Lactation

Milk production requires the greatest proportion of nutrients during lactation. Thus, maximizing feed intake and adequate dietary amino acids will prevent sow body reserve mobilization and sustain milk production for litter growth. This factsheet will discuss energy, amino acid, and vitamin and mineral recommendations for the lactating sow.

Energy

Genetic selection has dramatically increased litter size and milk production in sows. This has resulted in increased body energy demands. Furthermore, the modern prolific sow is characterized with having less body fat reserves, which are necessary to buffer energy needs not met by feed intake (Lewis and Bunter, 2011). When feed intake is lower than body energy demand, the sow will mobilize body stores from fat and muscle to sustain milk production. Restricted feeding, intentionally or unintentionally, will result in greater sow body tissue mobilization which causes excessive weight loss, less milk production, and reduced litter growth rate (De Bettio et al., 2016). Implementation of ad libitum feeding systems in farrowing houses have enhanced lactation feed intake and many producers in the US have adopted this technology.

Determining Energy Requirement

Maternal maintenance and milk production are the determining factors for the energy requirements of lactating sows. Similar to gestating sows, maintenance requirements can be expressed as $100 \times BW^{0.75}$ with bodyweight in kg (NRC, 2012). Maintenance energy requirements represent a relatively small contribution to the total energy requirement for lactating sows. This is because milk production represents 65 to 80% of the total energy requirement (Figure 1). The NE requirements for maintenance of lactating sows stays constant over lactation. Milk production, however, increases threefold within the first week of farrowing and demands are dictated by litter size and litter growth rate. Thus, large litter sizes and high litter growth rates will increase the energy requirement for milk production. Net energy intake for sows will increase as lactation progresses, but often will not meet the combined energy requirement for maintenance and milk production. Sows will mobilize body reserves to meet requirements (Table 1; Pedersen et al., 2019). The negative energy balance results in weight loss and excessive weight loss during lactation can lead to negative effects on subsequent reproductive performance (Thaker and Bilkei, 2005). Finally, gilts will have approximately 15% lower daily feed intake compared to older parity sows (Strathe et al., 2017). Therefore, maximizing gilt lactation feed intake is critical.

Energy Level and Source

Energy concentration in lactation diets will have an effect on total feed intake (Strathe et al, 2017). Increasing the energy concentration of the diet can increase energy intake, reduce weight loss, and increase litter growth rate at the same feed intake (Xue et al., 2012). However, a dietary energy concentration level is reached at which feed intake can be negatively affected (Xue et al., 2012). To achieve greater energy density in the diet, fats and oils are commonly used as they are a highly digestible energy source for sows. The additional energy from dietary fat is partitioned for milk and converted as milk fat output (Rosero et al., 2015). Addition of fats and oils to the diet have been shown to improve energy intake, milk fat output and improve litter growth rate (Rosero et al., 2016).

Dietary fat source quality should be considered. Addition of fats with high free fatty acids and peroxide profiles could be less digestible and more susceptible to oxidation. Furthermore, addition of high fiber ingredients lowers the energy density and increases the bulk density of the diet. However, feeding moderate levels of fiber in lactation is a strategy that can be employed in an effort to decrease feed costs.

In summary, if high quality fat is available, it is often recommended that corn-soybean meal lactation diets with 2 to 4% added fat be formulated to provide between approximately 1,120 and 1,200 kcal NE/lb to increase energy intake without adversely affecting feed intake.

Essential Fatty Acids

Linoleic and α-linolenic acid are classified as nutritionally essential fatty acids (EFA) because they cannot be synthesized by mammals. They can serve as precursors for other important polyunsaturated fatty acids (PUFAs) such as eicosapentaenoic acid (EPA), docosahexaenoic acid (DHA), and arachidonic acid (ARA) (Bontempo and Jiang, 2015). Linoleic and α-linolenic acid can be found in grain and vegetable oils, such as soybean and corn oil, while EPA and DHA are mainly found in fish oils. Addition of EFAs to lactating sow diets has shown improvements in litter performance and subsequent sow reproductive performance and played a role in stimulating an immune response in piglets (Farmer et al. 2010; Rosero et al., 2016). Therefore, the amount of essential fatty acids in the diet is important as sows will secrete EFAs in the milk. Research is still limited on the minimal total EFA provided from ingredients that improves lactation and subsequent reproductive performance. Rosero et al. (2016) recommends that sows consume 125 g/d of linoleic and 10 g/d of linolenic fat during lactation. Ingredients containing high levels of these EFAs (flax seed oil, corn oil, soybean oil and menhaden oil) can substantially increase diet costs. Therefore, nutritionists need to balance the cost of meeting minimal EFA levels with the potential benefits in reproductive performance.

Amino Acids

Milk protein synthesis constitutes approximately 70% of lactating sow amino acid requirements (Pedersen et al, 2019). Therefore, the number of pigs nursing in the litter and the litter growth rate will dictate the amino acid requirements of lactating sows (Table 2). It has been established that a balanced supply of amino acids close to the requirements is needed as this improves milk protein output and litter performance as well as reduces protein mobilization from tissues (Gourley et al., 2017; Strathe et al., 2017; Pederson et al., 2019).

Amino Acid Requirements

Lysine is the first limiting amino acid in most diets and lactating sows with larger and faster growing litters will require greater amounts of daily lysine to meet their needs. Previous research demonstrated that excessive weight loss and mobilization of body reserves during lactation impaired subsequent reproductive performance (Thaker and Bilkei, 2005). (Xue et al., 2012; Shi et al., 2015; Gourley et al., 2017). However, recent studies have shown inconclusive results on the influence of lysine intake on subsequent reproductive performance (Shi et al., 2015; Gourley et al., 2017). The equivocal results with reducing body reserve mobilization by increasing lysine intake could be due to the modern lactating sow having more protein reserves and being more resilient to the negative effects of body reserve mobilization from reduced feed intake (Patterson et al., 2011).

A sow lactation research summary using published data from 1972 to 1997 determined that approximately 11 g/ SID lysine intake per day was needed for each 1 lb increase in litter growth rate (Boyd et al., 2000). A more recent review has updated this regression analysis to include sows from 1998 to 2017 and determined that approximately 60 g/ SID lysine intake per day is needed to optimize litter growth rate for most sows (Figure 2; Tokach et al., 2019).

There is limited research directly measuring milk production or litter responses to other amino acids as compared to lysine (Fan et al., 2016; Greiner et al., 2017; Xu et al., 2017). After lysine levels are set, other amino acids relative to lysine can be calculated using the amino acid profile in milk and mammary tissue as well as the dynamic nature of body tissue mobilization during lactation (Kim et al., 2001). Amino acid recommendations for lactating sows are provided (Table 3).

Protein and Amino Acid Sources

The increased availability of feed-grade amino acids has allowed producers to reduce diet costs by including feed-grade amino acids to replace soybean meal in the diet while meeting amino acid requirements. Additionally, including more than 30% soybean meal in the diet can lead to reductions in feed intake (Gourley et al., 2019). Conversely, some research has observed decreases in litter growth rate based on parity and increases in preweaning mortality with increasing amounts of feed-grade amino acids in the diet (Touchette et al., 1998; Greiner et al., 2018). Current research indicates that lactation diets should be formulated with a minimum dietary digestible protein of 14% (approximately 16% crude protein; Strathe et al., 2017).

Vitamins and Minerals

Ca and P

The Ca and P requirements for lactating sows are largely determined by milk production and output of Ca and P in the milk (Bikker and Blok, 2017). With larger litter sizes and faster litter growth rates, calcium and phosphorus requirements will increase considerably throughout lactation to support the demand in milk production. Gilts and younger parity sows will have greater needs to support maternal growth and development as they have not yet reached mature size (NRC, 2012). Also, gilts and younger parity sows may require greater Ca and P requirements as they potentially could have smaller mineral reserves for body mobilization compared to older parity sows (NRC, 2012). Limited data exists on Ca and P requirements for lactating sows and the mobilization of body reserves makes these requirements more difficult to estimate. Recent data from Grez-Capdeville and Crenshaw (2022) suggest a minimum of 16.6 g/d STTD P in early lactation and 22.1 g/d STTD P in later lactation to meet basal requirements for milk production and maintenance. Higher levels may be needed to maximize bone mineralization. Most sow models suggest that 22 g/d STTD P will meet the requirements of most sows during lactation. For calcium, the NRC (2012) suggests a ratio of 2.0 to 2.3 total Ca:STTD P ratio. For sows consuming 13 lb during lactation, the diet would need to contain a minimum of 0.36% STTD P and 0.84% Ca. Because of the limited research that has been conducted to determine the Ca and P requirement for sows, nutritionists may want to add a margin of safety (ex. 10%) and not overvalue phytase when lowering the STTD P to these minimal levels (Table 4).

Vitamins and Trace Minerals

Similar to gestating sows, trace mineral and additional vitamin supplementation is provided through a premix and a sow add pack or a vitamin premix designed for sows only.

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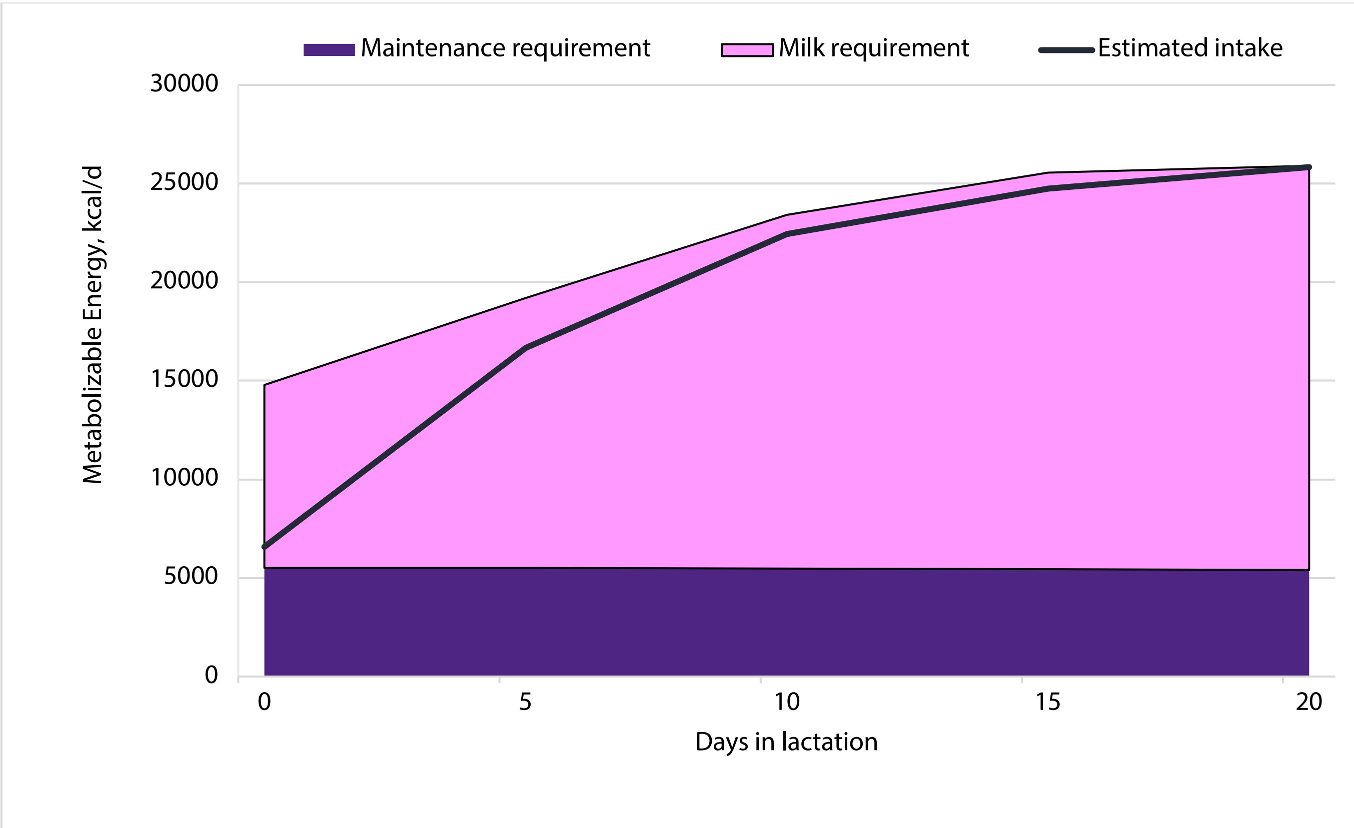

Figure 1. Estimated metabolizable energy (ME) requirements for maintenance and milk production and expected energy intake of lactating sows. Estimates were derived from the NRC (2012) assuming a litter size of 11.5 piglets and litter gain of 5.9 lb/d in a 21-d lactation period for multiparous sows.

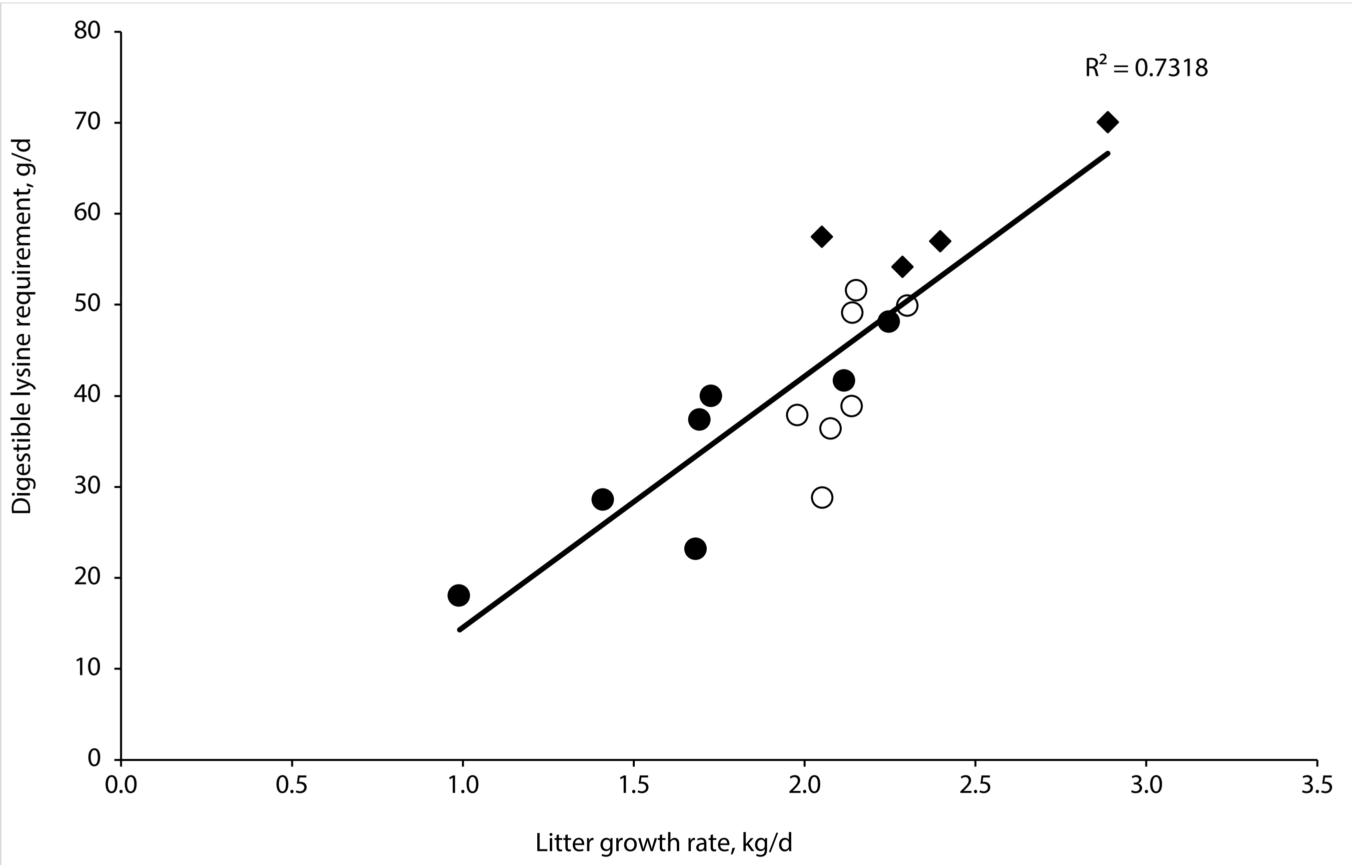

Figure 2. Relationship between dietary lysine intake and litter growth rate (Tokach et al., 2019).

Table 1. Daily milk production and mobilization of body reserves of lactating sows based on litter size and weaning weight[1]

Piglets per litter, n:	10	12	14	16
Piglet weaning weight, lb:	16	15	14	13
Milk production, lb/d	19	23	25	26
Sow body weight gain, lb/d	-0.45	-1.40	-2.02	-2.13
Sow body protein deposition, lb/d	-0.05	-0.14	-0.20	-0.21
Sow body fat deposition, lb/d	-0.23	-0.70	-1.00	-1.06

[1]Estimates derived from the NRC (2012) model assuming a feeding level of 14 lb/d of a lactation diet containing 1,122 kcal NE/lb in a 21-d lactation for multiparous sows.

Table 2. Daily SID lysine requirement (g/day) estimates of lactating sows based on litter size and weaning weight

	Piglets per litter, n			
Piglet weaning weight, lb	10	12	14	16
13	44	48	53	58
14	45	50	55	61
15	47	52	58	63

[1]Estimates derived from the NRC (2012) model assuming a feeding level of 14 lb/d of a lactation diet containing 1,122 kcal NE/lb in a 21-d lactation for multiparous sows. For primiparous sows, the lysine requirements in grams per day are approximately 5% lower due to lower milk production but approximately 5% higher as a diet percentage due to lower feed intake.

Table 3. Suggested minimum standardized ileal digestible lysine and amino acid to lysine ratios for lactating sows

SID amino acids[1]	
Lysine, %[2]	1.05
Amino acid to lysine ratio, %[3]	
Methionine	28-29
Methionine + Cysteine	53-54
Threonine	63-64
Tryptophan	19-21
Isoleucine	56
Valine	64-70

[1]Minimum levels based on the NRC (2012) ingredient loading values.
[2]Minimum lysine levels assuming a feeding level of 14 lb/d of a lactation diet containing 1,122 kcal NE/lb in a 21-d lactation for primiparous sows weaning 14 pigs.
[3]Data on amino acid requirements for contemporary sows is limited.

Table 4. Vitamin and mineral recommendations for lactating sows[1]	
Total calcium, %	0.85 to 0.95
Available phosphorous, %	0.35
STTD phosphorus , %	0.38 to 0.42
STTD calcium, %	0.56
Ca:STTD P	2.0 to 2.3
STTD Ca:STTD P	1.4
Vitamins[2]	
Vit A, IU/ton	7,500,000
Vit D, IU/ton	1,500,000
Vit E, IU/ton	60,000
Vit K (menadione), mg/ton	3,000
Vit B12, mg/ton	30
Niacin, mg/ton	45,000
Pantothenic Acid, mg/ton	25,000
Riboflavin, mg/ton	7,500
Biotin, mg/ton	200
Folic acid, mg/ton	2,000
Pyridoxine, mg/ton	900
Choline, mg/ton	500,000
Carnitine, mg/ton	45,000
Trace Minerals[2]	
Zinc, ppm	110
Iron, ppm	110
Manganese, ppm	33
Copper, ppm	17
Iodine, ppm	0.30
Selenium, ppm	0.30
Chromium, ppb	198

[1]Ca and P recommendations for lactating sows based on a 1,120 kcal of NE/lb diet.
[2]Added levels based on KSU vitamin, sow add pack, and trace mineral premixes.