Nutrition to Maximize Production of the High Producing Sow

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GESTATING SOWS

When designing a feeding program for gestating sows, we must remember the overall goals for the nutrition program: 1) prepare sows to be in proper body condition at farrowing; 2) maximize reproductive performance (farrowing rate and litter size); and 3) meet the daily nutrient requirements at the lowest cost possible (measured as cost per sow per day).

We are well aware of the problems with overfeeding gestating sows, including the unnecessary expense, potential problems with impaired mammary development, and reduced feed intake in lactation. Over-conditioned sows used to be the main problem on swine farms. In recent years, thin sows have become a more prevalent problem. Too little backfat reserves can reduce reproductive performance and increase sow mortality. Low backfat reserves also can be an animal welfare concern as thin sows have a greater chance of developing shoulder sores.

Management techniques for accurate feeding levels.

There is little disagreement on the importance of having sows in the correct body condition at farrowing. Although there is some disagreement on whether the ideal backfat level at farrowing should be 16 to 18 mm or 18 to 21 mm, most people agree that the most important point is to have as few of sows as possible over 24 mm or under 15 mm at farrowing. The big disagreement among nutritionists, veterinarians, and barn managers is the best way to set feeding levels to make sure this happens.

Backfat scanning on commercial farms has convinced us that body condition score is a poor predictor of actual backfat levels. The best correlation that we have found between backfat and condition score on any farm that we have measured is an r of 0.23. Others may argue that body condition score works for their system, but we would challenge you to measure backfat on sows at farrowing to determine the true backfat level of your sows. In reality, if over 75% of the sows are between 15 and 24 mm at farrowing, you are doing a pretty good job of setting feeding levels during gestation. That doesn't sound like a lofty target; however, I would challenge you to audit your farm for backfat levels at farrowing to determine if you are above that mark.

Because of our frustration with condition scoring, we have tested and implemented a method to feed sows based on backfat and body weight estimates using the concepts proposed by Dr. Frank Aherne. The methods that we use are presented in the next section. Whether you feed sows based on body weight and backfat or on body condition score, it is useful to understand the energy requirements of the sows and the energy level of your gestation diet to determine feeding range for your situation.

Regardless of the method used to set the daily feed allowance for each sow, it is useful to get a global picture of gestation feed usage for a swine farm to determine whether any long-term trends towards over or under-feeding is occurring. This can be done relatively simply by dividing the total feed delivery for the period by the number of gestation places in the farm and the number of days in the period (explained in Appendix 1). Certainly, if the sow space is not fully utilized on the farm, this measure will need to be adjusted for actual inventory; however, for most farms simply knowing the number of gestation spaces is adequate. This calculation is especially useful in production systems with multiple sow farms to determine if one sow farm routinely feeds 2.5 kg/d while another farm routinely feeds 2.1 kg/d when provided the same gestation diet. In reality, most farms should have gestation feed usage of 7.2 to 7.8 Mcal ME per sow per day, which equated to 2.3 to 2.5 kg/d of a gestation diet containing 3.1 Mcal ME/kg or 2.18 to 2.35 kg of a diet containing 3.3 Mcal ME/kg. If feed usage for the farm is outside of these bounds, reasons for the discrepancy should be explored.

Feeding sows based on backfat and estimated weight

The maintenance requirement of the sow accounts for the majority of the feed requirement. The next biggest component is the amount of weight that you want the sow to gain. Thus, an estimate of body weight is extremely important to accurately feed the sow. Because weighing individual sows is not feasible on many farms, we have established weight categories that can be estimated by using a girth or flank measurement. Girth is measured with a cloth tape directly behind the front legs and in front of the first mammary glands. The flank measurement is measured immediately in front of the back legs from the point of one flank over the back of the sow to the point of the other flank. The flank measurement is much easier to obtain, especially when sows are housed in gestation crates. Because of the importance of body weight in determining the daily feed allotment, it is essential that a high percentage of sows are measured for their body weight estimate.

Backfat can be measured with one of several different ultrasound machines. We are using a Renco machine on most farms because of the relatively low cost. Individuals conducting ultrasound measurements must be trained on how to use the machine and where to take the measurement. Sows are scanned at the last rib approximately 10 cm off the midline. We recommend scanning the sow on both sides and averaging the values to determine backfat.

Determining feeding levels.

The equations used to set the feeding levels are described in detail in Appendix 2. Using these equations, we can determine the energy requirements for maintenance, maternal gain, and uterine gain. An example of the results of these equations is shown in Table 1. The information is converted to a daily requirement of the sow and a feeding level for sows with various backfat levels in Table 2. Using these calculations in an excel spreadsheet, we develop a chart that can be laminated and placed in the barn for daily use. An example of such a chart, based on a diet with 3.1 Mcal ME/kg is presented in Table 3. Full details on procedures and the spreadsheet can be found at the website: www.asi.ksu.edu under the swine extension sow feeding tools link: (http://www.asi.ksu.edu/DesktopDefault.aspx?tabindex=429&tabid=235)

Table 1. Total gestation energy requirement for a 195 kg sow with a litter birth weight of 15 kg.

Target gain, kg	35	27	20	13
Target backfat gain, mm	9	6	3	0
ME, Mcal				
Maintenance	714	705	696	687
Maternal gain	263	188	113	39
Uterine gain	38	38	38	38
Total	1015	931	847	764

Table 2. Daily gestation energy requirement for a 195 kg sow with a litter birth weight of 15 kg.

Target gain, kg	35	27	20	13
Target backfat gain, mm	9	6	3	0
ME, Mcal				
Maintenance	6.21	6.13	6.05	5.97
Maternal gain	2.29	1.63	0.98	0.34
Uterine gain	.33	.33	.33	.33
Total	8.83	8.09	7.36	6.64
Feeding level, kg/d[a]	2.85	2.61	2.37	2.14

[a] Based on a dietary metabolizable energy level of 3.1 Mcal/kg

Table 3. Feeding levels (kg/d) for gestating sows based on backfat and weight category at breeding [a]

Flank to flank, cm	Estimated weight, kg	Backfat at breeding, mm			
		9 to 11	12 to 14	15 to 17	>18
< 90	< 150	2.3	2.1	1.8	1.6
90 to 97	150 to 180	2.5	2.3	2.1	1.8

97 to 104	180 to 215	2.7	2.5	2.3	2.0
104 to 111	215 to 250	3.0	2.7	2.5	2.3
> 111	>250	3.2	3.0	2.7	2.5

[a] Based on a diet containing 3.1 Mcal ME/kg.
Feeding level should be increased by 1 kg/d on day 101 of gestation.

Procedures to set feeding levels.

Once each week, the person responsible for setting feeding levels scans sows for backfat and determines the weight category. The backfat is written on the sow card and the feeding level is adjusted using a table customized for the farm based on the energy density of their diet and volume of their feed boxes.

At approximately 7 weeks post mating, sows that visibly appear to be very thin are marked and scanned to determine if backfat gains are on target. Approximately 10 to 15% of the sows will have to be scanned at this time. If the sows are not reaching targets, feed intake is increased by .5 kg/d. Sows remain on their feeding level until day 100 of gestation. On day 100, the feeding level is increased by 1 kg/day for the last 2 weeks before farrowing.

The procedure is relatively simple and easy to implement. The three main issues critical for the success of this feeding method are: 1) A person must be trained to scan and estimate weight; 2) you must know the energy level of the gestation diet; and 3) you must know the volume (kg) being dropped at each feed box setting.

Feed Intake Pattern During Gestation

Is the pattern of feed intake important during gestation? High or low feed intake during particular phases during gestation can cause deleterious effects or have specific advantages. In reality, the pattern of feeding isn't nearly as important as keeping sows in the proper body condition. However, a clear understanding of the impact of over- or under-feeding during each stage of gestation can help explain why negative effects can occur due to improper feeding programs.

Day 0 to 30. Several researchers have reported high intake before day 30 of gestation decreased embryo survival. The increased embryo mortality was attributed to a reduction in plasma progesterone concentration due to increased blood flow and hepatic clearance of progesterone caused by the high feed intake. Further research (Jindal et al., 1996) indicates the critical window to reduce feed intake to prevent embryo mortality may be during the first 48 to 72 hours after mating. The safest recommendation is to limit feed intake from breeding until day 12 after breeding.

The body condition or energy state of the sow also influences the response to high levels of feed intake after mating. Embryo mortality is only increased when high levels of feed are provided to sows in good body condition. Embryo mortality was actually reduced by providing extra feed for the first thirty days after breeding sows in poor body condition due to low lactation feed intake. Therefore, feeding according to body condition during the first 30 days of gestation is critical for minimizing embryo mortality. Recent unpublished data from Australia also credits high feeding during early gestation with increasing farrowing rate during the summer months when seasonal infertility is a problem.

By following the feeding guidelines listed above, sows that are in good body condition will not be fed high levels immediately after breeding. During the period from breeding until backfat is measured, a safe recommendation is to feed all sows approximately 6.8 Mcal of ME (2 to 2.2 kg/day of gestation diet).

Day 30 to 75. Current understanding of this period during gestation is not complete; however, recent research indicates this is a critical period for muscle differentiation of the developing fetuses. Sterle et al. (1995) found injections of porcine somatotropin (pST) between day 30 and 43 increased placental weight and weight of the lightest fetuses. The authors hypothesized that pST increased nutrient uptake and utilization by the fetuses by increasing nutrient transfer across the placenta. In another trial, pST injections from day 28 to 40 increased embryo survival, embryo weight, and specific gene expression for certain muscles (Kelly et al., 1995). Offspring from the sows injected with pST for the specific window of gestation (day 28 to 40) had reduced backfat and heavier trimmed loin weight at market than pigs from the control sows. Dwyer et al. (1994) observed a similar response by doubling feed intake (2.5 vs. 5.0 kg/day) from day 25 to 80 of gestation. The high feed intake increased the number of secondary muscle fibers and improved growth rate and feed efficiency of the offspring during the growing period (day 70 to 130 of age). We have conducted two experiments to further validate the benefit of high feed intake during mid gestation on fetal muscle fiber development and subsequent body composition at market weight. The results have been conflicting with a benefit to high levels of feed intake in one experiment (Musser et al., 1999) and no response in a second experiment (Musser et al., 2000a). Feeding large quantities of feed has some practical limitations. First, sows can become over conditioned limiting feed intake during lactation. Also, the extra feed intake adds cost and an extra management burden.

The research on high feed intake levels and pST indicates that the goal may be to increase levels of metabolic hormones, such as IGF-1 or IGF-2. In subsequent research, we have found that specific nutrients, such as carnitine, may be beneficial to increase IGF-1 levels in mid gestation without the negative effects of excessive energy intake. We have found that adding L-carnitine to the gestation diet increased circulating IGF-1 concentrations in mid gestation and carcass leanness of the offspring (Musser et al.; 2000b). In another trial, Musser et al. (2001) found that adding L-carnitine to the diet increased total muscle fiber number in the offspring at birth. Further research is needed to validate these results and determine whether other nutrients may have similar responses.

Day 75 to 100. This period is critical for mammary development. Excessive energy intake during this period increases fat deposits and reduces the number of secretory cells, DNA, and RNA in the mammary gland (Weldon et al., 1991). The result is lower milk production during lactation. Excess feed intake should be avoided during this time.

Day 100 to 112. Feed intake should be increased by 1 to 2 kg (2 to 4 lb) from day 100 to 112 of gestation to prevent sows from losing weight during this period of rapid fetal growth. Failure to increase feed intake during this period results in sows in an extremely catabolic state at farrowing. The catabolic state contributes to gorging and sows "going off feed" during lactation.

Day 112 to 114. Feeding pattern during the last few days of gestation is a controversial area. We prefer to feed 2 kg or more from day 112 to 114. Field experience indicates that extremely low intake of 1 kg or less during this time, limits the producers' ability to increase feed intake rapidly during early lactation. In extreme cases, ulcers can be created by the extended period of low intake around farrowing. After the long period without feed, sows often overeat if provided free access to feed. The sows will go off feed or have a noticeable dip in feed intake. Many people recommend limit feeding as a cure for the sows going off feed instead of correcting the problem that originally caused the problem (the extended period of little or no feed intake prior to and immediately after farrowing).

Gestation Summary

Feeding levels in particular stages of gestation have been shown to influence sow productivity and performance of their offspring. However, the periods where excessive feed intake is most detrimental is immediately after breeding (d 0 to 2) for gilts and from day 75 to 90 of gestation. From a practical perspective, feeding pattern is less important than providing a total energy level over the entire gestation period that prevents excessive fat gain or inadequate body reserves at farrowing. Feeding sows based on backfat and weight category at breeding is a method that can help producers reach this goal.

LACTATING SOWS

The nutritional demands of both the modern lactating sow and its litter have significantly changed. Today's genetics provide pigs that have faster growth rates, better feed efficiencies, and improved leanness. However, these developments created new challenges in feeding lactating sows, which generally have lower voluntary feed intake, less backfat, and greater body size at maturity. Likewise, contemporary litters of piglets have increased growth potential, yet most high milk producing sows cannot produce enough milk to meet their requirements. These rapid changes in both sow and piglet performance potential make it important to continuously evaluate and develop sow nutritional programs that account for these changes to maximize both reproductive and litter performance.

Producers need to start with the right attitude when it comes to feeding lactating sows. Many producers seem to accept that it is ‘normal’ for sows to lose body condition through the course of lactation. However, the fact that there are farms that have successfully minimized lactation weight loss demonstrates that lactation weight loss can be nominal. Some studies suggested that the maximum allowable weight loss during lactation should be 30-35 lbs without negative effects on performance. Still, if we can have the attitude to consider any amount of weight loss as unacceptable, then there is higher likelihood that you minimize sow lactation weight loss.

The three main goals of the nutrition program for lactating sows are: 1) maximize intake of a properly formulated diet; 2) match the amino acid and other nutrient levels to the level of feed intake that is achieved; 3) maintain a reasonable feed cost per weaned pig.

Similar to the situation of not wanting to over-feed gestating sows, most understand the importance of maximizing feed intake during lactation. The disagreement is on the best way to achieve high feed intake. In the lactation section of this paper, we will review the importance of nutrient intake during lactation, discuss how to determine the correct amino acid levels; and provide a practical feeding strategy that can be used during lactation.

Importance of Maximizing Nutrient Intake during Lactation.

Restricting protein and(or) energy intake during any period of lactation will reduce milk production and impair subsequent reproductive performance (King and Martin, 1989; Tokach et al., 1992; Koketsu et al., 1997). The negative influence on reproduction is particularly evident during summer months and can contribute to seasonal infertility.

The importance of increasing both amino acid and energy intake for milk production and subsequent reproduction are shown in Figures 1 and 2, respectively. At low energy intake (6.5 Mcal/d), increasing lysine intake from 9 to 45 g/d had little effect on milk yield. At an energy intake of 16.5 Mcal/d, increasing dietary lysine increased milk production markedly. These results reveal that milk yield is dependent on both lysine and energy intake, because the response to one is contingent on the adequate intake of the other. Thus, energy intake must be considered when making lysine recommendations for lactating sows. Increasing dietary lysine as a remedy for low litter weaning weights will have no effect and only increase diet costs unless there is adequate energy intake to support milk production.

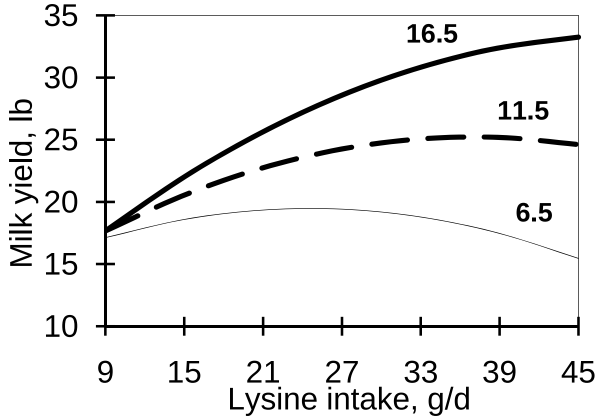

Figure 1. Influence of lysine and ME intakes on sow milk yield.

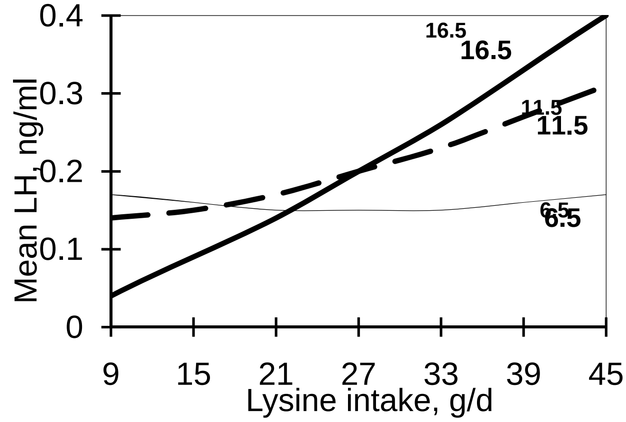

Figure 2. Influence of lysine and energy intake on LH secretion.

Energy and lysine intake also influence secretion of reproductive hormones and subsequent reproductive performance in an interactive manner. At low energy intake (6.5 Mcal ME/d), increasing lysine intake had little influence on mean luteinizing hormone (LH). The influence of lysine intake on LH secretion increased as energy intake increased. These results reveal that LH secretion, similar to milk production is reduced by restrictions of either lysine or energy intake. Zak et al. (1997a), Quesnel et al. (1998), and Jones and Stahly (1999) also have shown that low total feed intake or protein intake during lactation decreased LH pulsatility before and after weaning. Nutrient intake also influences the quality of the follicles available for ovulation. Restricting first-parity sows in either protein (Clowes et al., 2003a) or feed (Zak et al., 1997b; Quesnel et al., 1998) during lactation resulted in fewer potential preovulatory follicles at weaning and poorer quality follicles after weaning. Restricting lactation feed intake of first-parity sows also lowers ovulation rate (Zak et al., 1997a). These negative impacts can be partially ameliorated by having adequate body size (protein reserves) at farrowing (Clowes et al., 2003b).

Application of these data indicate that all steps should be taken to increase total feed consumption during lactation before attempting to customize dietary lysine levels to a particular swine farm. Increased dietary amino acids has little effect on sow and litter performance unless energy or feed intake is simultaneously increased. Therefore, it is essential to do everything possible to maximize lactation feed intake.

The most practical method of increasing energy intake is to increase total food consumption. However, when decreased energy intake is a problem, sometimes, high levels of added fat (greater than 5%) are added to lactation diets to compensate for total low feed intake. It is important to remember that dietary fat is preferentially used by the mammary gland and results in production of “high fat” milk rather than used by the sow as an energy source. Use of high dietary fat levels during lactation will improve litter weaning weights, but may actually impair subsequent reproductive performance by reducing the number of LH peaks in early lactation (Kemp et al., 1995). Therefore, while some added fat (0 to 5%) may be beneficial to improving litter performance, high levels of added dietary fat (greater than 5%) should not be used as a remedy for poor lactation feed intake.

While most nutritionists and veterinarians agree that maximal intake throughout lactation is the correct goal, considerable debate exists on the method to achieve maximal intake. The debate concerns how quickly feed intake should be increased in early lactation. Some advocate feeding extremely low levels of feed (1 kg or less) prior to and immediately after farrowing. Field experience indicates that extremely low intake during this period limits the producers ability to increase feed intake rapidly during early lactation. In extreme cases, ulcers can be created by the extended period of low intake around farrowing. After the long period without feed, sows often overeat if provided free access to feed. The sows will go off feed or have a noticeable dip in feed intake. Then to compensate for this dip 5 to 10 days into lactation, people recommend limit feeding as a cure instead of correcting the management that originally caused the problem (the extended period of little or no feed intake prior to and immediately after farrowing). Therefore we recommend that immediately prior to farrowing sows be fed at least 1.8 kg/d (4 lb/d).

Determining the Correct Dietary Lysine Level.

Our understanding of the amino acid requirements of lactating sows has improved greatly in recent years. As discussed previously, we know that the lysine requirement during lactation is influenced by energy intake. Furthermore, recent data has suggested that the lysine requirement to minimize muscle loss and improve subsequent reproductive performance is higher than the requirement for maximum milk production. Amino acids other than lysine also are much more important for maximum milk production than previously thought.

Over the years, lysine is the amino acid that has been most intensely investigated. Research by Stahly et al. (1990), Johnston et al. (1991), and Tokach et al. (1992b) suggest that the lysine requirement is greater for high producing sows than previously suggested. In all of these trials, total protein level of the diet was increased with lysine considered to be the first limiting amino acid. However, every experiment conducted has suggested different requirements for the lactating sow. The different recommendations from the various experiments are due largely to differences in sow productivity and feed intake. An excellent summary and explanation of the different recommendations for dietary lysine during lactation was presented by Pettigrew (1993). He indicated that the driving factor for the different lysine recommendations is the production level of the sows. Therefore, as litter growth rate increases the grams of lysine required per day increases. Pettigrew (1993) determined that 11.8 g of lysine is required for every pound of daily litter weight gain (26 g of lysine per kg of litter weight gain). A daily maintenance requirement (49 mg/kg $BW^{0.75}$ or approximately 2 g/d of lysine for a 150 kg sow) should be added, while the lysine contributed from tissue breakdown (approximately .1 g lysine/kg (.2 g lysine/lb) BW loss) should be subtracted from the requirement for litter gain to provide an estimate of the sow's requirement.

Based on expected feed intake, the grams/day requirement can be converted into a dietary percentage. For example, if a 150 kg (330 lb) sow weans a litter weighing 61 kg (135 lb) at 21 days, the litter birth weight was 16 kg (35 lb), and the sow lost 4.5 kg (10 lb) during lactation, the sow would require 56 g dietary lysine/d.

45 kg litter gain/21 d = 2.14 kg/d
2.14 kg/d x 26 g lysine/kg = 56 g lysine for litter gain
56 g lysine for litter gain + 2 g lysine for maintenance - 2 g lysine from tissue breakdown = daily lysine need of 56 g.

The values presented in Table 4 have been derived using the lysine requirement estimates developed by Pettigrew (1993) across a range of lactation feed intakes. Lactation feed intake can be determined from feed intake cards or from calculations based on monthly lactation feed deliveries (described in Appendix 1). If the previous lactation diet is higher in lysine than the recommended level from the table, it may be possible to reduce the dietary lysine level without affecting performance. If the previous lysine level is lower or the same as the recommendation, the producer may want to increase the lysine (protein) level and reexamine performance records to determine whether litter weaning weight increases. This is a relatively simple approach that has worked well for us to customize sow lactation diets.

Table 4. Dietary lysine percentage based upon litter weaning weight and sow feed intake

Litter wean	Sow feed intake, kg/d								Lysine
Wt, kg	3.5	4	4.5	5	5.5	6	6.5	7	Grams/d
45	1.06	0.93	0.83	0.74	0.68				37
50	1.24	1.08	0.96	0.87	0.79	0.72			43
55		1.24	1.10	0.99	0.90	0.83	0.76		50
60			1.24	1.11	1.01	0.93	0.86	0.80	56
65				1.24	1.13	1.03	0.95	0.88	62
70					1.24	1.13	1.05	0.97	68

What about other amino acids?

Research has demonstrated that NRC (1988) lysine estimates are not adequate for lactating sows nursing large litters. The question then remains: what levels should other amino acids be formulated to as dietary lysine is increased? Researchers have demonstrated that the valine, isoleucine, threonine, and methionine requirements are much higher than previously predicted by NRC (1988) or ARC (1981). More research is needed with these amino acids; however, results to date indicate these amino acids must be carefully considered in diet formulation to prevent costly limitations during lactation. In practical diet formulation, we formulate to meet the lysine requirement of the sow and attempt to maintain valine, isoleucine, and methionine as high as possible without incurring excess cost. Usually, this is accomplished by limiting the use of synthetic lysine in these diets. As more data becomes available these amino acids may be added as standard ingredients in lactation diets, similar to the use of synthetic lysine in starter and grow-finish diets. Practical ratios that can be used when formulating diets for gestating and lactating sows are provided in Table 5.

Table 5. Suggested true digestible amino acid ratios for sows.

	Gestation	Lactation
Lysine	100%	100%
Methionine	28%	30%
Met & Cys	70%	60%
Threonine	80%	70%
Tryptophan	20%	20%
Isoleucine	60%	60%
Valine	67%	90%

Should All Sows Receive the Same Lactation Diet?

First parity sows require special consideration when formulating lactation diets for two reasons. First, their level of feed intake is typically about 20% less than the average of the herd. Thus, if the average sow is consuming 5.5 kg/d, the first parity sows will average about 4.5 kg/d. Using Table 4, first parity sows would require approximately 0.20% higher lysine lactation diet to maintain the same level of litter weaning weight. Second, researchers have demonstrated that first parity sows require higher lysine for maximum reproductive performance than required for maximal milk production. King et al. (1993) reported that first litter gilts nursing nine pigs required a 1.08% lysine diet (40.5 g/d) to maximize litter growth rate when feed consumption was 3.8 kg. However, to minimize nitrogen loss, a 1.30% lysine diet (48.8 g/d) was required. These results are supported by Touchette et al. (1998) where they demonstrated the lysine requirement for minimizing weight loss (54 g/d) or loin muscle loss (58 g/d) were considerably higher than the amount needed to maximize litter weaning weights.

When all sows are housed in the same facility, management is faced with a choice. They must either provide higher amino acid levels than required by the multiparity sows in order to meet the requirements of young sows or formulate closer to the requirements of the older sows and not meet the requirements of the young sows. In most situations, the choice is to formulate closer to the requirements of the young sows and over-supply nutrients to the older sows. An advantage of segregated parity flow is that old sows can be fed diets formulated closer to their nutrient requirements in gestation and lactation, resulting in reduced feed cost.

Practical Feeding Strategy during Lactation

In order to maximize lactating sow feed intake, many factors must be considered including sow comfort (effective environmental temperature, flooring, etc), feeder design, water intake, and feeding method. Many different feeding methods will work to obtain maximum feed intake. The most important facet of any feeding method is to ensure that the sow always has access to feed. The simplest method we advocate is if the feeder is empty, put feed in it. We also advocate feeding sows at least three times per day. However, many producers are concerned with detecting sows that go off feed. Therefore, we advocate the following method as a simple procedure that can be introduced to a wide variety of personnel with a minimum amount of training that will ensure the early detection of sows that are off feed. We suggest using the procedure diagrammed in Table 6 and outlined below to maximize sow feed intake.

Sows are fed 0, 1, or 2 scoops at each of three feedings during the day. A scoop holds approximately 1.8 kg or 4 lb. If the feeder has feed left from the previous meal, no feed will be added to the feeder. If a small amount of feed is left, 1 scoop will be added. If the feeder is empty, 2 scoops will be fed. The only deviation from this pattern is for day 0 to 2 after farrowing. During this time, the decision is to give 0 or 1 scoop at each meal. The sows should not receive 2 scoops at a single feeding during this period. Following is an example of the decision process at each feeding.

Morning Feeding — All sows are fed 1 scoop if a small amount of feed (< ½ scoop) is left in the feeder and 2 scoops if the feeder is empty.

Late Morning Feeding — A second feeding is done later in the morning or immediately after lunch using the same scheme (1 scoop if a small amount of feed remains and 2 scoops if the feeder is empty). If no feed has been consumed since the morning feeding, the sow is then investigated to determine if she has a fever, retained pig, or other detectable reason for being off feed.

Evening Feeding — A similar scheme is used for the evening feeding; however, some judgement will have to be used if there is some feed left in the feeder. The sows that have had good appetites throughout the day but some feed remaining should receive two scoops. Sows that appear to be reaching appetite receive 1 scoop, and again if the feed has not been touched since the last feeding, the sow is investigated to see if there is a detectable reason for being off feed.

Table 6. A suggested feeding procedure during lactation.

Number of 1.8 kg (4 lb) scoops to feed at each feeding from day 0 to 2		
Feed in Feeder	Feeding	
	AM	PM
Empty	1	1
< ½ scoop	0	0.5
> ½ scoop	0	0

Number of 1.8 kg (4 lb) scoops to feed at each feeding from day 2 to weaning			
Feed in Feeder	Feeding		
	AM	Noon	PM
Empty	2	2	2
< ½ scoop	1	1	2
> ½ scoop	0	0	1

A key to this method of feeding is developing a communication method between various employees to gauge an individual sows appetite for the previous 2 or 3 meals. The communication method is needed to aid in the decision making process as to how long the sow has been off-feed. Various methods are used including daily feed intake recording, clothes pins clipped on the feeder, or movement of the farrowing card to indicate poor appetite in previous meals.

Automatic Lactation Feeding Systems

The popularity of automatic lactation sow feeds has increased rapidly over the past few years. The three most popular systems are: 1) Self-fed lactation feeder that contains a hopper where feed is dispensed by the sow triggering a mechanism to drop more feed; 2) Gestation drop boxes installed for each crate and are triggered several times a day dropping feed into the lactation feeder; and 3) Tube directly connecting the feed line and sow feeder which acts as a self-fed tube type feeder for each sow. Each system has inherent advantages and disadvantages that must be considered with the biggest question being whether management in the barn can use it to increase feed intake while decreasing labor input.

Production systems that have implemented automatic feeding systems have reported increased feed intake (disappearance) and improved reproductive performance (Hill, 2007). In addition, research conducted by Peng et al., (2007) showed increased feed disappearance for sows utilizing a self-fed feeder compared to sows hand fed twice daily (2007). While the overall goal of these systems is increased feed intake, continued emphasis on providing clean, fresh feed is equally important in these systems. Producers must recognize that these systems do not diminish the time and dedication necessary to ensure that fresh feed is available at all times. Also, it can be more challenging to monitor individual sow feed intake with these systems. Also, managing of the amount feed fed for the first 2 days post-farrowing may not be possible unless the sows are hand fed the desired amount, which requires labor devoted to feeding sows during this period of time.

Lactation Summary

In conclusion, the scientific evidence is clear that maximizing lactation intake results in increased milk production and increased subsequent reproductive performance. However, we commonly observe management induced lactation energy and protein deficiency. If 21-day litter weaning weights are not above 60 kg, we would suggest trying an alternate strategy for maximizing feed intake, such as the method that we have proposed, which concentrates on providing multiple small meals each day during the lactation period. Also, investigating the use of an automatic feeding system may be beneficial to improving overall feed intake.

POSTWEANED SOWS

Several trials have been conducted to determine whether feed intake level from weaning to breeding influenced subsequent reproductive performance. The results have been mixed. Many of the trials have demonstrated that feeding level from weaning to breeding had no influence on subsequent productivity. However, other experiments have found an advantage to increasing energy intake between weaning and breeding. Increasing feed intake between weaning and rebreeding reduced the weaning to estrous interval (Brooks and Cole,1972; King and Williams, 1982) and increased subsequent litter size (Brooks and Cole, 1972) in first parity sows. Grandhi (1992) demonstrated that increasing energy intake reduced the weaning to estrous interval and increased the number of normal embryos at d 30 of gestation in sows that with high weight loss in lactation, but had no impact on reproduction in sows with low weight loss in lactation.

Based on the available data, sows should be encouraged to eat as much feed as possible during the period from weaning to rebreeding. However, because of the difficulty with obtaining high intake during this period and the abundant data demonstrating the negative impact of low feed consumption during lactation, primary emphasis should be placed on obtaining high intake in lactation.

Other Key Factors Influencing Reproductive Performance

Lactation length/Weaning Age

Numerous research trials have demonstrated the decreasing lactation length increases the weaning-to-service interval (Xue et al., 1993), reduces subsequent litter size (Koketsu et al., 1997, Costa et al., 2004); reduces first-service farrowing rate (Mabry et al., 2004); and increases culling rate (Xue et al., 1997; Tantasuparuk et al., 2001). The impact of lactation length on subsequent reproductive performance is magnified with first parity sows as compared to multiple parity sows. Thus, management techniques to increase lactation length of first parity sows to at least 21 days should be encouraged. Recent research (Main et al., 2004) demonstrating the high value of increasing weaning age due to increasing growth performance of the weaned pig during the growing period has made adoption of older weaning ages more acceptable by the industry.

Techniques to Stimulate Folliculogenesis

Split weaning (removal of the largest half of the litter for two or more days before weaning the rest of the litter) has been demonstrated to reduce the weaning-to-service interval. Split weaning can be particularly important in first parity sows because it can reduce the weight loss associated with nursing large litters and extend lactation length, which is most important for first parity sows. Barry et al. (2003) demonstrated that split weaning increased the number of large diameter follicles, mean size of the largest 10 follicles, and mean follicular follicle volume in first parity sows. Thus, split weaning protocols should be considered for first parity sows, particularly when litter size is large.

Another method increase the interval from farrowing to service while decreasing catabolism is to wean the first parity sow and use a progesterone product, such as Matrix, to delay the return to estrous. The delay in return allows the first parity sow to be in a more positive energy balance, similar to the effect of skipping the initial service after weaning without accruing as many nonproductive days.

Key Summary Points

- Minimize sow weight loss from farrowing to rebreeding
    - Maximize feed intake during lactation
        - Don't make sows fat prior to farrowing
        - Full feed during lactation
    - Don't dilute the energy level of the lactation diet
        - Eliminate ingredients with high fiber content
        - Use high energy grain sources
    - Match the amino acid levels to the level of milk production
    - Don't limit consumption between weaning and rebreeding

- Increasing lactation length (at least through 21 days) increases profitability
    - Improves subsequent reproductive performance
    - Increases wean-to-finish growth performance and survivability of the weaned pigs

- Split weaning stimulates follicle development

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Appendix 1. Calculating sow feed intake

Gestation intake

The easiest method to determine gestation feed intake is to divide total feed delivery over a period of time by the number of gestation crates in the barn and the number of days in the period. For example, a 3,000 sow farm containing 2,800 gestation crates used 1,210 tons of feed in a 6 month period. The calculations are as follows:

$$\frac{\text{Total Feed}}{\text{Crates X Days}} = \frac{\text{1,109 metric tons x 1,000 kg}}{\text{2,800 crates x 182 days}} = \text{2.18 kg/d}$$

The above number can be modified to account for changes in sow inventory; however, the simple use of number of crates is relatively accurate unless the sow farm is undergoing a depopulation or repopulation. A period of 6 months or longer should be used with this method to account for fluctuations in feed deliveries. A 6-month rolling average is a good method to use to track gestation feed usage.

Lactation intake

Two calculations are helpful to determine actual feed intake. The first calculation uses crate days and feed delivery and estimates the lowest amount of feed disappearance per sow per day. The second calculation relies on the number of farrowings and lactation length and estimates the highest amount of disappearance that could have occurred. The average of these two values should be used as the feed intake estimate. Because these calculations rely on feed delivery, which can be sporadic, a period of 4 to 6 months should be the shortest period used for the calculations. A six month rolling average is a good way to view feed intake when using this method.

A 3,000-sow farm with 450 farrowing crates is used as an example. During the 6-month period, 3,615 litters were weaned with an average litter weaning weight of 46 kg at 19 d of age. During this 6-month period, 419 tons of lactation feed was delivered to the farm.

The first method using crate days estimates feed disappearance as:

$$\frac{\text{Total Feed}}{\text{Crates X Days}} = \frac{\text{381 metric tons x 1,000 kg}}{\text{450 crates x 182 days}} = \text{4.65 kg/d}$$

The second method using number of lactating days estimates feed disappearance as:

$$\frac{\text{Total Feed}}{\text{Litters X Lactation Length}} = \frac{\text{381 metric tons x 1,000 kg}}{\text{3,615 x 19 d}} = \text{5.55 kg/d}$$

The first method should underestimate average lactation feed intake because of days that crates are empty or contain prefarrowed sows that are eating lactation feed. The second number overestimates lactation feed intake because the feed to prefarrowing sows is counted as feed fed to lactating sows. However, the true daily lactation feed intake has to be somewhere between 4.65 and 5.55 kg. An average of the two values (5.1 kg/d) can be used as a good estimate of actual intake.

Appendix 2: Determining gestation energy requirements

The equations listed below allow for the calculation of the daily energy requirement for a gestating sow. To ease calculation, we use an excel spreadsheet, whereby you can change the energy density of the diet and the feed levels are automatically recalculated. In the current example 35 kg of body weight gain is required to get 9 mm of backfat gain.

Body Weight at service, kg	=	195	≡	(430 lb)
Diet ME, Mcal/kg	=	3.1	≡	(1,406 kcal/lb)
Uterine contents per pig, kg	=	1.85	≡	(4.08 lb)
Birth weight per pig, kg	=	1.15	≡	(2.53 lb)
Body Weight (BW) gain, kg	=	35	≡	(77.16 lb)
Backfat (P2) at breeding, mm	=	10	≡	(0.39 in.)
Expected backfat (P2) gain, mm	=	9	≡	(0.35 in.)
Efficiency of ME use for maternal gain	=	0.75		
Efficiency of ME use for fetal gain	=	0.50		
Total born	=	11		

Gestation Uterine and fetal gain, kg = Uterine contents per pig * Total born
= 2.29 * 11
= 25.19

ME for Maternal gain, Mcal = (9.7 * BW gain, kg + 54 * Backfat gain, mm)/Efficiency of ME use for maternal gain
= ((9.7 * 35 + 54 * 9)/0.75)/4.184
= 263.1 (Dourmad et al., 1996, 1997, 1998).

ME for Uterus gain, Mcal = (4.8 * Fetal BW gain, kg)/Efficiency of ME use for fetal gain
= ((4.8 * 11 * 1.50)/0.5)/4.184
= 37.9 (Noblet et al., 1985b).

Total ME for Maternal + Uterine gain, Mcal = 263.1 + 37.9
= 301.0

ME for Maintenance per day, Mcal = 0.45 * $BW^{0.75}$, kg where, BW = BW at service + ½ gestation BW gain + ½ uterine and fetal gain
= $(0.45 * (195 + ½ (35) + ½ (25.19))^{0.75}$/ 4.184
= 6.25 (Noblet and Etienne, 1987b).

Total ME requirement for gestation, Mcal = (ME for Maintenance per day * 115) + ME for Maternal and Uterine gain
= (6.25 * 115) + 301
= 1,020

Daily ME requirement for gestation, Mcal = 1020/115
= 8.87

Daily ME requirement for gestation, kg = 8.87 Mcal/3.1 Mcal/kg
= 2.86