, or 12.9) for sows fed the 2.7, 3.6, or 5.4 kg/d, respectively. Parity of the sow did not influence the response to feeding level. Graham et al. had only ideal and fat sows in their study, thus may have limited the benefit of high feed intake, and thin sows may still benefit from higher feeding levels. Ad libitum feed intake vary with season and parity profile of the weaned group, thus, to maximize feed intake, sows in the weaning row are typically fed twice a day. Additionally, there is great variation on voluntary feed intake among weaned sows. Thus, identifying thin sows with high voluntary feed intake and adjust feed drops accordingly is key to meet their daily needs. Given the limited research and conflicting results in this area to this point, current PIC recommendation is to feed thin sows ad libitum and ideal/fat sows a minimum of 3.6 kg until further research.

FIGURE I11. FEEDER IN THE WEANING ROW WITH NOT ENOUGH FEED.

FIGURE I12. FEEDER IN THE WEANING ROW WITH ADEQUATE AMOUNT OF FEED.

FIGURE I13. FEEDER IN THE WEANING ROW WITH FEED WASTAGE.

NURSERY PIG

The goal of the nursery nutrition program is to maximize feed intake in the first week after weaning with highly digestible diets to ease the transition to simpler diets, such as the finishing diets.

The nursery feeding program corresponds to, approximately, 10 to 15% of total feed cost for producing a pig. Due to the high input costs of the dairy products and high-quality protein in early nursery diets, these ingredients must be reduced quickly after weaning.

Weaning age is an important factor affecting nursery diet formulation because it directly impacts pig performance and profitability. From a nutrition perspective, this is driven by the weaning of a pig that is more physiologically mature and better able to transition to dry feed. Many global production systems are currently increasing weaning age as it is estimated that increasing weaning age from 18 to 21 days of age can increase profitability by approximately US$1 to 2.5 per pig or US$25 to 65 per sow space per year after accounting for increased use of lactation space (Main et al., 2004).

Ad libitum access to feed and water in the nursery phase from the first hour after placement is essential and can greatly impact the weight at the end of the nursery. Weaned pigs are extremely dependent on energy intake and, thus maximizing feed intake is essential. Increasing feed intake during the first week increases digesta flow and decreases proliferation of bacteria in the gut and reduces the incidence of diarrhea. A large epidemiological study indicated that low feed intake after weaning increases the likelihood of developing diarrhea compared to high feed intake (Madec et al., 1998). Therefore, age at weaning and high feed intake after weaning are critical to maximize performance in the nursery phase. For information on management aspects that can improve feed intake after weaning, please refer to the PIC Wean to Finish Manual at http://na.picgenus.com/resources.aspx.

Phase feeding

Based on the development of the digestive system of weaned piglets, typically 3 to 4 diets are fed during the nursery period (Table I5).

3.5 to 7.5 kg pigs

Weaning pigs lighter than 5.5 kg pose a great challenge for the adaptation to the nursery environment and feed and therefore, it is strongly encouraged to develop production flows and systems that do not routinely produce average weaning weights below 5.5 kg. Feeding pigs below 7.5 kg requires a diet designed to maximize feed intake. Therefore, these diets typically have a greater cost per ton compared to the subsequent phases due to greater inclusions of highly digestible carbohydrates and protein sources (i.e., fish meal, animal plasma, enzymatically treated soybean meal, etc.). The most commonly used highly digestible carbohydrates are sources of lactose (dried whey, whey permeate, etc). Other highly digestible carbohydrates sources can replace part of the lactose if input prices offer economic opportunities (i.e., maltose, dextrose, micronized corn, micronized rice, maltodextrin, etc). Care must be taken with the source of lactose and generally, edible-grade lactose sources are the preferred option (Bergstrom et al., 2007). Similarly, there is evidence that different sources of fish meal (i.e., with different crude protein, ash, and oil levels) have different effects on performance (Jones et al., 2015).

The SID lysine in this diet is slightly higher than in the late nursery diets. A standard practice is for a small inclusion of soybean meal to aid in the adaptation of the pigs to a simpler diet in subsequent phases; however, it is important to consider the quality of available soybean meal (i.e., anti-nutritional factors, crude protein levels, and overheating). Research has shown that high inclusion of feed-grade AA (up to 0.50% L-Lysine-HCl) can be used as partial replacement of specialty proteins as long as the requirement of the other essential AA are met (Nemecheck et al., 2011).

7.5 TO 11.5 KG PIGS
This phase has lowering levels of highly digestible protein and carbohydrates sources but increased levels of soybean meal. For lactose sources, dried whey is preferred however high quality whey permeate can partially replace lactose.

11.5 TO 23 KG PIGS
This diet is primarily comprised of a grain source, soybean meal and synthetic amino acids and generally contains very similar ingredients to diets of finishing pigs. It is of extreme importance to adapt the pigs to start the consumption of grain soybean meal-based diets as soon as possible. Minor adjustments in diet formulation of this phase can bring positive economic benefits due to the large impact in the total nursery cost (approximately half of the total nursery feed cost).

TABLE I5. EXAMPLE FEEDING PROGRAM AND FEED BUDGET[a].

WEAN AGE, d WEAN WEIGHT, kg	18 5.5	21 6.5	24 7.5
FEED BUDGET PER PIG, kg			
Phase 1	2.3	1.8	1.6
Phase 2	4.1	4.1	3.4
Phase 3	18.1	18.1	18.1
Total Feed	24.5	24.0	23.1
Total Gain	17.2	16.6	15.9
Feed:Gain	1.42	1.45	1.46

[a]Budget assumes 23 kg end weight for Nursery and F/G shown in nursery nutrient specifications table.

FINISHING PIG

The goal of the finishing phase is to formulate diets that will allow for optimum protein deposition and maximum economic profit.

The steps in diet formulation of finishing pigs are:

1) Determine the most economical energy level;
2) Determine the lysine:calorie ratio to use for the gender;
3) Determine the ratio for the other amino acids;
4) Determine the available or digestible phosphorus level;
5) Set levels of calcium, vitamins, trace minerals, salt, and other ingredients.

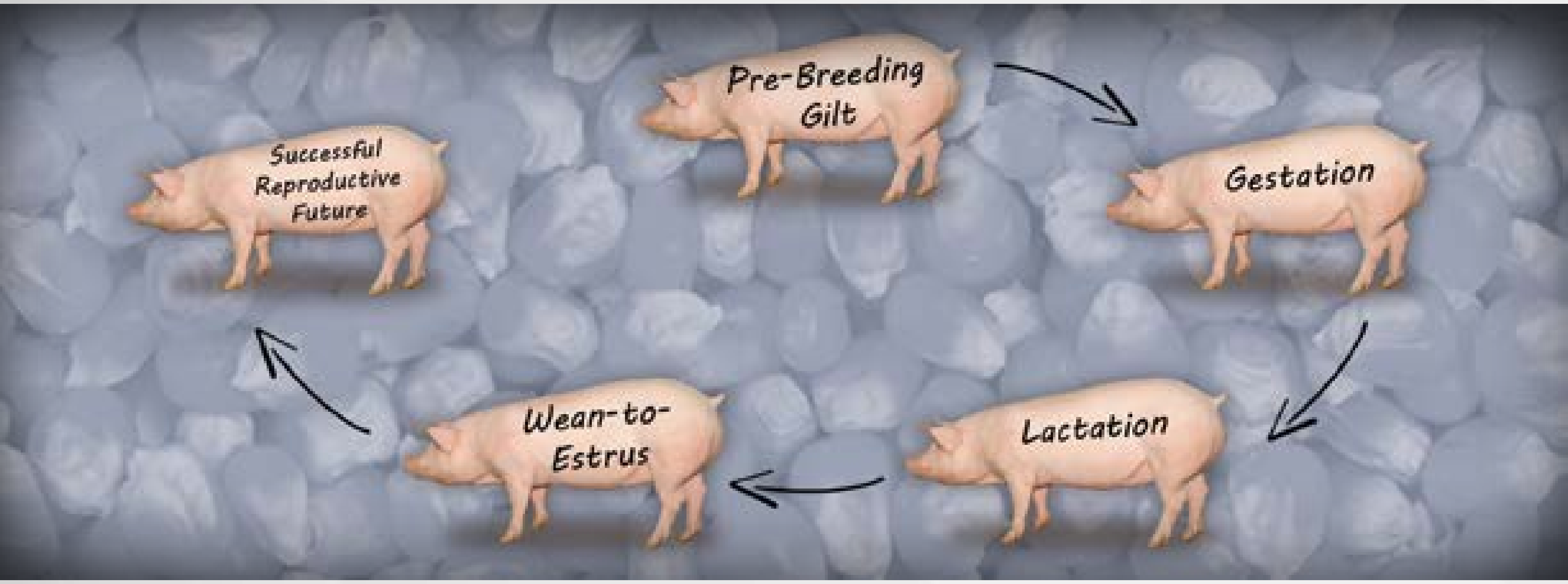
In a review from the literature, Tokach and Gonçalves (2014) summarized the key concepts related to energy and amino acids in the feeding of finishing pigs:

> ***Dietary energy.*** *The pigs' nutrient requirement for lean deposition has two different phases: an energy dependent phase and a protein dependent phase. In the energy dependent phase, feed intake is the limiting factor because the voluntary feed intake is below the pigs' growth potential. On the other hand, in the protein dependent phase, feed intake is not a limiting factor because the voluntary feed intake is above the pigs' requirement for protein deposition (Dunkin et al., 1986). Any consumption beyond that required for maximal protein deposition results in increased fat deposition (Campbell et al., 1988). Whether a pig consumes feed beyond that required for maximal protein deposition depends on several factors, including the pigs' genetic potential, energy density of the diet, and environmental constraints (Ex. heat, space allowance, feeder capacity and adjustment). In general, modern genetics housed under field conditions remain in an energy dependent stage of growth to much heavier body weights than older genetics. Thus, pigs can be full fed to much heavier weights than in the past without depositing excess backfat.*
>
> *During the energy dependent phase of growth, diets should be formulated on a lysine:energy ratio as an increase in feed intake will increase energy consumption and the requirement of amino acids to support the extra protein deposition that can be accomplished with the extra energy. In the protein dependent phase of growth, when pigs are consuming more energy than required for their maximal protein deposition, diets should be formulated to meet the grams per day requirement. Thus, any increase in consumption can be accompanied by a reduction in dietary amino acid levels as the pig will not further increase protein deposition with the extra energy.*
>
> *It is again important to note that the point at which pigs' transition from the energy to protein dependent phase of growth is highly dependent on genotype and gender. Boars will rarely eat enough feed prior to market weights to maximize protein deposition. Similarly, gilts of many genotypes will be in the energy dependent phase of growth to market weights under most field conditions. Conversely, physical-castrated or immunologically-castrated barrows will often have a daily energy intake beyond their energy requirements for maximum protein deposition in the later finishing phases.*
>
> ***Dietary amino acids.*** *Feeding diets below the amino acid requirement will decrease protein deposition and increase fat deposition (Main et al., 2008). Dietary amino acids fed in the late finishing period have the greatest impact on carcass lean content. In general, deficiencies of amino acids that do not have a major impact on feed intake (ex. lysine, methionine, threonine) will result in greater increases in carcass fat content than diets deficient in amino acids that have a greater impact on feed intake when below the requirement (ex. tryptophan, valine, isoleucine).*

Nutrient specifications presented at the end of this manual are for lean growth optimization for market gilts and barrows, respectively. Performance was determined under commercial condition. Lysine specifications are presented as grams per Mcal of NRC NE and ME. There are typically two approaches to feed pens of pigs with both gilts and barrows: 1) use an average SID Lys requirement between gilts and barrows, or 2) use the SID Lys requirement for gilts. An example of how to calculate the percent SID lysine level of a diet is provided after each table. When formulating diets of variable energy levels, one should follow the SID lysine:calorie ratio that is provided in the tables. Actual dietary energy levels require a number of considerations that are specific to market and environment (Usry et al., 1997). This was also discussed in the introductory chapters of this manual.

To help prevent vices and to help realize the expected performance, the minimum nutrient specs below should be followed. Typically, nutritional stimulants for vices can be when amino acids, sodium and/or phosphorus levels are not adequate. Feed outages and feed restrictions can also be risk factors for vices. Other environmental conditions can cause vices as discussed in the PIC Wean to Finish Manual at http://na.picgenus.com/resources.aspx.

SOW FEEDING MILESTONES



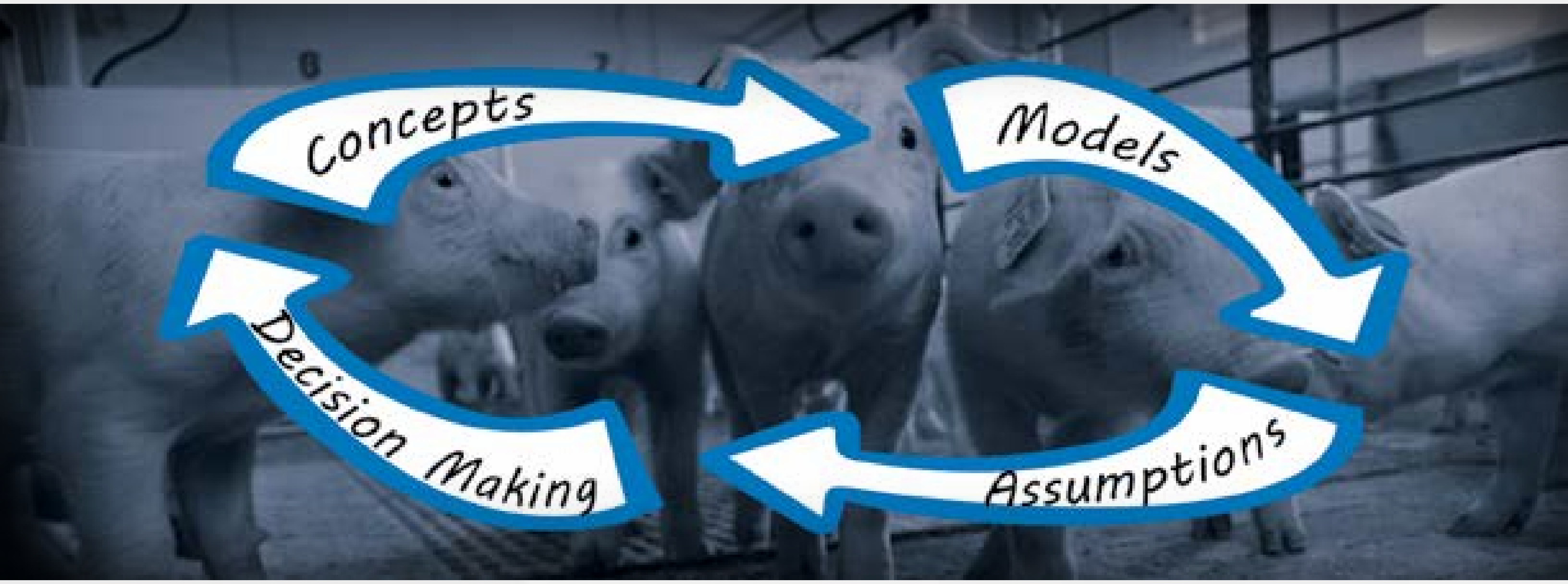
PIC sows are highly feed efficient. Overfeeding and underfeeding must be avoided to maximize the success of PIC sows and their offspring.

TABLE J1. SOW FEEDING TARGETS[a].

MILESTONE	AMOUNT, kg/d	NRC MCAL ME/d	NRC MCAL NE/d	FEED TYPE
Pre-breeding gilt	Full Feed			Gilt Developer[e]
Gestation: 0 to 28 d				
Gilt	1.8	5.9	4.3	Gestation
Sow	2.3	7.3	5.4	Gestation
Gestation: 29 to 90[b] d				
Gilt	1.8	5.9	4.3	Gestation
Sow	1.8	5.9	4.3	Gestation
Gestation: 90 to 114[c] d				
Gilt	2.7	8.8	6.5	Gestation
Sow	1.8	5.9	4.3	Gestation
Regardless of phase of gestation:				
Thin sows	3.2	10.3	7.6	Gestation
Fat sows	1.6	5.1	3.8	Gestation
Pre-farrow 2 to 4 d	2.3	7.3	5.4	Lactation
Lactation: 1 d to weaning	Full Feed[d]			Lactation
Weaning through breeding				Gestation[f]
Thin sows	Full Feed			Gestation[f]
Ideal/fat sows	3.6			Gestation[f]

[a]Assumes 3230 kcal NRC ME/kg or 2390 kcal NRC NE/kg for gestation and 3362 kcal NRC ME/kg or 2488 kcal NRC NE/kg for lactation diets.
[b]Objective is to reclaim body reserves (fat, protein, bone minerals) by 28 d of gestation.
[c]Average gestation length, 116d.
[d]Full feeding or having self-feeders in lactation is common in many farms around the world. This allows the lactating female access to feed 24 hours a day. There should be no restriction for a lactating female. As long as gestation body condition is in line, females will eat as much as they want without a reduced feed intake later in lactation.
[e]After 170 days of age, gilts can be switched to the gestation diet.
[f]Where possible, the weaned sow should be fed 2 to 3 times per day; the gestating sow can be fed once or twice daily. Feeding gestating sows once a day may mitigate the inaccuracy of feed boxes and reduce labor when automatic feeding is not available.

DYNAMIC DECISION MAKING TOOLS



Decision making in a swine production system requires an in depth understanding of all key drivers of the production chain. Thus, it becomes essential for nutritionists to have available a set of tools that can help them navigate through these highly dynamic scenarios and make informed decisions.

PIC ADJUSTED CALORIC EFFICIENCY CALCULATOR BY SIRELINE

There are multiple factors that influence feed efficiency of wean to finish pigs. Three major factors affecting feed efficiency are entry and final body weight, dietary energy, and sireline. Most production systems adjust feed efficiency for final weight in the nursery phase and entry and final weight in the finishing phase in order to have a meaningful comparison between close outs. A recent adjustment that has been added in some production systems is for dietary energy (Gaines et al., 2012). A 1% change in net energy of the diet is expected to change feed efficiency by 1% (Euken, 2012). Dietary energy changes through time because of changing ingredient prices. Therefore, adjusting for dietary energy to compare between close outs and to evaluate performance changes overtime becomes important. Finally, different sirelines have different growth rate and feed efficiency. Thus, using sireline-specific coefficients to adjust for entry and final weights is now possible. Download this tool at http://na.picgenus.com/tech_support/nutrition/adjusted_caloric_efficiency_calculator.aspx

ECONOMIC MODEL FOR OPTIMUM TRYPTOPHAN:LYSINE RATIO FOR NURSERY AND FINISHING PIGS

This tool, developed by Kansas State University and Ajinomoto Heartland, calculates the most economical SID tryptophan (Trp) to lysine (Lys) ratio by taking into account information specific to your production system and market price. The underlying models were developed using PIC genetics under commercial conditions. The tool also takes into account if the production system is marketing pigs on a fixed time versus a fixed weight basis and the impact of different SID Trp:Lys to maximize profitability. Download this tool at http://www.lysine.com/en/tech-info/TrpLys.aspx

OPTIMUM CORN DDGS CALCULATOR

This calculator developed by Kansas State University attempts to consider economic return per pig from change in diet cost, feed efficiency, and growth rate. It does not account for any economic impact on yield or iodine value. Download this tool at http://www.asi.k-state.edu/species/swine/research-and-extension/calculators.html

Section L:

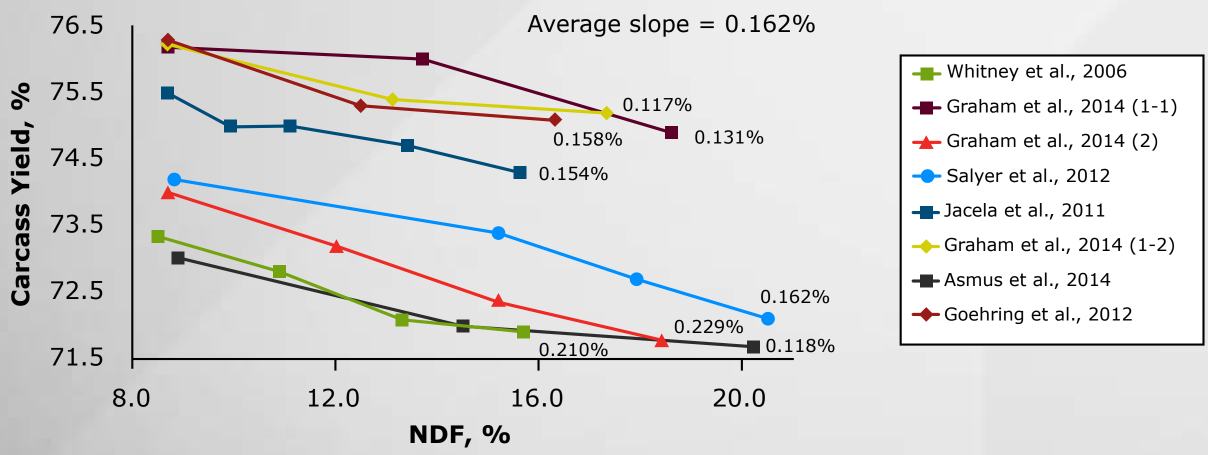
CARCASS QUALITY

Ensuring high carcass yield and pork quality is one of the roles of swine nutrition.

HIGH-FIBER INGREDIENTS ON CARCASS YIELD

It has been shown by multiple studies (Jacela et al., 2010b; Asmus et al., 2014; Coble et al., 2015) that feeding high-fiber ingredients until market can reduce yield. It is recommended that a diet with less than 9% neutral detergent fiber (NDF) be fed for 15 to 20 days prior to market. Figure L1 shows the effects of increasing NDF on carcass yield. This has also been shown to be the most economic approach in multiple economic scenarios; however, there are scenarios when high-fiber ingredients can be cheap enough to economically offset the loss in yield.

FIGURE L1. EFFECTS OF INCREASING NEUTRAL DETERGENT FIBER ON CARCASS YIELD (COBLE ET AL., 2015).



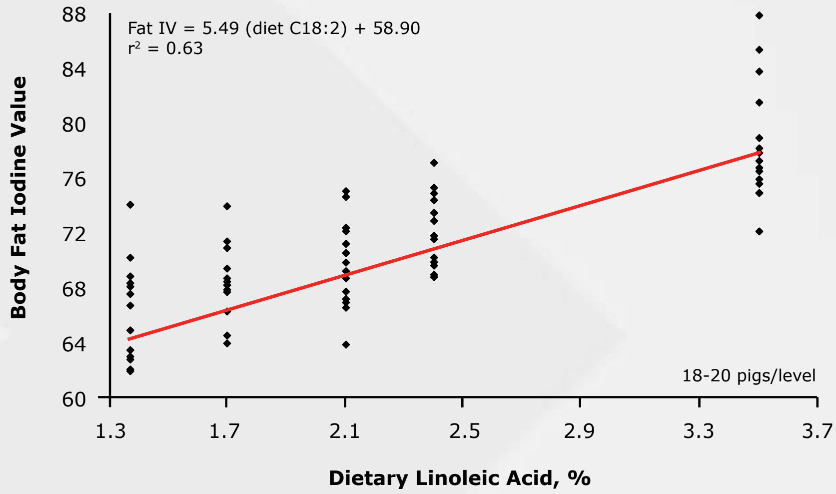
PIC

PORK FAT QUALITY

The current "standard" measure of fat firmness is iodine value. Iodine value is a measure of the unsaturation of fats and is expressed in terms of the amount of iodine absorbed by a fat sample. Basically, the iodine value (IV) determines the unsaturation level of the fat through the number of double bonds in the fatty acids. The focal point of nutrition should be on the "complete" diet and not individual ingredients within the diets. There are multiple prediction equations for iodine value of fat carcass available (Wu et al., 2016), the key is to be consistent on the equation used and when comparing estimates. A predicted backfat IV equation was developed for PIC pigs (predicted backfat IV = 0.32 × (IVP) + 52.4; Technical memo 153). Efforts to manage fat quality should be aligned with the expectations set forth by pork processors.

Research has proven that when dietary linoleic (Figure L2) and linolenic acid is increased this will cause IV to increase. Producers must work closely with their nutritionists to implement ingredients with high linoleic acid in their diets.

FIGURE L2. THE EFFECTS OF DIETARY LINOLEIC ACID ON BODY FAT IODINE VALUE (PIC TECHNICAL MEMO 153).

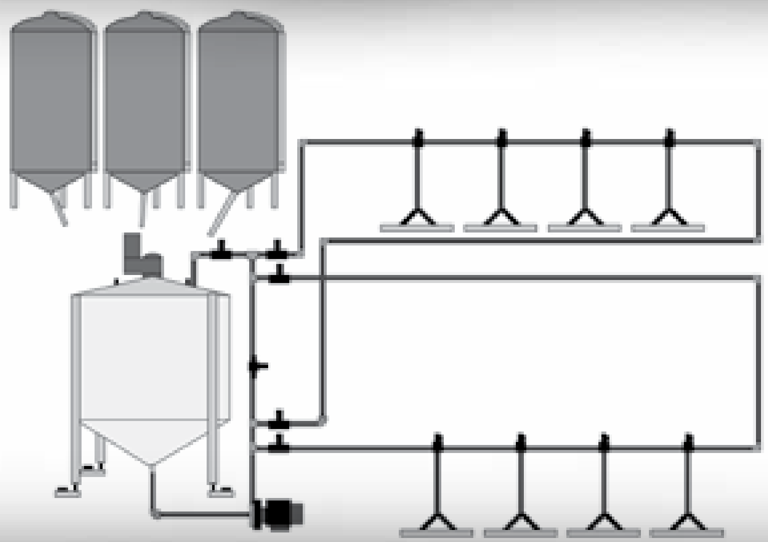


A useful Iodine value prediction spreadsheet is available at http://www.asi.k-state.edu/species/swine/research-and-extension/calculators.html. For more information access PIC's summary on pork fat quality at http://www.pic.com/Images/Users/1/SalesPortal/Newsletters/CuttingEdge/CuttingEdge1stQ10New.pdf

For more in-depth information on fat quality please refer to Apple (2013).

Section M:

FEEDING PIC PIGS UNDER SPECIFIC PROGRAMS



PIC pigs can perform under a variety of environments and production systems with proven performance around the world.

For information regarding feeding PIC pigs under specific programs (requirements of finishing boars, immunocastration, split sex, liquid feeding, feeding under hot environments, outdoor production, Parma and Serrano ham production) please download from here.

Section N:

FEED MANUFACTURING

A successful nutrition program needs not only an adequate diet formulation but also a high-quality, consistent, feed manufacturing process.

Particle size and feed form are discussed below. For more information regarding feed manufacturing download the "Feed manufacturing guidelines for PIC pigs" here.

PARTICLE SIZE

Particle size, depending on the phase of production, can be managed to maximize nutrient digestibility or to maximize longevity. Research has shown that for every 100 micron reduction in grain particle size feed efficiency improves 1.0 to 1.2% (Steinhart, 2011a). Practical particle size recommendations are generally coarser for boars, gilt development, and gestation and finer for lactation, nursery, and finishing. Grain particle size is influenced by testing methodology and therefore, consistent testing practices are a key for successful particle size management.

Boars, gilt development, and gestation

A primary focus for boars, gilt development, and gestation is to maximize longevity while achieving good nutrient digestibility. Previous research has shown that reduced or highly variable particle size can increase the incidence of stomach ulcers (Steinhart, 2011a) and potentially mortality (Goodband et al., 2002). Based on the combination of these factors it is important to follow the acceptable range of grain particle size presented in Table N1.

TABLE N1: GRAIN PARTICLE SIZE FOR PIC PIGS[a].
Lactation

PHASE OF PRODUCTION	AVERAGE GRAIN MICRON, μ
Boars	750-900
Gilt Development	750-900
Gestation	750-900
Lactation	500-600
Nursery[b]	500-600
Finishing[b]	450-550
If only one bin is available for ground grain	550-650
If two bins are available for ground grain (preferred)	
Boars, gilt development, and gestating sows	750-900
Lactation, nursery, and finisher	450-600

[a]If flow agent is used, the optimum range will be reduced by approximately 50 microns.
[b]If diets are pelleted, grain micron can be below 500 microns for nursery and finishing pigs to improve pellet quality.

The focus of grain particle size for lactating sows is to maximize nutrient digestibility and, thus, milk output. Therefore, particle size should range from 500 to 600 microns on average. For every 100 micron reduction from 1200 to 400 microns, litter weight gain increased 1.3% (Wondra et al., 1995).

Nursery
Typically, the grain particle size recommended for the nursery phase is 500 to 600 microns for mash diets and, approximately, 400 microns for pelleted diets. Grain particle sizes in meal diets greater than 600 microns will reduce the digestibility of nutrients and grain particle sizes smaller than 500 microns will decrease feed intake (Woodworth et al., 2015). The response to reducing particle size is similar for corn, sorghum, and wheat (Woodworth et al., 2015).

Finishing
Finishing is the phase of production where nutrient digestibility needs to be maximized the most. Most feed mills will grind grain as fine as possible as long as feed can still flow in bins, feed lines, and feeders. Pelleting diets reduces feed flow ability problems. Woodworth et al. (2015) reviewed the literature and concluded that there is little benefit to reduce below 600 microns in high quality pelleted diets; however, lower particle size often is used to improve pellet quality.

Particle size and ground grain storage capability
As shown in Table N1, if the feed mill only has one bin for ground grain, a compromise between all phases would be 550 to 650 microns; however, it must be noted that feeding gestating sows with fine grain particle size can negatively impact sow mortality. Thus, two ground grain bins are recommended. Another approach is to limit the ground corn inclusion in the gestation diet by using other ingredients, such as DDGS that mitigate some of the negative effects of finely ground grain.

If the feed mill has two storage bins for ground grain, one bin could store grain at 450 to 600 microns for lactation, nursery, and finisher and the other at 750 to 900 microns for boars, gilt development, and gestating sows.

Evaluating particle size

For details about particle size testing methodology (time and whether to use an agitator or flow agent) please refer to Steinhart (2011b) and to Benz and Goodband (2015). For current methodology on particle size evaluation please visit http://www.asi.k-state.edu/species/swine/research-and-extension/particle-size-information.html.

PELLET VS. MEAL

Pigs fed high-quality pellets will have improved feed efficiency. As pellet quality becomes poorer, the advantage in feed efficiency declines until no difference is found when the feed contains 50% fines or more at the feeder. Diet formulation has a major impact on pellet quality. Equally important is checking the pellet mill temperature, cooled pellet temperature, and pellet durability.

For nursery pigs, feeding pelleted diets in the first phase has been shown to increase feed intake and F/G by, approximately, 8% (Groesbeck et al., 2005) and to improve flow ability of the diets (DeRouchey et al., 2007). However, due to inclusion of high amounts of lactose and specialty protein sources, the inclusion of 2 to 3% fat is needed to facilitate the pelleting process. Diets with high inclusion of lactose sources are difficult to pellet, thus, care must be taken when using high inclusion rate (Leaver, 1988). Furthermore, in Phase 1 diets, pelleting temperatures lower than 170°F are typically used to avoid denaturing proteins from these diets that more typically contain higher levels of animal plasma and milk products (Steidinger et al., 2000). For pelleted diets, it is important to have less than 20% fines or otherwise the positive effects of pelleting are likely lost (Nemechek et al., 2012). A recent summary of experiments concluded that feed efficiency would increase 0.03 for each 10% increase in fines (De Jong, 2015).

PIC has performed a number of large scale trials comparing feed form of meal and pellets on feed efficiency. Trial results typically show that feeding high quality pellets to finishing pigs improve feed efficiency in all sire lines by, approximately, 6% (PIC internal data); however, the improvement of full-value pigs may be higher (1 to 3%) in meal diets for some lines.

Section O:

FEEDING SYSTEMS, FEEDER SPACE, DRINKING SYSTEMS

Once a diet is correctly formulated and manufactured, the appropriate feeding system and feeder space need to be in place. Similarly, ad libitum water through adequate drinker availability is a must.

For information on feeding systems, feeder space, and drinking systems please refer to PIC management manuals at http://na.picgenus.com/resources.aspx.

Section P:

NUTRIENT SPECIFICATION TABLES

PIC NUTRIENT SPECIFICATIONS FOR SEXUALLY ACTIVE BOARS (AS-FED).

This tables are presented in percentage for practical reasons. Nutrients should be considered in grams of intake per day based on farm-specific feed intake.

ITEM[a]	UNIT	AMOUNT
NRC NE[b]	kcal/kg	2308
NRC ME	kcal/kg	3086
Estimated feed intake + 5% wastage	kg/day	2.5
Neutral Detergent Fiber (NDF), min.	%	11
Standardized Ileal Digestible amino acids		
Lysine	%	0.62
Methionine + cysteine:Lysine	Ratio	70
Threonine:Lysine	Ratio	74
Tryptophan:Lysine	Ratio	20
Valine:Lysine	Ratio	67
Isoleucine:Lysine	Ratio	58
Leucine:Lysine	Ratio	65
Histidine:Lysine	Ratio	30
Phenylalanine + tyrosine:Lysine	Ratio	114
L-Lysine-HCl, max.[c]	%	0.25
Minerals[d]		
Total calcium	%	0.80
Av. phosphorus	%	0.40
STTD phosphorus[e]	%	0.40
Sodium[f]	%	0.22
Chloride	%	0.22
Added trace minerals		
Zinc	PPM	125
Iron	PPM	100
Manganese	PPM	50
Copper	PPM	15
Iodine	PPM	0.62
Selenium[g]	PPM	0.3
Added vitamins[h,i]	per kg diet	
Vitamin A	IU/kg	11025
Vitamin D	IU/kg	2000
Vitamin E	IU/kg	110
Vitamin K (menadione)	mg/kg	4
Choline[j]	mg/kg	660
Niacin	mg/kg	44
Riboflavin	mg/kg	10
Pantothenic acid	mg/kg	33
Vitamin B12	mcg/kg	37
Folic Acid	mcg/kg	1655
Biotin	mcg/kg	550
Thiamin	mg/kg	2
Vitamin B6 (Pyridoxine)	mg/kg	3.3
Linoleic acid	%	1.90

[a]These feed specifications should be used as a guide. They require adjustment for feed intake, local conditions, and markets.
[b]Net energy was estimated using a conversion factor of 0.74 from metabolizable energy. For different diet compositions this may vary (i.e., 0.73 to 0.76) depending on the ingredients used.
[c]L-Lysine-HCl maximum inclusions are recommended based on corn and soybean meal based diets and are to be used as a guideline.
[d]Calcium and phosphorus values are considering release due to phytase; however, release values need to be based on suppliers' recommendation established from peer-reviewed scientific research.
[e]Standardized total tract digestible phosphorus.
[f]Sodium: if sodium levels are not known in major ingredients use at least 80% of sodium coming from sodium chloride.
[g]Organic selenium is typically used for boars.
[h]Boars tend to be 2.5x NRC for vitamins in general with extra margins set for several micronutrients. Add 5.1 IU of Vitamin E/kg of complete diet for each 1% fat above 3% total dietary fat.
[i]Pelleting and (or) expanding decreases vitamin stability by 10-12% and 15-20% respectively. Consult vitamin manufacturer to verify their specific vitamin stability under pelleting conditions so additional fortification can be made as required.

PIC NUTRIENT SPECIFICATIONS FOR GILT DEVELOPMENT (AS-FED).

This tables are presented in percentage for practical reasons. Nutrients should be considered in grams of intake per day based on farm-specific feed intake.

ITEM[a]	UNIT	BODY WEIGHT, kg				
		23-40	40-60	60-80	80-105	105-135
Standardized Ileal Digestible amino acids						
Lysine:Calorie NE[b]	g/Mcal	4.94	4.18	3.58	3.17	3.03
Lysine:Calorie ME[b]	g/Mcal	3.67	3.10	2.65	2.35	2.26
Methionine + cysteine:Lysine	Ratio	56	57	57	58	58
Threonine:Lysine	Ratio	61	62	63	64	66
Tryptophan:Lysine	Ratio	18	18	18	18	18
Valine:Lysine	Ratio	67	67	67	67	67
Isoleucine:Lysine	Ratio	56	56	56	56	56
Leucine:Lysine	Ratio	101	101	101	101	102
Histidine:Lysine	Ratio	34	34	34	34	34
Phenylalanine + tyrosine:Lysine	Ratio	94	94	94	95	96
L-Lysine-HCl, max.[c]	%	0.45	0.40	0.35	0.275	0.25
Minerals[d]						
Total calcium	%	0.70	0.70	0.70	0.70	0.70
Av. phosphorus	%	0.35	0.35	0.35	0.35	0.35
STTD phosphorus[e]	%	0.35	0.35	0.35	0.35	0.35
Sodium[f]	%	0.25	0.25	0.25	0.25	0.25
Chloride	%	0.25	0.25	0.25	0.25	0.25
Added trace minerals						
Zinc	PPM	120	120	125	125	125
Iron	PPM	80	80	100	100	100
Manganese	PPM	30	30	50	50	50
Copper	PPM	12	12	15	15	15
Iodine	PPM	0.4	0.4	0.35	0.35	0.35
Selenium	PPM	0.30	0.30	0.30	0.30	0.30
Added vitamins[g]	per kg diet					
Vitamin A	IU/kg	6615	6615	9920	9920	9920
Vitamin D	IU/kg	1215	1215	1985	1985	1985
Vitamin E[h]	IU/kg	33	33	66	66	66
Vitamin K	mg/kg	3.3	3.3	4.4	4.4	4.4
Choline[i]	mg/kg	---	---	660	660	660
Niacin	mg/kg	40	40	44	44	44
Riboflavin	mg/kg	6	6	10	10	10
Pantothenic acid	mg/kg	20	20	33	33	33
Vitamin B12	mcg/kg	26	26	37	37	37
Folic Acid	mcg/kg	---	---	1325	1325	1325
Biotin	mcg/kg	---	---	220	220	220
Thiamine	mg/kg	---	---	2.2	2.2	2.2
Pyridoxine	mg/kg	---	---	3.3	3.3	3.3

[a]These feed specifications should be used as a guide. They require adjustment for feed intake, local conditions, and markets.
[b]Lysine specifications are based on a series of 27 trials conducted under commercial research conditions (9 of them in partnership with JBS United). These equations are only valid for pigs from 23 to 135 kg BW.
Equation used for Lysine requirement (Gilts), g/Mcal ME: 0.000043*(weight*2.2046)^2 - 0.02154*(weight*2.2046) + 4.9538
Equation used for Lysine requirement (Gilts), g/Mcal NE: 0.000056*(weight*2.2046)^2 - 0.02844*(weight*2.2046) + 6.6391
Figuring SID Lysine % for the diet for the 23-40 kg weight phase: (Lysine:Calorie ratio * NRC NE of diet/kg)/10000
Example = (4.94*2420)/10000= 1.20% SID Lysine.
[c]L-Lysine-HCl maximum inclusions are recommended based on corn and soybean meal based diets and are to be used as a guideline.
[d]Calcium and phosphorus values are considering release due to phytase; however, release values need to be based on suppliers' recommendation established from peer-reviewed scientific research.
[e]Standardized total tract digestible phosphorus.
[f]Sodium: if sodium levels are not known in major ingredients use at least 80% of sodium coming from sodium chloride.
[g]Pelleting and (or) expanding decreases vitamin stability by 10-12% and 15-20% respectively. Consult vitamin manufacturer to verify their specific vitamin stability under pelleting conditions so additional fortification can be made as required.
[h]Add 5.1 IU of Vitamin E/kg of complete diet for each 1% fat above 3% total dietary fat.
[i]Choline content is based on corn and soybean meal based diets. For other diet compositions, a total level of 1325 mg of choline per kg should be achieved.

PIC NUTRIENT SPECIFICATIONS FOR GESTATING GILTS AND SOWS IN IDEAL BODY CONDITION (AS-FED).

This tables are presented in percentage for practical reasons. Nutrients should be considered in grams of intake per day based on farm-specific feed intake.

ITEM[a,b]	UNIT	GILTS	SOWS	HERD
NRC Net energy (NE) diet[c]	kcal/kg	2390	2390	2390
NRC NE, d 0-28	Mcal/d	4.3	5.4	---
NRC NE, d 28-90	Mcal/d	4.3	4.3	---
NRC NE, d 90-112	Mcal/d	6.5	4.3	---
NRC Metabolizable energy (ME) diet	kcal/kg	3230	3230	3230
NRC ME, d 0-28	Mcal/d	5.9	7.3	---
NRC ME, d 28-90	Mcal/d	5.9	5.9	---
NRC ME, d 90-112	Mcal/d	8.8	5.9	---
Estimated feed intake + 5% wastage[d,e]	kg/day	2.18	2.09	2.13
Standardized Ileal Digestible amino acids				
Lysine	%	0.60	0.60	0.60
Methionine + cysteine:Lysine	Ratio	70	70	70
Threonine:Lysine	Ratio	76	76	76
Tryptophan:Lysine	Ratio	19	19	19
Valine:Lysine	Ratio	71	71	71
Isoleucine:Lysine	Ratio	58	58	58
Leucine:Lysine	Ratio	92	92	92
Histidine:Lysine	Ratio	35	35	35
Phenylalanine + tyrosine:Lysine	Ratio	96	96	96
L-Lysine-HCl, max.[f]	%	0.25	0.25	0.25
Minerals[g]				
Total calcium	%	0.85	0.85	0.85
Av. phosphorus	%	0.40	0.40	0.40
STTD phosphorus[h]	%	0.44	0.44	0.44
Sodium[i]	%	0.24	0.24	0.24
Chloride	%	0.24	0.24	0.24
Added trace minerals				
Zinc	PPM	125	125	125
Iron	PPM	100	100	100
Manganese	PPM	50	50	50
Copper	PPM	15	15	15
Iodine	PPM	0.35	0.35	0.35
Selenium	PPM	0.3	0.3	0.3
Added vitamins[j,k]	per kg diet			
Vitamin A	IU/kg	9920	9920	9920
Vitamin D	IU/kg	1985	1985	1985
Vitamin E[l]	IU/kg	66	66	66
Vitamin K (menadione)	mg/kg	4.4	4.4	4.4
Choline[m]	mg/kg	660	660	660
Niacin	mg/kg	44	44	44
Riboflavin	mg/kg	10	10	10
Pantothenic acid	mg/kg	33	33	33
Vitamin B12	mcg/kg	37	37	37
Folic Acid	mcg/kg	1325	1325	1325
Biotin	mcg/kg	220	220	220
Thiamin	mg/kg	2.2	2.2	2.2
Vitamin B6 (Pyridoxine)	mg/kg	3.3	3.3	3.3

[a]These feed specifications should be used as a guide. They require adjustment for feed intake, local conditions, and markets.
[b]Assumption: Gilt – 135 kg body weight (BW) at breeding and 34 kg net maternal gain, Sow – 180 kg BW at breeding and 9 kg net maternal gain.
[c]Net energy was estimated using a conversion factor of 0.74 from metabolizable energy. For different diet compositions this may vary (i.e., 0.73 to 0.76) depending on the ingredients used.
[d]For thin sows, provide 10.2 Mcal ME or 7.6 Mcal NE per day until recovery. For fat sows, provide 5.2 Mcal ME or 3.8 Mcal NE per day until return to ideal condition.
[e]If gestating gilts or sows are fed less than the recommended amount of feed per day, the percentage levels need to be adjusted to achieve the minimum amount in grams per day of each nutrient.
[f]L-Lysine-HCl maximum inclusions are recommended based on corn and soybean meal based diets and are to be used as a guideline.
[g]Calcium and phosphorus values are considering release due to phytase; however, release values need to be based on suppliers' recommendation established from peer-reviewed scientific research.
[h]Standardized total tract digestible phosphorus.
[i]Sodium: if sodium levels are not known in major ingredients use at least 80% of sodium coming from sodium chloride.
[j]Gilts and sows vitamins tend to be 2.5 x NRC in general.
[k]Pelleting and (or) expanding decreases vitamin stability by 10-12% and 15-20% respectively. Consult vitamin manufacturer to verify their specific vitamin stability under pelleting conditions so additional fortification can be made as required.
[l]Add 5.1 IU of Vitamin E/kg of complete diet for each 1% fat above 3% total dietary fat.
[m]Choline content is based on corn and soybean meal based diets. For other diet compositions, a total level of 1325 mg of

PIC NUTRIENT SPECIFICATIONS FOR LACTATING GILTS AND SOWS (AS-FED).

This tables are presented in percentage for practical reasons. Nutrients should be considered in grams of intake per day based on farm-specific feed intake.

ITEM[a,b]	UNIT	GILTS	SOWS	HERD
Net Weight Body Loss[b]	%	<10	<10	<10
Fat Loss, Max[b]	mm	0-2	0-2	0-2
Litter Growth[b]	kg/d	2.50	2.72	2.61
NRC NE[c]	kcal/kg	2489	2489	2489
NRC NE	Mcal/d	13.0	15.4	14.9
NRC ME	kcal/kg	3362	3362	3362
NRC ME	Mcal/d	17.5	20.7	20.1
Average Feed Intake (21-d lactation)	kg/d	5,22	6,01	5,99
Average Feed Intake (28-d lactation)	kg/d	5,49	6,44	6,26
Standardized Ileal Digestible amino acids				
Lysine	g/d	63	63	63
Lysine (21-d lactation)	%	1.21	1.02	1.05
Lysine (28-d lactation)	%	1.15	0.98	1.01
Methionine + cysteine:Lysine	Ratio	53	53	53
Threonine:Lysine	Ratio	64	64	64
Tryptophan:Lysine	Ratio	19	19	19
Valine:Lysine	Ratio	64	64	64
Isoleucine:Lysine	Ratio	56	56	56
Leucine:Lysine	Ratio	114	113	114
Histidine:Lysine	Ratio	40	40	40
Phenylalanine + tyrosine:Lysine	Ratio	113	112	113
L-Lysine-HCl, max.[d]	%	0.45	0.45	0.45
Minerals[e]				
Total calcium	%	0.85	0.85	0.85
Av. phosphorus	%	0.40	0.40	0.40
STTD phosphorus[f]	%	0.44	0.44	0.44
Sodium[g]	%	0.24	0.24	0.24
Chloride	%	0.24	0.24	0.24
Added trace minerals				
Zinc	PPM	125	125	125
Iron	PPM	100	100	100
Manganese	PPM	50	50	50
Copper	PPM	15	15	15
Iodine	PPM	0.35	0.35	0.35
Selenium	PPM	0.3	0.3	0.3
Added vitamins[h,i]	per kg diet			
Vitamin A	IU/kg	9920	9920	9920
Vitamin D	IU/kg	1985	1985	1985
Vitamin E[j]	IU/kg	66	66	66
Vitamin K (menadione)	mg/kg	4.4	4.4	4.4
Choline[k]	mg/kg	660	660	660
Niacin	mg/kg	44	44	44
Riboflavin	mg/kg	10	10	10
Pantothenic acid	mg/kg	33	33	33
Vitamin B12	mcg/kg	37	37	37
Folic Acid	mcg/kg	1325	1325	1325
Biotin	mcg/kg	220	220	220
Thiamin	mg/kg	2.2	2.2	2.2
Vitamin B6 (Pyridoxine)	mg/kg	3.3	3.3	3.3

[a]These feed specifications should be used as a guide. They require adjustment for feed intake, local conditions, and markets.
[b]Assumption: Gilt – 135 kg body weight (BW) at breeding and 34 kg net maternal gain, sow – 180 kg BW at breeding and 9 kg net maternal gain. Assuming 175 kg BW post farrowing, 10 kg weight loss and 2500-2800 g/d litter growth.
[c]Net energy was estimated using a conversion factor of 0.74 from metabolizable energy. For different diet compositions this may vary (i.e., 0.73 to 0.76) depending on the ingredients used.
[d]L-Lysine-HCl maximum inclusions are recommended based on corn and soybean meal based diets and are to be used as a guideline.
[e]Calcium and phosphorus values are considering release due to phytase; however, release values need to be based on suppliers' recommendation established from peer-reviewed scientific research.
[f]Standardized total tract digestible phosphorus.
[g]Sodium: if sodium levels are not known in major ingredients use at least 80% of sodium coming from sodium chloride.
[h]Sows tend to be 2.5 x NRC for vitamins in general.
[i]Pelleting and (or) expanding decreases vitamin stability by 10-12% and 15-20% respectively. Consult vitamin manufacturer to verify their specific vitamin stability under pelleting conditions so additional fortification can be made as required.
[j]Add 5.1 IU of Vitamin E/kg of complete diet for each 1% fat above 3% total dietary fat.
[k]Choline content is based on corn and soybean meal based diets. For other diet compositions, a total level of 1325 mg of choline per kg should be achieved.

PIC NUTRIENT SPECIFICATIONS FOR NURSERY PIGS (AS-FED).

This tables are presented in percentage for practical reasons. Nutrients should be considered in grams of intake per day based on farm-specific feed intake.

		BODY WEIGHT, kg			
ITEM[a]	UNIT	3.5-5.5	5.5-7.5	7.5-11.5	11.5-23
Growth rate	lb/d	---	0,23	0,41	0,66
Feed intake[b]	lb/d	---	0,26	0,54	1,00
Feed:gain	Ratio	---	1.16	1.31	1.52
NRC NE[c,d]	kcal/lb	2513	2513	2513	2513
NRC ME[c]	kcal/lb	3395	3395	3395	3395
Standardized Ileal Digestible (SID) Amino acids[e]					
Lysine	%	1.46	1.46	1.42	1.33
Methionine + cysteine:Lysine	Ratio	58	58	58	58
Threonine: Lysine	Ratio	60	60	60	60
Tryptophan: Lysine	Ratio	20	20	19	19
Valine: Lysine	Ratio	67	67	67	67
Isoleucine:Lysine[f]	Ratio	55	55	55	55
Leucine:Lysine	Ratio	100	100	100	100
Histidine:Lysine	Ratio	34	34	34	34
Phenilalanine+Tyrosine:Lysine	Ratio	92	92	92	92
Minerals[e,g]					
Total calcium	%	0.85	0.85	0.79	0.71
Available phosphorus	%	0.55	0.55	0.40	0.37
STTD phosphorus[h]	%	0.57	0.57	0.44	0.39
Sodium[i]	%	0.35-0.60	0.35-0.40	0.25-0.30	0.25
Chloride	%	0.35-0.60	0.35-0.40	0.25-0.30	0.25
Added trace minerals					
Zinc[j]	PPM	150	150	150	150
Iron[k]	PPM	200	200	200	200
Manganese	PPM	50	50	50	50
Copper[l]	PPM	18	18	18	18
Iodine	PPM	0.65	0.65	0.65	0.65
Selenium	PPM	0.30	0.30	0.30	0.30
Added vitamins[m,n]	per lb diet				
Vitamin A	IU/lb	11025	11025	11025	11025
Vitamin D	IU/lb	1765	1765	1765	1765
Vitamin E	IU/lb	85	85	85	85
Vitamin K	mg/lb	5.5	5.5	5.5	5.5
Choline[o]	mg/lb	595	595	595	595
Niacin	mg/lb	70	70	70	70
Riboflavin	mg/lb	13	13	13	13
Pantothenic acid	mg/lb	40	40	40	40
Vitamin B12	mcg/lb	55	55	55	55
Folic Acid	mcg/lb	1050	1050	1050	1050
Biotin	mcg/lb	275	275	275	275
Thiamine	mg/lb	3.5	3.5	3.5	3.5
Pyridoxine	mg/lb	7.0	7.0	7.0	7.0
Maximum specifications					
Soybean meal[p]	%	15	20	28	28-32
Total Lysine:CP[q]	Ratio	7.1	7.1	7.1	7.1
Recommended specifications					
Highly dig. protein[r]	%	8-12	5-10	3-5	---
Highly dig. carbohydrate[s]	%	20	15	7.5	---
Added fat[t]	%	2 to 3	3 to 5	3 to 5	3 to 5

[a]These specifications should be used as a guideline and adapted for local conditions, legislation, and markets. All values using NRC (2012) ingredient loading values.
[b]Average Intake shown for 11,5-23 kg pig assumes pelleted. Add 5% for grind and mix.
[c]Energy levels are guidelines and should be adjusted according to market price and specific-farm scenario.
[d]Net energy was estimated using a conversion factor of 0.74 from metabolizable energy. For different diet compositions this may vary (i.e., 0.73 to 0.76) depending on the ingredients used.
[e]Nutrients should be factored accordingly when feeding differing energy values.
[f]Diet with < 2% blood cells. If great than 2% blood cells the SID Isoleucine:Lysine should be 0.60.
[g]Calcium and phosphorus values are considering release due to phytase; however, release values need to be based on suppliers' recommendation established from peer-reviewed scientific research.
[h]Standardized total tract digestible phosphorus.
[i]Sodium: if sodium levels are not known in major ingredients use at least 80% of sodium coming from sodium chloride.
[j]Maximum duration from weaning to 11,5 kg BW. High levels of zinc to improve growth performance follow: < 7,5 kg use 3000 PPM; and for 7,5-11,5 kg use 2000 PPM. Different countries have different regulations regarding the use of zinc as growth promoter, follow your country's regulation.
[k]Supplemental iron are 200 ppm because of the substantial iron content of di-calcium phosphate and because high iron intake encourages E. coli proliferation in the young pig.
[l]High levels of copper to improve growth performance is 250 PPM for 11,5-23 kg pigs. Inorganic forms assumed. Different countries have different regulations regarding the use of copper as growth promoter, follow your country's regulation.
[m]Vitamins supplemented at, approximately, 4 x NRC (2012) on average. Add 5,1 IU of Vitamin E/kg of complete diet for each 1% fat above 3% total dietary fat.
[n]Pelleting and (or) expanding decreases vitamin stability by 10-12% and 15-20% respectively. Consult vitamin manufacturer to verify their specific vitamin stability under pelleting conditions so additional fortification can be made as required.
[o]Choline content is based on corn and soybean meal based diets. For other diet compositions, a total level of 1325 mg of choline per kg should be achieved.
[p]Suggested levels for commercial production and good to high health. High health pigs can tolerate higher levels of SBM (30% for 7,5-11,5 kg and 32% for 11,5-23 kg BW).
[q]Based on Ratliff et al., 2005.
[r]For example, high quality fish meal, animal plasma, blood meal, enzymatically treated soybean meal, etc.;
[s]The most common highly digestible carbohydrate source is edible-grade lactose. Other highly digestible carbohydrates source can replace part of lactose if economical (i.e., maltose, dextrose, micronized corn, micronized rice, maltodextrin, etc).
[t]If Phase 1 is pelleted, use at least 2 to 3% added fat to facilitate the pelleting process.

PIC NUTRIENT SPECIFICATIONS FOR FINISHING GILTS (AS-FED).

This tables are presented in percentage for practical reasons. Nutrients should be considered in grams of intake per day based on farm-specific feed intake.

ITEM[a]	UNIT	BODY WEIGHT, kg						
		23-40	40-60	60-80	80-105	105 -MARKET	105-MARKET W/ RACTOPAMINE <21 D	105-MARKET W/ RACTOPAMINE >21 D
Growth rate	kg/d	0.81	0.87	0.98	0.94	0.90	1.02	0.98
Feed intake	kg/d	1.36	1.94	2.54	2.59	2.71	2.77	2.81
Feed:gain	Ratio	1.69	2.24	2.60	2.75	3.02	2.71	2.88
Standardized Ileal Digestible amino acids								
Lysine:Calorie NE[c]	g/Mcal	4.94	4.18	3.58	3.17	3.03	4.24	4.10
Lysine:Calorie ME[c]	g/Mcal	3.67	3.10	2.65	2.35	2.26	3.17	3.06
Methionine + cysteine:Lysine	Ratio	56	57	57	58	58	58	58
Threonine:Lysine	Ratio	61	62	63	64	66	68	68
Tryptophan:Lysine	Ratio	18	18	18	18	18	18	18
Valine:Lysine	Ratio	67	67	67	67	67	67	67
Isoleucine:Lysine	Ratio	56	56	56	56	56	56	56
Leucine:Lysine	Ratio	101	101	101	101	102	100	100
Histidine:Lysine	Ratio	34	34	34	34	34	33	33
Phenylalanine + tyrosine:Lysine	Ratio	94	94	94	95	96	94	95
L-Lysine-HCl, max.[b]	%	0.45	0.40	0.35	0.28	0.25	0.45	0.45
Minerals[d]								
Total calcium	%	0.71	0.65	0.60	0.55	0.50	0.64	0.63
Available phosphorus	%	0.30	0.28	0.26	0.25	0.24	0.28	0.27
STTD phosphorus[e]	%	0.33	0.30	0.28	0.26	0.24	0.30	0.29
Sodium[f]	%	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Chloride	%	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Added trace minerals								
Zinc	PPM	120	120	120	100	100	100	100
Iron	PPM	80	80	80	66	66	66	66
Manganese	PPM	30	30	30	25	25	25	25
Copper	PPM	12	12	12	10	10	10	10
Iodine	PPM	0.4	0.4	0.4	0.33	0.33	0.33	0.33
Selenium	PPM	0.30	0.30	0.30	0.25	0.25	0.25	0.25
Added vitamins[g,h]	per kg diet							
Vitamin A	IU/kg	6615	6615	6615	5510	5510	5510	5510
Vitamin D	IU/kg	1215	1215	1215	1015	1015	1015	1015
Vitamin E[i]	IU/kg	33	33	33	28	28	28	28
Vitamin K	mg/kg	3.3	3.3	3.3	2.8	2.8	2.8	2.8
Niacin	mg/kg	40	40	40	31	31	31	31
Riboflavin	mg/kg	5.7	5.7	5.7	4.9	4.9	4.9	4.9
Pantothenic acid	mg/kg	20	20	20	17	17	17	17
Vitamin B12	mcg/kg	26	26	26	22	22	22	22

[a]These feed specifications should be used as a guide. They require adjustment for feed intake, local conditions, and markets.

[b]Lysine specifications are based on a series of 27 trials conducted under commercial research conditions (9 of them in partnership with JBS United). These equations are only valid for pigs from 23 to 135 kg BW.

Equation used for Lysine requirement (Gilts), g/Mcal ME: 0.000043*(weight*2.2046)^2 - 0.02154*(weight*2.2046) + 4.9538

Equation used for Lysine requirement (Gilts), g/Mcal NE: 0.000056*(weight*2.2046)^2 - 0.02844*(weight*2.2046) + 6.6391

Figuring SID Lysine % for the diet for the 23-40 kg weight phase: (Lysine:Calorie ratio * NRC NE of diet/kg)/10000

Example = (4.94*2425)/10000= 1.20% SID Lysine.

[c]L-Lysine-HCl maximum inclusions are recommended based on corn and soybean meal based diets and are to be used as a guideline.

[d]Calcium and phosphorus values are considering release due to phytase; however, release values need to be based on suppliers' recommendation established from peer-reviewed scientific research.

[e]Standardized total tract digestible phosphorus.

[f]Sodium: if sodium levels are not known in major ingredients use at least 80% of sodium coming from sodium chloride.

[g]Vitamins in the finishing phase are approximately at 2.5 x NRC.

[h]Pelleting and (or) expanding decreases vitamin stability by 10-12% and 15-20% respectively. Consult vitamin manufacturer to verify their specific vitamin stability under pelleting conditions so additional fortification can be made as required.

[i]Add 5.1 IU of Vitamin E/kg of complete diet for each 1% fat above 3% total dietary fat.

PIC NUTRIENT SPECIFICATIONS FOR FINISHING BARROWS (AS-FED).

This tables are presented in percentage for practical reasons. Nutrients should be considered in grams of intake per day based on farm-specific feed intake.

		BODY WEIGHT, lb						
							105-MARKET W/ RACTOPAMINE	
ITEM[a]	UNIT	23-40	40-60	60-80	80-105	105 -MARKET	<21 D	>21 D
Growth rate	kg/d	0.83	0.90	1.02	0.98	0.91	1.02	0.98
Feed intake	kg/d	1.43	2.06	2.64	2.67	2.77	2.77	2.81
Feed:gain	Ratio	1.73	2.30	2.58	2.73	3.05	2.71	2.88
Standardized Ileal Digestible amino acids								
Lysine:Calorie NE[b]	g/Mcal	4.71	4.04	3.48	3.05	2.82	4.07	3.93
Lysine:Calorie ME[b]	g/Mcal	3.48	2.99	2.57	2.25	2.07	2.98	2.88
Methionine + cysteine:Lysine	Ratio	56	57	57	58	59	58	58
Threonine:Lysine	Ratio	61	62	63	65	67	68	68
Tryptophan:Lysine	Ratio	18	18	18	18	18	18	18
Valine:Lysine	Ratio	67	67	67	67	67	67	67
Isoleucine:Lysine	Ratio	56	56	56	56	56	56	56
Leucine:Lysine	Ratio	101	101	101	102	102	100	100
Histidine:Lysine	Ratio	34	34	34	34	34	33	33
Phenylalanine + tyrosine:Lysine	Ratio	94	94	95	95	96	95	95
L-Lysine-HCl, max.[c]	%	0.45	0.40	0.35	0.28	0.25	0.45	0.45
Minerals[d]								
Total calcium	%	0.70	0.64	0.58	0.53	0.48	0.63	0.60
Available phosphorus	%	0.30	0.28	0.26	0.25	0.24	0.28	0.27
STTD phosphorus[e]	%	0.33	0.30	0.27	0.25	0.24	0.29	0.28
Sodium[f]	%	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Chloride	%	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Added trace minerals								
Zinc	PPM	120	120	120	100	100	100	100
Iron	PPM	80	80	80	66	66	66	66
Manganese	PPM	30	30	30	25	25	25	25
Copper	PPM	12	12	12	10	10	10	10
Iodine	PPM	0.4	0.4	0.4	0.33	0.33	0.33	0.33
Selenium	PPM	0.30	0.30	0.30	0.25	0.25	0.25	0.25
Added vitamins[g,h]	per kg diet							
Vitamin A	IU/kg	6615	6615	6615	5510	5510	5510	5510
Vitamin D	IU/kg	1215	1215	1215	1015	1015	1015	1015
Vitamin E[i]	IU/kg	33	33	33	28	28	28	28
Vitamin K	mg/kg	3.3	3.3	3.3	2.8	2.8	2.8	2.8
Niacin	mg/kg	40	40	40	31	31	31	31
Riboflavin	mg/kg	5.7	5.7	5.7	4.9	4.9	4.9	4.9
Pantothenic acid	mg/kg	20	20	20	17	17	17	17
Vitamin B12	mcg/kg	26	26	26	22	22	22	22

[a]These feed specifications should be used as a guide. They require adjustment for feed intake, local conditions, and markets.

[b]Lysine specifications are based on a series of 27 trials conducted under commercial research conditions (9 of them in partnership with JBS United). These equations are only valid for pigs from 23 to 135 kg BW.

Equation used for Lysine requirement (Barrows), g/Mcal ME: 0.000031*(weight*2.2046)^2 - 0.0176*(weight*2.2046) + 4.5523

Equation used for Lysine requirement (Barrows), g/Mcal NE: 0.000042*(weight*2.2046)^2 - 0.02372*(weight*2.2046) + 6.1452

Figuring SID Lysine % for the diet for the 23-40 kg weight phase: (Lysine:Calorie ratio * NRC NE of diet/kg)/10000

Example = (4.71*2425)/10000= 1.14% SID Lysine

[c]L-Lysine-HCl maximum inclusions are recommended based on corn and soybean meal based diets and are to be used as a guideline.

[d]Calcium and phosphorus values are considering release due to phytase; however, release values need to be based on suppliers' recommendation established from peer-reviewed scientific research.

[e]Standardized total tract digestible phosphorus.

[f]Sodium: if sodium levels are not known in major ingredients use at least 80% of sodium coming from sodium chloride.

[g]Vitamins in the finishing phase are approximately at 2.5 x NRC.

[h]Pelleting and (or) expanding decreases vitamin stability by 10-12% and 15-20% respectively. Consult vitamin manufacturer to verify their specific vitamin stability under pelleting conditions so additional fortification can be made as required.

[i]Add 5.1 IU of Vitamin E/kg of complete diet for each 1% fat above 3% total dietary fat.

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DISCLAIMER

Performance data shown in the nutrient specification tables were obtained in commercial settings and under conditions of thermo-neutral temperature and good management. They are not guaranteed levels of performance. A competent nutritionist should adapt suggested nutrient levels to farm-specific conditions. These concepts are discussed in greater detail in nutrition technical updates for sows, nursery pigs and finishing pigs.

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