Energy and amino acid requirements for sows during lactation

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From 2004 through 2016, the sow has had an increase of 3.4 piglets per litter; however, sow body dimension has not changed. Furthermore, sow milk production and composition has increased (Table 1). The selection for leaner finishing pigs has resulted in leaner body mass, prolific sows with the potential for lower feed intake.

by Laura Greiner,
Assistant Professor,
Iowa State University, USA.

Thus, the ability to meet the amino acid (AA) and energy requirements of the hyperprolific sow while not causing a loss of maternal stores are a concern when considering the high demand of energy needed for lactation, body growth in the young female, the development of the mammary gland, and milk production (Table 2).

Furthermore, not only does the reduction in feed intake have the potential to create weight loss during lactation, it can result in long-term negative impacts on litter growth rate and sow reproductive performance (Table 3).

Amino acid function in lactation

Amino acid uptake increases during lactation by the mammary gland (95% of indispensable AAs during peak lactation) from the bloodstream for growth of the mammary tissue and milk protein synthesis. If the sow cannot meet the demand of milk production through protein consumption in the feed (for example feed intake), then the sow must mobilise body tissues.

Amino acid uptake in the mammary gland does not appear to be directly correlated to AA composition of the milk. Trottier (1997) determined that the uptake of arginine, leucine, isoleucine, valine, phenylalanine and threonine was significantly higher than the concentration of these AAs in the milk, which indicates that the mammary gland may be utilising these AAs for another purpose.

Furthermore, mammary gland output of lysine and methionine was closely regulated by mammary protein synthesis and valine was not correlated to lysine. While in vitro data has demonstrated that indispensable AAs by the mammary epithelial cells is rate limiting for milk protein, Bequette et al. (2000) demonstrated that in goats the extraction efficiency of a non-essential AA increased to prevent a reduction in milk production by utilising peptide bond AAs along with free AAs.

The conclusion is that the fate of the excess AAs in the mammary gland could result in multiple outcomes such as in the case of the branched chain AAs in which the AAs will be used as a potential energy source or precursors to fatty acids and other metabolites and that the requirements for AAs may be influenced in the case of early lactation by the utilisation of peptide bound AAs, the transfer of immunoglobulins, the remodelling of adipose tissue, and the regression of the uterus.

Data by Hurley and Bryson (2014) further supports the use of AAs for other functions than milk production by demonstrating that valine is oxidised to carbon dioxide and leucine is converted into fat synthesis by the tissue.

Milk protein synthesis requires multiple steps through the mammary plasma flow (MPF) that can be influenced by AA supply such as supply to the mammary gland, AA transport and intracellular metabolism. Therefore, it is critical to establish the limiting AAs in the order in which the mammary gland will require them to fulfill the demands of lactation.

Lysine

According to the NRC (2012) recommendations, estimates of AAs for lactation can be predicated based on individual pig ADG and litter size and hence milk production [(daily milk N output x 6.38 x 0.0701 – maternal body protein mobilisation x 0.0674/0.868)/0.75] x 1.1197 with Milk N output (g/day) = 0.0257 x mean litter gain (g/day) +0.42 x litter size.

Previous studies associated with lysine requirements have been conducted by evaluating graded levels of dietary crude protein.

Titton et al. (1996) demonstrated that feeding greater than 58g/d total lysine during the first parity increased subsequent litter size from 9.6 to 10.7 pigs born. However, others demonstrated that increasing lysine intake above that required to maximise milk production decreased second litter size.

Higher dietary lysine is needed to minimise body nitrogen loss than for milk production. Lysine requirement by parity does not appear to be different with the estimated SID lysine requirement between 60-63g/d. Further estimates of total lysine requirement estimates can be based on litter growth rate

Table 1. The change in sow performance and milk composition from 1985 to 2012 (Rosero et al., 2016).

	1985	2012	
	Average sow	Average sow	Elite sow
Total pigs born (n)	11.2	13.4	15.1
Pigs weaned (n)	8.6	10.3	11.5
Litter gain (kg/d)	1.60	2.09	2.35
Milk production (kg/d)	6.9	8.2	9.2
Nutrient output (g/d)			
Lactose	385	458	512
Protein	379	450	501
Fat	526	626	699

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((0.0266*LGR(g/d))-7.549). The requirements of the other AAs can be estimated based on the ratio of the other AAs relative to lysine.

	Week				
	1	2	3	4	Mean
Piglet weight (kg)	2.5	4.0	6.0	8.0	–
Growth (g/d)	160	220	280	280	235
Milk yield (kg/d)	6.4	8.8	11.2	11.2	9.4
Energy required (Mcal DE/d)	17.5	22.3	27.1	27.1	23.5
Feed/day required (kg)	–	6.7	8.1	8.1	7.0
Actual feed/day (kg)	4.4	5.5	6.0	5.9	5.5
Sow weight loss (kg/week)	2.6	4.1	7.5	7.8	Total = 22kg

* Diet containing 3.34 Mcal DE/kg

Table 2. Example of the predicted requirements for a 150kg lactating sow nursing 10 piglets (Aherne, 2007).

Threonine

Previous research demonstrated that total threonine requirement of 37-40g/d for sow growth and 36-39g/d for litter growth and an estimated 0.50% standardised ileal digestible threonine requirement (28g/d) or 57% Thr:Lys ratio. NRC (2012) recommends 31.1g SID Thr/d for the mature female that is nursing piglets gaining approximately 230g/d.

In a study conducted by Greiner et al. (2017), sows consumed between 21-33g SID Thr/d.

Subsequent sow reproduction was optimised when SID Thr:Lys ratio was at 68% (SID Thr was at 27.6g/d) and daily litter gain was optimised at 65%.

Total sulphur AAs

Schneider et al. (2005 and 2006) demonstrated that the requirement of the lactating sow is below a SID TSAA:Lys ratio of 50%.

This is lower than the NRC (2012) estimate of 53%.

Tryptophan

Fan et al. (2017) demonstrated that feeding a SID Trp:Lys ratio of 0.25 (0.22% SID Trp) reduced primiparous sow weight loss and feed intake was maximised at a SID Trp:Lys ratio of 0.22 (0.19% SID Trp). Greiner et al. (2017) showed that a SID Trp:Lys ratio of 17.6 is required for optimal sow average daily feed intake and 17.2 for optimal wean to oestrus interval.

The NRC (2012) estimated tryptophan requirements based on piglet growth rate. For example, a sow with a litter gaining 230g/d will require a consumption of 9.3g SID Trp/d or a ratio of 18.9.

Branched chain AAs

Branched-chain amino acids (BCAA) regulate blood sugar and can be used as an energy source. While reducing soybean meal may improve tryptophan uptake into the brain, the reduction of soybean meal will reduce the amount of BCAAs available.

Research concerning valine requirements for the lactating sow has been varied. Carter et al. (2000) and Strathe et al. (2016) reported no differences in sow reproductive performance or litter growth rate when the Val:Lys ratios ranged from 76-122%.

Other studies demonstrate that sow reproduction and litter growth rate are optimised at a total Val:Lys ratio of 73 and 86%.

A potential reason for some of the conflicting data associated with Val is that a sow that mobilises tissue during lactation has a different sequence of limiting order of AAs (Lys, Thr and then Val) compared to a sow that is not mobilising tissue (Lys and then Val).

Krogh et al. (2017) demonstrated that Lys and Leu are the limiting essential AAs for milk production as the average mammary extraction was greatest for Leu (51%) at peak lactation and Lys (57%) was the highest for the preprandial extraction.

Arginine

The benefit of arginine in lactation has been difficult to assess. In a study conducted by Krogh et al. 2017, while higher levels of plasma Arg was detected, there was no change in the mammary plasma flow.

Energy metabolism

A sow produces more milk per kg of body weight than a lactating dairy cow. Excess energy consumption results in increased lipid and protein deposition and reduced intake results in a loss in body condition.

When body condition declines, reproductive hormones that utilise lipids decline causing a reduction in fertility. While estimates can be made on the energy requirement to support milk production and body maintenance using NRC (2012) equations, practical considerations on the type of fat used to support the energy needs should be considered.

Rosero et al. (2012) demonstrated that during periods of high ambient temperatures, animal-vegetable blend fat reduced feed efficiency compared to choice white grease, but both sources of fat resulted in improved subsequent total born and sow reproduction.

Rosero et al., (2015) demonstrated that lipid supplementation to sow lactation diets improves milk fat secretion and that the fatty acid composition of the milk mimicked the dietary essential fatty acid (EFA) levels.

In a review by Rosero et al. (2016), farrowing rate improvements were based on linoleic acid intake ([[-1.5 X 10-3 x linoleic acid intake (g/d)2 + (0.52 x linoleic acid intake (g/d)) + (45.2)]) and subsequent total born increased as linoleic acid increased ([[9.4 x 10-5 x linoleic acid intake (g/d)2) + (0.04 x linoleic acid intake (g/d)) + (10.94)]) or approximately a minimum of 10g/d of α-linolenic acid and 125g/d of linoleic acid to maximise reproductive performance.

Estimates of litter growth rate can be used to determine milk production

By estimating milk production, equations can be used to determine the energy requirements and crude protein output in milk along with the Lys output.

The understanding of mammary efficiency will allow for the determination of dietary Lys requirements and the AA ratios relative to Lys; however, some AA requirements may not match milk levels due to other fates of the AAs.

Recent studies concerning fat and fat types define the impact of both factors on sow and litter performance. Furthermore, the requirements for linoleic and α-linolenic acid demonstrate the need for EFA's in reproduction.

As sow production continues to increase, further research needs to be conducted evaluating a sow's needs during periods of both weight loss, weight maintenance or gain to better define AA requirements relative to lysine.

Additional research should also be considered to better understand the activity of total branched chain AAs and how they influence milk production. ■

References are available from the author on request

Table 3. The impact of feed intake on SID Lys intake, sow wean to oestrus interval, weight loss/gain and piglet growth rate (Unpublished data produced by Greiner, et al. and Carthage Innovative Swine Solutions, LLC).

ADFI (kg)	SID Lys (g/d)	Wean to oestrus (d)	Weight diff (%)	Piglet ADG (kg/d)	Estimated litter gain (kg/d)
3	31.5	6.3	-5.1	0.22	2.31
4	42.0	5.0	-4.8	0.23	2.42
5	52.5	4.4	-1.0	0.25	2.63
6	63.0	4.4	2.1	0.25	2.63
7	73.5	4.2	5.4	0.25	2.63
8	84.0	4.4	6.6	0.26	2.73
9	94.5	4.3	5.6	0.27	2.84