Feeding strategies to improve sow satiety in pen gestation housing

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Summary

Feeding systems should focus on providing sows protection when eating and equal feeding opportunities to prevent competition. Sows should be allowed to consume their entire meal during a single visit to the feeder to minimize aggression at mealtime. Generally, 30% neutral detergent fiber has been recommended to increase satiety; however, soluble fiber on a gram per day basis may be more useful to determine optimal fiber source and inclusion levels to achieve sow satiety. When combining the limited data available, increasing soluble fiber above 100 g/d appears to have the greatest potential to improve satiety.

Keywords: swine, group housing, pen gestation, sow satiety, feeding strategies

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Resumen - Estrategias de alimentación para mejorar la saciedad de las cerdas en corrales de gestación

Los sistemas de alimentación deben centrase en ofrecer a las cerdas protección cuando comen y oportunidades similares para prevenir la competencia. Para minimizar la agresión a la hora de comer, las cerdas deben consumir su ración completa en una sola visita al comedero. Generalmente, se recomienda una inclusión de 30% de fibra detergente neutra para aumentar la saciedad; sin embargo, la fibra soluble en gramos por día puede ser más útil para determinar la fuente óptima de fibra y los niveles de inclusión para lograr la saciedad de las cerdas. Al combinar la información limitada disponible, aumentar la fibra soluble sobre 100 g/d parece tener el mayor potencial para mejorar la saciedad.

Résumé - Stratégies d'alimentation pour améliorer la satiété des truies en hébergement dans des enclos de gestation

Les systèmes d'alimentation devraient viser à fournir une protection pour les truies lorsqu'elles s'alimentent ainsi que des opportunités égales de se nourrir afin de prévenir la compétition. On devrait permettre aux truies de consommer l'entièreté de leur repas au cours d'une visite unique à la mangeoire afin de minimiser les agressions au moment du repas. Généralement, une proportion de 30% de fibres détergentes neutres est recommandée pour augmenter la satiété, toutefois, la quantité de fibre soluble sur une base de gramme par jour serait plus utile pour déterminer la source optimale de fibre et les niveaux d'inclusion pour atteindre la satiété des truies. En combinant la quantité limitée de données disponibles, une augmentation de la quantité de fibre soluble au-delà de 100 g/j semble avoir le plus grand potentiel pour améliorer la satiété.

As group housing systems for gestating sows continue to replace individual housing systems, strategies to manage social interactions have become increasingly important. Because gestating females are limit fed to prevent excessive weight gain rather than being fed to satiety, motivation to express foraging behavior often goes unmet.[1] In response, sows may become increasingly frustrated, developing stereotypic behaviors that result in aggressive interactions towards pen mates.[2-4] Social hierarchy establishment elicits intense aggression that is generally resolved 2 days after initial mixing, whereas aggression related to pen resources is more chronic[5] and can occur throughout gestation,[1] particularly when sow satiety is not reached. Sow satiety is often measured by assessing self-directed or substrate-directed stereotypic behavior.[6] Self-directed behaviors include sham-chewing, teeth-grinding, and tongue-playing, while substrate-directed behaviors involve substrates such as floor rooting, chain manipulation, bar chewing, or interactions with pen mates. This practice tip will focus on feeding and management strategies that decrease stereotypic behavior immediately after mixing and throughout gestation.

Nutritional strategies

Feeding system

Feeding systems should offer sows protection from pen mates to avoid high levels of aggression during mealtime. This is particularly important for submissive sows that are more likely to be the recipient of aggressive behavior, which can lead to feeder displacement and subsequent reductions in feed intake and body condition compared to dominant sows.[4,7] In general, electronic sow feeders (ESF) or free access stalls with hind

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gates offer sows more protection at mealtime and, therefore, greater access to feed resources within a pen compared to short stanchions or floor feeding.[7,8] However, ESF systems require sows to eat in sequence, which goes against their natural tendency to feed in groups. This presents a unique set of challenges regarding feeding order and potential aggressive interactions around ESF systems.[9] Hence, there is no perfect feeding system.

Feed allowance

The common practice of limit feeding gestating sows leads to increased activity around the feeder prior to mealtime. Daily feed allowance and number of feedings per day are important considerations when assessing ways to increase sow satiety and decrease aggressive behavior. The amount of feed individual sows receive depends on the energy concentration of the diet and should be based on achieving a target body condition score such that over conditioned sows receive less feed than under conditioned sows. Unfortunately, the optimal number of feedings per day to meet the target daily allowance is less clear. In human studies, decreasing the time interval between meals helps sustain satiety[10]; however, in group housed sows it appears that increasing meals from 1 to 2 or 2 to 6 times per day increased vocalization and decreased skin lesions with no effect observed in group housed gilts.[11,12] Although significant, these differences were small. Hence, this response may be related to the natural eating habits of gestating sows who eat on average 1.17 meals per day when given a choice.[13] Likewise, since aggressive interactions around the feeder increase at feeding time, one strategy which may provide a benefit would be to allow sows to consume their entire meal during a single visit to the ESF or stanchion rather than receiving multiple meals per day. In a similar fashion, since aggression is highest at the time of mixing, it may be helpful to feed sows their full daily allowance while in individual stalls immediately prior to mixing. This practice could ensure a level of satiety at mixing that may reduce aggressive interactions. Some also suggest that increasing feed allowance for up to 4 days after mixing is beneficial in reducing fights, although there is limited research available that supports this recommendation.[5]

Dietary fiber

Outside of providing sows *ad libitum* feed, which can have negative consequences on body condition, fiber concentration in the diet has the greatest potential to increase sow satiety. The response to dietary fiber is largely dependent on source, inclusion rate, and physicochemical properties of the chosen fiber source.[14,15] Present data indicate solubility (which is often a proxy for fermentability), fatty acid production, water-holding capacity, and digesta passage rate are the most important characteristics when selecting a fiber source.[6] Solubility and fermentability are typically used interchangeably throughout the literature, but vary slightly in functionality, although these differences are not fully understood. Nevertheless, the main physicochemical properties that affect short-term and long-term satiety differ. Shortly after feeding, bulkiness or abdominal discomfort appears to elicit satiety, whereas fermentability and solubility have the greatest influence on long-term satiety.[15] Sows fed ingredients that are high in slowly fermented or soluble polysaccharides, such as sugar beet pulp, soybean hulls, or resistant starch, exhibit prolonged reductions in physical activity (increased satiety) compared to other fiber sources such as pectin, inulin, guar gum, and lignocellulose.[14,16,17] Fermentable fibers provide a gradual supply of glucose throughout the day due to increased gastrointestinal retention of nutrients.[18,19] Likewise, increased water binding capacity and short-chain fatty acid (SCFA) production from fermentation in the colon may contribute to glucose and insulin stabilization, which increase satiety related hormones such as glucagon-like peptide-1 and peptide YY.[14,20] For example, Serena et al[21] observed a more uniform uptake of SCFA and less variation in blood glucose and insulin levels when feeding 111 g of soluble fiber per day to nonpregnant sows compared to 44 g of soluble fiber.

Duration of satiety may also be affected by energy intake, which decreases with the addition of fiber in the diet.[14,22] This is a particular concern if daily feed allowance is not increased as fiber concentration of the diet is increased. Inclusion of fiber without changing dietary energy supply has been shown to decrease stereotypic behaviors and general restlessness shortly after feeding, but such effect tends to decrease over time.[22,23] This is likely a result of gastrointestinal distension wearing off over time and the metabolic energy demand of the sow not being met. Specifically, glucagon-like peptide-1 and peptide YY are secreted from the gut in relation to caloric intake, thus if the caloric density of the diet is reduced because feed allowance is maintained or feed intake is limited, satiety related hormones could also be reduced.[24] More recent studies have shown that increasing fermentable fiber in the diet improved satiety regardless of lower metabolizable energy intake.[14,16] This may be a result of the physicochemical property of the fiber sources fed. Despite these inconsistencies, it is important to ensure that the energy requirements of the sow are being met when high-fiber diets are fed to prevent reductions in body condition. This can be achieved by increasing feed allowance, or if economically feasible, adding fat to the diet. The level and source of fiber in the diet will determine to what extent feed allowance should be increased to maintain body condition. In general, 30% neutral detergent fiber (NDF) is recommended to increase satiety.[15,23,25] However, this level of NDF is difficult to achieve using a single fiber source unless a highly fermentable ingredient, such as soybean hulls or sugar beet pulp, is fed where a 40% or 60% inclusion level is needed, respectively. At these levels, bulkiness of the diet increases and there is risk that physical capacity for feed intake could be reached prior to meeting the energy requirements of the sow leading to reductions in body condition.[26] Likewise, significantly decreasing the bulk density of the diet will require more feed deliveries because less weight is delivered per truck load. Therefore, it may be more practical to feed a diet containing 20% NDF which can be achieved by feeding 25%, 15%, or 5% soybean hulls in a corn-soybean meal diet containing 0%, 20%, or 40% dried distillers' grains with solubles (DDGS), respectively. As soybean hulls in the diet decrease and DDGS increase, NDF on a gram per day basis decreases from 440 to 396 g/d when adjusting for a metabolizable energy intake of 6.0 Mcal/d. Unfortunately, the literature available on the benefit of feeding a diet with less than 30% NDF to reduce stereotypic behavior is not consistent. It appears that satiety inducing responses observed are dependent on basal diet formulation, source of fermentable fiber, level of inclusion, duration of feeding, and feed allowance.

A review by Reese et al[27] suggested that feeding 350 to 400 g/d NDF could improve sow reproductive performance. While sow behavior and reproductive performance are two separate traits, Sapkota et al[19] used a similar approach to assess sow satiety by evaluating NDF on a gram per day basis rather than a percentage. Three diets containing either sugar beet pulp, soybean hulls, or resistant starch were formulated to a constant energy level to achieve a 17.5% NDF or 350 g/d NDF (using Reese et al[27] as a reference) and fed for 21 days prior to mixing. A significant reduction in biting frequency was observed in sows fed resistant starch in the first hour after mixing compared to the other fiber treatments, but no differences were observed thereafter. This response is likely tied to the soluble fiber percentage as resistant starch diets contained 11% (221 g/d) soluble fiber and sugar beet pulp and soybean hull diets contained less than 5% (under 100 g/d) soluble fiber. However, this did not affect long-term satiety. In the same review, Reese et al[27] suggested that sows did not need to consume more than 46 g/d of soluble fiber to elicit a reproductive benefit, but soluble fiber levels appear to be required at higher levels to elicit satiety. This is supported by the work of Serena et al[21] in which 111 g of soluble fiber was needed to decrease variation in glucose and insulin levels when sows were fed once per day. Hence, using soluble fiber intake on a gram per day basis may be a better approach to determine the optimal fiber source and inclusion level needed to achieve sow satiety in group housing systems compared to percent NDF. Regrettably, limited trials specifically designed to test this hypothesis are available. Lastly, some suggest that feeding high-fiber diets prior to mixing will increase fullness, therefore reducing aggression at mixing; however, the responses observed using this strategy have been minimal.[5,19]

Management considerations

To ensure successful husbandry of group housed females, parity differences should be considered. In group housing systems, increased aggression is observed in sows of parity 3 or greater compared to younger sows resulting in increased injury scores in gilts when older parity sows are housed with gilts.[28] Likewise, it is suggested to house parity 1 and 2 sows separate from older parity sows[1,29] because gilts eat slower than sows.[13] Aside from parity, timing of mixing is one of the most important management tools to minimize the consequences of mixing aggression and subsequent reduction in gestation feed intake. While much of the available literature contradicts itself, it is best to avoid high levels of stress from day 11 to 16 post insemination when maternal recognition of pregnancy occurs.[1] Hence, females should either be mixed within the first week of insemination or 3 to 4 weeks following insemination. Floor space allowance, group size, and pen layout also contribute to the social behaviors of group housed sows. When combined, the primary goal is to ensure group pens allow for separate sleeping, eating, and defecating areas, while also providing enough space for sows to avoid one another and escape aggression as needed.[4] A more detailed review on these management strategies can be found elsewhere.[1]

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Conflict of interest

None reported.

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References

1. Spoolder HAM, Vermeer HM. Gestation group housing of sows. In: Farmer C, ed. *The Gestating and Lactating Sow.* Wageningen Academic Publishers; 2015:47-65. **https://doi.org/10.3920/978-90-8686-803-2_3**

2. Terlouw EMC, Lawrence AB, Illius AW. Influences of feeding level and physical restriction on the development of stereotypies in sows. *Anim Behav.* 1991;42:981-991. **https://doi.org/10.1016/S0003-3472(05)80151-4**

3. Zonderland JJ, de Leeuw JA, Nolten C, Spoolder HAM. Assessing long-term behavioural effects of feeding motivation in group-housed pregnant sows; what, when and how to observe. *Appl Anim Behav Sci.* 2004;87:15-30. **https://doi.org/10.1016/j.applanim.2003.12.009**

4. Lopez M, Salak-Johnson JL. A review: Aggression concerns with group-housed sow well-being. *J Dairy Vet Anim Res.* 2016;4:319-323. **https://doi.org/10.15406/jdvar.2016.04.00122**

5. Greenwood EC, Dickson CA, van Wettere WHEJ. Feeding strategies before and at mixing: The effect on sow aggression and behavior. *Animals.* 2019;9:23. **https://doi.org/10.3390/ani9010023**

6. de Leeuw JA, Bolhuis JE, Bosch G, Gerrits WJJ. Effects of dietary fibre on behaviour and satiety in pigs. *Proc Nutr Soc.* 2008;67:334-342. **https://doi.org/10.1017/S002966510800863X**

7. Pacheco E, Lopez M, Salak-Johnson JL. Social status differentially affects behavioral and immunological outcomes of group-kept sows fed different dietary fiber using different length feeding barriers. *Front Anim Sci.* 2021;2:719136. **https://doi.org/10.3389/fanim.2021.719136**

8. Verdon M, Zegarra N, Achayra R, Hemsworth PH. Floor feeding sows their daily allocation over multiple drops per day does not result in more equitable feeding opportunities in later drops. *Animals.* 2018;8:86. **https://doi.org/10.3390/ani8060086**

9. Bench CJ, Rioja-Lang FC, Hayne SM, Gonyou HW. Group gestation housing with individual feeding—I: How feeding regime, resource allocation, and genetic factors affect sow welfare. *Livest Sci.* 2013;152:208-217. **http://doi.org/10.1016/j.livsci.2012.12.021**

10. Smeets AJ, Westerterp-Plantenga MS. Acute effects on metabolism and appetite profile of one meal difference in the lower range of meal frequency. *Br J Nutr.* 2008;99:1316-1321. **https://doi.org/10.1017/S0007114507877646**

11. Holt JP, Johnston LJ, Baidoo SK, Shurson GC. Effects of a high-fiber diet and frequent feeding on behavior, reproductive performance, and nutrient digestibility in gestating sows. *J Anim Sci.* 2006;84:946-955. **https://doi.org/10.2527/2006.844946x**

12. Schneider JD, Tokach MD, Dritz SS, Nelssen JL, DeRouchey JM, Goodband RD. Effects of feeding schedule on body condition, aggressiveness, and reproductive failure in group-housed sows. *J Anim Sci.* 2007;85:3462-3469. **https://doi.org/10.2527/jas.2007-0345**

13. Vargovi L, Hermesch S, Athorn RZ, Bunter KL. Feed intake and feeding behavior traits for gestating sows recorded using electronic sow feeders. *J Anim Sci.* 2021;99:1-12. **https://doi.org/10.1093/jas/skaa395**

14. da Silva CS, van den Borne JJGC, Gerrits WJJ, Kemp B, Bolhuis JE. Effects of dietary fibers with different physicochemical properties on feeding motivation in adult female pigs. *Physiol Behav.* 2012;107:218-230. **https://doi.org/10.1016/j.physbeh.2012.07.001**

15. Meunier-Salaün MC, Bolhuis JE. High-fibre feeding in gestation. In: Farmer C, ed. *The Gestating and Lactating Sow.* Wageningen Academic Publishers; 2015:95-109. **https://doi.org/10.3920/978-90-8686-803-2_5**

16. da Silva CS, Bolhuis JE, Gerrits WJJ, Kemp B, van den Borne JJGC. Effects of dietary fibers with different fermentation characteristics on feeding motivation in adult female pigs. *Physiol Behav.* 2013;110-111:148-157. **https://doi.org/10.1016/j.physbeh.2013.01.006**

17. Huang S, Wei J, Yu H, Hao X, Zuo J, Tan C, Deng J. Effects of dietary fiber sources during gestation on stress status, abnormal behaviors and reproductive performance of sows. *Animals.* 2020;10:141. **https://doi.org/10.3390/ani10010141**

18. de Leeuw JA, Zonderland JJ, Altena H, Spoolder HAM, Jongbloed AW, Verstegen MWA. Effects of levels and sources of dietary fermentable non-starch polysaccharides on blood glucose stability and behaviour of group-housed pregnant gilts. *Appl Anim Behav Sci*. 2005;94:5-29. **https://doi.org/10.1016/j.applanim.2005.02.006**

19. Sapkota A, Marchant-Forde JN, Richert BT, Lay DC. Including dietary fiber and resistant starch to increase satiety and reduce aggression in gestating sows. *J Anim Sci.* 2016;94:2117-2127. **https://doi.org/10.2527/jas.2015-0013**

20. de Leeuw JA, Jongbloed AW, Verstegen MWA. Dietary fiber stabilizes blood glucose and insulin levels and reduces physical activity in sows (*Sus scrofa*). *J Nutr.* 2004;134:1481-1486. **https://doi.org/10.1093/jn/134.6.1481**

21. Serena A, Jørgensen H, Bach Knudsen KE. Absorption of carbohydrate-derived nutrients in sows as influenced by types and contents of dietary fiber. *J Anim Sci*. 2009;87:136-147. **https://doi.org/10.2527/jas.2007-0714**

22. Robert S, Rushen J, Farmer C. Both energy content and bulk of food affect stereotypic behaviour, heart rate and feeding motivation of female pigs. *Appl Anim Behav Sci*. 1997;54:161-171. **https://doi.org/10.1016/S0168-1591(97)00067-1**

23. Meunier-Salaün MC, Edwards SA, Robert S. Effect of dietary fiber on the behavior and health of restricted fed sows. *Anim Feed Sci Technol*. 2001;90:53-69. **https://doi.org/10.1016/S0377-8401(01)00196-1**

24. Strader AD, Woods SC. Gastrointestinal hormones and food intake. *Gastroenterol.* 2005;128:175-191. **https://doi.org/10.1053/j.gastro.2004.10.043**

25. DeRouchey J, Tokach M. Group housing systems: Nutritional considerations. Published 2013. Accessed April 11, 2022. **https://porkcdn.s3.amazonaws.com/sites/all/files/documents/2013SowHousingWebinars/5%20-%20Group%20Housing%20Systems.Nutritional%20Considerations-03647.pdf**

26. Brouns F, Edwards SA, English PR. Influence of fibrous feed ingredients on voluntary intake of dry sows. *Anim Feed Sci Technol*. 1995;54:301-313. **https://doi.org/10.1016/0377-8401(95)00767-H**

*27. Reese D, Prosch A, Travnicek DA, Eskridge KM. Dietary fiber in sow gestation diets - An updated review. *Nebraska Swine Reports*. 2008;45:14-18. **http://digitalcommons.unl.edu/coopext_swine/45**

28. Li YZ, Baidoo SK, Johnston LJ, Anderson JE. Effects of tryptophan supplementation on aggression among group-housed gestating sows. *J Anim Sci.* 2011;89:1899-1907. **https://doi.org/10.2527/jas.2010-3125**

29. Li YZ, Wang LH, Johnston LJ. Sorting by parity to reduce aggression toward first-parity sows in group-gestation housing systems. *J Anim Sci.* 2012;90:4514-4522. **https://doi.org/10.2527/jas.2011-4869**

* Non-refereed reference.