Feeding the Gestating 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^2 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 to 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 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 prescribe 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.

References

Baltranena, E., G. R. Foxcroft, F. X. Aherne, and R. N. Kirkwood. 1991. Endocrinology of nutritional flushing in gilts. Can. J. Anim. Sci. 71:1063.

Dourmad, J. Y., M. Etienne, and J. Noblet, 1996. Reconstitution of body reserves in multiparous sows during pregnancy : effect of energy intake during pregnancy and mobilization during the previous lactation. J. Anim. Sci. 74:2211-2219.

Dourmad, J. Y., M. Etienne, J. Noblet, and D. Causeur. 1997. Prediction de la compostion chimique des truies reproductrices a partir du poids vif et de l'epaisseur de lard. Journees Rech. Porcine en France 29: 255-262.

Dourmad, J. Y., J. Noblet, M. C. Pere, and M. Etienne. 1998. Mating, pregnancy and prenatal growth. In I. Kyriazakis (ed.) A quantitative biology of the pig. P 129-153, CAB International, Wallingford.

Dwyer, C.M., N.C. Stickland, and J.M. Fletcher. 1994. The influence of maternal nutrition on muscle fiber number development in the porcine fetus and on subsequent postnatal growth. J. Anim. Sci. 72:911.

Jindal, R., J. R. Cosgrove, F. X. Aherne, and G. R. Foxcroft. 1996. Effect of nutrition on embryo mortality in gilts: association with progesterone. J. Anim. Sci. 74:620.

Kelley, R. L., S. B. Jungst, W. F. Owsley, D. D. Wolfe, T. A. Powe, W. B. Mikel, C. H. Rahe, and D. R. Mulvaney. 1995. Possible use of pST administration to gestating gilts to alter gene expression in fetal muscle, enhance postnatal growth and carcass characteristics of progeny. J. Anim. Sci. 73:.

LEAN-MEATER, Renco Corporation, 116 Third Avenue North, Minneapolis, Minnesota 55401, USA.

Musser, R. E., D. L Davis, R. D. Goodband, J. L. Nelssen, and M. D. Tokach. 2000a. Maternal and fetal growth and metabolic characteristics affected by increased feed intake from d 30 to 57 of gestation. J. Anim. Sci. 78(Suppl. 2):30(Abstr.).

Musser, R. E., S. S. Dritz, R. D. Goodband, M. D. Tokach, D. L. Davis, J. L. Nelssen, K. Q. Owen, S. Hanni, J. S. Bauman, and M. Heintz. 2000b. Added L-carnitine in sow gestation diet improves carcass characteristics of the offspring. J. Anim. Sci. 78(Suppl. 2):30(Abstr.).

Musser, R. E., S. S. Dritz, M. D. Tokach, D. L. Davis, R. D. Goodband, J. L. Nelssen, M. Heintz, and J. Bauman. 1999. Effects of increased feed intake in early gestation on sow farrowing performance and offspring carcass characteristics. J. Anim. Sci. 77(Suppl. 1):163(Abstr.).

Musser, R. E., R. D. Goodband, K. Q. Owen, D. L. Davis, M. D. Tokach, S. S. Dritz, and J. L. Nelssen. 2001. Determining the effect of increasing L-carnitine additions on sow performance and muscle fiber development of the offspring. J. Anim. Sci. 79(Suppl. 1): (Abstract).

NRC. 1988. Nutrient Requirements of Swine. Ninth Revised Edition. National Academy Press, Washington, DC.

Noblet, J., W. H. Close, R. P. Heavens, and D. Brown, 1985b. Studies on energy metabolism of the pregnant sow. Uterus and mammary tissue development. Br. J. Nutr. 53: 251-265.

Noblet, J., and M. Etienne, 1987b. Metabolic utilization of energy and maintenance requirements in pregnant sows. Livest. Prod. Sci. 16: 243-257.

Sterle, J. A., T. C. Cantley, W. R. Lamberson, M. C. Lucy, D. E. Gerrard, R. L. Matteri, and B. N. Day. 1995. Effects of recombinant porcine somatotropin on placental size, fetal growth, and IGF-I and IGF-II concentrations in pigs. J. Anim. Sci. 73:2980.

Weldon, W. C., O. A. Thulin, L. J. Johnston, E. R. Miller, and H. A. Tucker. 1991. Effect of increased dietary energy and protein during late gestation on mammary development in gilts. J. Anim. Sci. 69:194.

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