National Swine Nutrition Guide
factsheet
Pork Information Gateway

Factors Affecting Nutrient Recommendations for Swine

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Introduction

Efficient and profitable swine production depends upon an understanding of the concepts of genetics, environment, herd health, management, and nutrition. These areas interact with each other, and their net output determines the level of production and profitability (1). Many factors affect a pig's requirement for specific nutrients, impacting subsequent performance. Taking these factors into account, which differ across various production units and systems, will allow the development of farm-specific diets and feed programs that more closely meet nutrient needs of the herd while optimizing performance and economical return.

Objectives

- Identify and describe the major factors that affect requirements of nutrients in swine
- Increase understanding of how to incorporate factors when formulating practical diets

Factors Affecting the Performance of Swine

Feed intake

Feed intake is one of the most critical, and often overlooked, factors that determine nutrient levels in feed (2). Pigs have daily requirements for quantities of nutrients to maintain body processes and support production, including growth and/or milk production. Numerous factors influence feed intake and thus the amount of nutrients consumed. For example, a pig eating 5 lb/day of a diet containing 1.00% lysine consumes 0.05 lb lysine/day, but if feed intake decreases to 4 lb/day, the pig is only consuming 0.04 lb lysine/day. At the reduced feed intake of 4 lb/d, the diet needs to contain 1.25% lysine for the pig to consume 0.05 lb lysine/day. The underfeeding of nutrients results in suboptimal performance while overfeeding nutrients increases feed cost and nutrient excretion. Thus, measuring feed intake is critical. Once feed intake is known for a specific group of pigs, nutrient concentration in the diet can be adjusted in order to more accurately meet the pig's requirement on an amount-per-day basis. When determining feed intake, it is important to note that often feed disappearance is actually measured, which is the combination of feed intake and feed wastage. Thus feed wastage can significantly increase estimates of feed intake. Good feeder design and management are essential to minimize feed wastage.

In full-feeding situations, such as is typically provided for growing pigs and lactating sows, voluntary feed intake is driven in large part by the energy density of the diet (3). Under ideal conditions when voluntary intake is not restricted, it is assumed that pigs adjust their voluntary intake in order to achieve a constant energy intake that can be estimated based on their age, body weight, or day of lactation. Equations that can be used to estimate energy intake are presented in Table 1.

Table 1. Estimating the voluntary digestible energy intake (DE_i) of pigs	
Suckling pig	$DE_i = 46.9 \times D - 634.7$
Weanling pig	$DE_i = 1933 \times BW - 40.7 \times BW^2 - 6397$
Growing pig	$DE_i = 55071 \times (1 - e^{-0.0176 \times BW})$
Lactating sow	$DE_i = (56067 + 2494 \times D) - 72 \times D^2$

Adapted from NRC, 1986 (4)
D = age of the pig and the day of lactation for the suckling pig and lactating sows, respectively
BW = bodyweight of the weanling and growing pig, in kg

Extreme conditions of very low or high energy densities in the diet, resulting in a physical limitation of gut volume or lack of gut fill, respectively, these relationships may not apply. Utilizing high energy ingredients in diets, such as fats and oils, increase the energy concentration of the diet and tend to reduce voluntary feed intake, while low energy feedstuffs, particularly ingredients high in fiber, will reduce dietary energy concentration and result in the pig consuming more feed to meet daily energy needs. More information regarding energy concentration of feed ingredients are provided in PIG Factsheet 07-02-04 (Energy Sources for Swine Diets) and PIG Factsheet 07-07-09 (Composition and Usage Rate of Feed Ingredients for Swine Diets).

Productivity level

Pigs require nutrients in order to maintain body tissues and processes in addition to supporting productive purposes, which may include growth and/or milk production, and thus productivity level of the pig certainly affects nutrient requirements. A sow raising 12 pigs will produce more milk and therefore require more nutrients than a similar sow raising only 8 pigs. Likewise, a pig gaining 0.75 lb of lean tissue daily requires a larger quantity of nutrients than one depositing 0.60 lb of lean tissue daily. Nutrient needs for maintenance are largely a function of body weight within each phase of production, and thus can be estimated by determining current body weight or body weight ranges and utilizing equations such as those provided in NRC 1998 (5).

Productivity levels of the swine herd can be measured on the farm, but potential performance level is usually not known. Setting nutrient levels somewhat above those that support current performance levels and then measuring performance will determine if nutrient levels should be greater than current levels to meet potential untapped performance. Progressively adjust nutrient levels upward until the optimal level of performance is achieved (i.e. the level of performance that provides the greatest economical return).

Research has indicated that breed, genetic background, and gender of the pig will greatly affect performance potential and thus nutrient requirements. For example, barrows consume greater amounts of feed and grow faster during the grow-finish period compared to gilts, but are less efficient in converting feed into lean gain and accumulate greater amounts of carcass fat as they approach market weight. More detailed information regarding recommended nutrient allowances with respect to phase of production and performance level are provided in PIG Factsheet 07-01-08 (Nursery Swine Nutrient Recommendations and Feeding Management), PIG Factsheet 07-01-09 (Grow-Finish Swine Nutrient Recommendations and Feeding Management), PIG Factsheet 07-01-10 (Replacement Gilt & Boar Nutrient Recommendations and Feeding Management), PIG Factsheet 07-01-11 (Gestating Swine Nutrient Recommendations and Feeding Management), PIG Factsheet 07-01-12 (Lactating Swine Nutrient Recommendations and Feeding Management), PIG Factsheet 07-01-13 (Breeding Boar Nutrient Recommendations and Feeding Management), and PIG Factsheet 07-01-14 (Cull Sows Feeding Management).

Environment (temperature, weather, housing, and competition for feed)

Environment can serve as a significant factor affecting both voluntary feed intake level and overall nutrient requirements for pigs. Temperature, probably more than any other environmental factor, can be used to explain a majority of the variation associated with differences in feed intake and performance among groups of pigs. The preferred temperature range for pigs, called thermoneutral zone, is the range of temperature in which the pig is comfortable and does not require additional or reduced energy intake to maintain body temperature. The thermoneutral zone will differ dependent on size of the pig and is also influenced, to a lesser degree, by flooring type, as presented in Table 2. These are ambient temperature ranges, and assume minimal wind movement and dry conditions – drafts and wetness in cold weather will further decrease the effective temperature the animal experiences.

Table 2. Thermoneutral range of pigs as affected by body weight and flooring type				
Pig wt	**Straw (°F)**	**Solid concrete (°F)**	**Perforated metal (°F)**	**Slatted concrete (°F)**
5 kg (11lb)	81 - 86	82 - 88	84 - 90	86 - 90
10kg (22lb)	68 - 75	72 - 79	75 - 82	77 – 82
20 kg (44 lb)	59 - 73	61 - 75	66 - 79	66 - 77
30 kg (66 lb)	55 - 73	57 - 75	64 - 75	63 – 77
90 kg (198 lb)	52 - 72	54 - 73	63 - 77	59 - 75

Adapted from Muirhead and Alexander, 1997 (6)

As a general rule, for every 2 °F decrease below or above the thermoneutral zone, energy intake in growing pigs will be increased or decreased, respectively, by about 40 kcal/day (7). In cold conditions, the pig increases energy metabolism to generate body heat and maintain internal body temperature. These physiological adaptations are exacerbated when drafts or wet conditions are present. In contrast, when environmental temperatures are above the thermoneutral zone, pigs eat less feed to reduce the extra heat produced by digestion of feed and metabolism of nutrients. In both situations, increased proportion of the energy consumed is utilized for maintenance, resulting in less energy available for growth, and thus results in poorer feed conversion. Similar relationships occur in sows.

Other environmental factors can also affect feed intake and/or animal performance, and thus influence nutrient requirements in swine. Inadequate quality or quantity of water, for instance, can greatly decrease voluntary feed intake. Refer to PIG Factsheet 07-02-08 (Water Recommendations and Systems for Swine), for information regarding water requirements and considerations. Decreasing floor space allowance below space allocation recommendations, such as those provided for growing pigs in Figure 1, results in decreased feed intake and growth. Individually-housed pigs and sows are more susceptible to low effective temperatures, while group-housed pigs are more negatively affected by high effective temperatures, particularly when crowded for space. Significant increases in physical activity of pigs can impact nutrient requirements by increasing the amount of energy allocated towards supporting the additional movement and associated heat production, although in most commercial conditions, this effect is generally minimal.

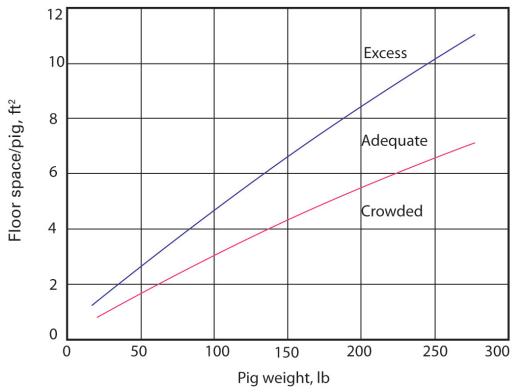

Figure 1. Space allocation recommendations for growing pigs
Adapted from ISU Life Cycle Swine Nutrition, 2002 (8)

Health status of the herd

Herd health programs can be fully effective only if pigs have adequate nutrition. Similarly, nutrient utilization efficiency can only be optimized if pigs have high health status. It is well known that high productivity increases nutrient requirements. High health status increases productivity and efficiency, but also increases nutrient requirements. However, during an immune challenge, nutrients are diverted away from productive functions (i.e., lean tissue growth) and toward nutrient demands of the immune system. These metabolic changes increase basal metabolic rate which increases carbohydrate utilization and subsequently increases the energy requirement.

An immune challenge decreases tissue protein synthesis and increases protein degradation rates in part as a result of reduced feed intake and an increased need for nitrogen to synthesize immunological products which may alter specific amino acid needs. The net results of these metabolic adjustments are reduced body growth rate, less efficient utilization of feed for growth, and potentially fatter carcasses. Additional information regarding pig health and nutrient requirements is presented in PIG Factsheet 07-01-16 (Diet and Health Interactions in Swine).

Feed processing

Feed processing type and quality will influence pig performance. Particle size reduction has a great impact on the efficiency of feed utilization. Decreasing particle size improves digestibility of nutrients by increasing surface area, which allows digestive enzymes in the pig's gastrointestinal tract to digest the nutrients in the feed. Digestibility of protein, energy and other nutrients is generally improved as particle size is re-

duced. However, care should be taken to ensure particle size does not become too fine, as this may cause increased incidence of ulcers in pigs, more dusty feeds that may cause reduced feed intake, bridging of feed in feeders and bins, and increased feed processing cost. A feed particle size of 600 to 800 microns is recommended for most pigs. Pelleting swine diets improves feed efficiency by reducing feed wastage and improving nutrient digestibility. Various studies have suggested a 3 to 10 percent improvement in growth rate and feed efficiency when pigs are fed pelleted diets rather than a meal (9). Pelleting appears to improve the nutritional value of high-fiber feed ingredients to a greater extent than that of low-fiber ingredients. More information regarding proper feed processing procedures and their effect on pig performance are presented in PIG Factsheet 07-04-03 (Swine Feed Processing & Manufacturing).

Feed and ingredient quality

Many common feedstuffs contain natural toxins or undigestible nutrient forms that may impair pig performance and/or voluntary feed intake, thus affecting nutrient requirements. These include phytate, trypsin inhibitors, saponins, tannins, and glucosinolates. Phytate is a naturally occurring compound in many grains that binds phosphorus in such a way reducing the availability to the pig. The adverse effects can be overcome by supplementing the diet with additional available phosphorus. Additionally, supplementing the diet with the enzyme phytase effectively liberates a portion of the phosphorus from phytate. Trypsin inhibitors are present in soybeans that have not been properly heat processed as well as in alfalfa, rye and barley. Trypsin inhibitors manifest their anti-nutritional effects by binding to the protein-digesting enzymes trypsin and chymotrypsin, rendering them inactive. Saponins are commonly found in legumes such as alfalfa, soybeans, chickpeas, and beans, and impair pig performance due to a bitter taste and irritating effect on the lining of the mouth and gut. Tannins elicit their negative effects by binding to proteins and inhibiting protein digestion. Tannins also are present in soybeans, faba beans, sunflower seeds, sorghum, and alfalfa and can, at elevated concentrations, reduce palatability. Glucosinolates are present in rapeseed, mustard and turnips. Glucosinolates in sufficiently high concentrations can reduce palatability and impair function of the thyroid gland However, many of the newer varieties of the feedstuffs have been bred to reduce the level of anti-nutritional factors.

Another group of anti-nutrition factors that can affect feed intake and pig performance are mycotoxins which are produced by specific molds under specific environmental conditions. Many naturally occurring mycotoxins have been identified, but only a few have been shown to cause significant, detrimental health and performance problems in swine fed contaminated plant based feedstuffs. Aflatoxin, Zearalenone, Deoxynivalenol (DON or vomitoxin), Fumonisin, T-2 toxin, and ergot are all mycotoxins that can negatively affect swine health. For example, dietary deoxynivalenol levels greater than 1 ppm have been shown to reduce voluntary feed intake, with increasing levels resulting in feed refusal. Additional details regarding mycotoxins and other anti-nutritional factors are provided in PIG Factsheet 07-06-07 (Utilization of Weather-Stressed Feedstuffs in Swine Diets) and PIG Factsheet 07-01-16 (Diet and Health Interactions in Swine).

Inclusion of feed additives or growth promotants

Feed additives are compounds added to swine diets for the purpose of enhancing animal performance, and thus may affect nutrient requirements. The products provide minimal nutritional value, but instead elicit their effects by improving pig health, enhancing nutrient digestion and absorption, increasing growth performance, modifying metabolic partitioning of nutrients, enhancing gastro-intestinal microflora, and/or improving feed palatability. Classes of feed additives include anti-microbials, metabolic modifiers, probiotics, prebiotics, acidifiers, botanicals, and enzymes, and are covered in more detail in PIG Factsheet 07-03-03 (Feed Additives for Swine).

Recommendations vs. Requirements

The various factors that have been described affect nutrient requirements of the pig. These requirements indicate the minimum daily nutrient levels required based on current average animal performance, but do not include any safety allowances. Nutrient recommendations include "safety margins," and should be used when formulating practical swine diets. Safety margins are necessary to ensure animal performance is not impaired due to variation in actual ingredient nutrient levels and digestibility of nutrients in the ingredients used in diet formulation. Individual pig performance and feed intake will vary within a group of pigs, regardless of uniformity in age, genetics, health, etc.. Additionally, feed nutrient concentrations can

vary due to feed processing and delivery, and human error. Nutrient recommendations provided in the National Swine Nutrition Guide take into account these sources of variation, and also consider the risk of nutrient deficiencies and cost of nutrient excesses, in order to provide recommendations that will result in optimal performance at the ideal cost for most pork producers.

Summary

Pigs have daily requirements for absolute quantities of specific nutrients. Various factors affect voluntary feed intake and/or performance of swine, and thus will affect the concentration of nutrients that should be provided in the diet. Underfeeding nutrients can result in suboptimal performance, and overfeeding often increases feed cost and nutrient excretion. Thus, understanding the factors involved and adjusting diet formulations accordingly is essential to ensure optimal production at an economical cost. Nutrient needs are influenced by phase of production, genetics, gender, environment, health status, and overall management of pigs, equipment, and facilities. Taking these factors into account and providing allowances for variation in individual animal performance and feed nutrient composition results in nutrient recommendations for diets that should allow for success in the pork production feeding system.

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