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Summary and Implications

Gestation sows are well suited to utilize high-fiber, low-density diets. They utilize fiber better than growing pigs and during gestation have a high feed intake capacity relative to their energy requirement. When research results from several studies were pooled and weighted according to the number of litters produced, sows fed additional fiber during gestation farrowed and weaned more pigs/litter than sows fed control diets. Feeding fiber during gestation also improved lactation feed intake, but reduced sow weight gain during pregnancy and pig birth weight. Sows fed fibrous diets also exhibit less stereotypic behavior (i.e., bar-biting), which may be an indication of improved welfare. It is likely there are several factors influencing the response to extra fiber in the sow diet, but it appears the amount of neutral detergent fiber consumed and the source of fiber are important. The metabolizable energy content of fibrous feed ingredients for sows is greater than that for growing pigs. There are limitations to feeding high-fiber diets related to the physical nature of fibrous feed ingredients and the greater volume of manure produced. Potential opportunities exist for pork producers to lower gestation sow feeding costs and/or improve sow reproductive performance by using fibrous feed ingredients during gestation.

Introduction

Gestating sows are excellent candidates for high-fiber diets. Limit-fed gestating sows derive more energy from fibrous feedstuffs than growing pigs allowed ad libitum access to feed. Because of their low feed intake and resulting slow rate of passage, sows have a higher fermentation capacity in the hindgut. Also, sows can consume more of a concentrate diet than necessary to meet their energy requirement during gestation. This excess feed intake capacity can be exploited by offering sows low energy feeds.

There may be certain situations that justify using fibrous feed ingredients in sow gestation diets. However, before decisions can be made it is important to examine the role and feasibility of added fiber in sow gestation diets.

Overall Effects on Reproductive Performance

Results from over 30 years of research are mixed on the effects of added fiber in gestation diets on sow and litter performance. Because of this, it is difficult for producers and nutritionists to decide whether to add fiber to sow gestation diets. Part of the reason for the mixed results is the large variation often observed in reproductive data. Until recently there was no study reported where the number of litters evaluated was sufficient to detect significant differences in performance of sows fed a control or a high-fiber diet.

That study involved feeding gestation sows a fortified corn-soybean meal diet at 4 pounds/day or the same diet (4 lb/d) plus ground wheat straw (.7 lb/d). Wheat straw is a fairly nonfermentable fiber source and was assumed to contribute no nutrients to the diet. It was ground to a fiber length of .25 to .5 inches. All sows were allowed ad libitum access to a corn-soybean meal diet during lactation. Treatments continued for three consecutive reproductive cycles.

The results of the study showed no significant effects of diet on any sow performance traits except lactation feed intake. Sows fed wheat straw during gestation consumed .3 pounds/day more feed during lactation. There was significant diet x parity interaction for litter size born alive, because sows fed wheat straw farrowed more pigs than control sows in cycles 2 (10.5 vs 9.0) and 3 (10.6 vs 10, $P < .015$) but not in cycle 1 (9.9 vs 10.4). Sows fed wheat straw also weaned significantly more (.7) pigs than control sows. Other litter traits were not affected by wheat straw.

Besides having a more adequate number of sows/diet than previous experiments, the following unique features about this study strongly supports the idea that fiber *per se* improved reproductive performance in gestation sows.

- Energy and nutrient intake during gestation were not confounded with the effect of fiber.
- Both diets were supplemented with folic acid and biotin which are known to increase litter size.

To further understand the role fiber has in gestation diets, careful study of previous research is warranted. An analysis of multiple studies was conducted to gain an overall perspective on how added fiber affects sow and litter performance. Mean responses for sow and litter performance were weighted according to the number of litters represented by each mean.

A summary of the net effects of feeding fiber seen in the wheat straw study, as well as, those observed in previous studies is shown in Table 1. In general, the net effect of fiber fed during gestation is similar between the two data sets for most traits. However, the effect of fiber on the number of pigs weaned per litter was over twice as high for sows fed wheat straw. Moreover, there appears to be disagreement on the effect of fiber on the percentage of sows completing the experiment

Table 1. A summary of changes in sow and litter performance due to added fiber observed in a wheat straw study and previous studies

	Study	
	Wheat straw[a]	Previous[b]
Sow traits		
ME/d, Mcal[c]	0	-0.1
Gestation wt. gain, lb	-9	-6
Lactation wt. loss, lb	0	-3
Lactation feed/d, lb	+0.3	+0.6
% completion[d]	0	+10
Litter traits		
Pigs born alive	+0.5	+0.3
Pigs weaned	+0.7	+0.3
Pig birth wt, lb	-0.1	-0.2
Pig weaning wt, lb	-0.7	+0.9

[a]Ewan et al.,1996.
[b]Data from 20 references representing 14 fiber sources and over 1,113 litters produced from sows fed control and high-fiber diets during gestation.
[c]Metabolizable energy intake.
[d]% completion = number of females that completed the study/number assigned to each treatment.

(i.e., sow longevity) and pig weaning weight. These results suggest at least a portion of the responses observed in previous studies was due to fiber intake *per se*, not other factors such as differences in sow nutrient intake.

Effect of Fiber Source on Performance

Knowing if there are fiber source effects on sow and litter performance will enable producers and nutritionists to make better decisions about feeding gestation sows. Unfortunately, few studies have directly compared different fiber sources. Comparisons that have been made include wheat straw to soybean hulls, alfalfa hay to prairie hay, alfalfa hay to alfalfa meal and alfalfa meal to corn cobs. These studies do not provide conclusive evidence that sow and litter performance is affected by fiber source, because no study evaluated more than 18 litters per diet. Thus, the data from previous studies (described in Table 1) were sorted according to fiber source. In an attempt to reduce bias from the analysis, only data from fiber sources evaluated at more than one location were selected and summarized. Daily neutral detergent fiber (NDF) intake during gestation for sows fed control and fibrous diets was calculated. Means were weighted according to the number of litters evaluated for each fiber source.

Table 2 shows the average change in the number of pigs born alive and weaned according to the fiber source given to the sow during gestation. It appears negative responses occurred when alfalfa meal and distillers grains were fed during gestation. The decrease in litter size observed with alfalfa meal is due to results from one of the three evaluated studies. Negative responses also were observed in both studies where distillers grains were evaluated. In contrast, alfalfa hay/haylage, corn gluten feed, oat hull/oats and wheat straw gave positive responses. The largest response in litter size born alive occurred when oat hulls/oats was fed; however, those sows consumed at least 54% more NDF/day than sows fed the other fiber sources. In addition, pigs from sows fed oat hull/oats had the lowest preweaning survival rate. Interestingly, feeding alfalfa hay/haylage, corn gluten feed, or wheat straw increased the number of pigs born alive similarly (.5, .7, and .5 pigs/litter, respectively). A similar increase in the number of pigs weaned was also observed when alfalfa hay/haylage, oat hulls/oats or wheat straw were provided (.8, .7, and .7 pigs/litter, respectively).

Additional research is necessary to provide conclusive evidence that fiber source influences sow reproductive performance. It is possible a fiber source x NDF intake interaction exists, suggesting the amount of NDF necessary to elicit an increase in litter size may depend on the source of NDF. Supporting evidence for this can be observed in Table 2. Sows fed wheat straw consumed about 50% less NDF/d than sows fed alfalfa hay/haylage, but the improvement in litter size was similar.

Response in Sow and Litter Performance in Relation to Fiber Intake

Better decisions regarding feeding fiber to gestation sows are possible if the response in sow and litter performance for each unit of additional fiber consumed is known. Unfortunately, few dose titration studies have been conducted with fiber in gestation diets.

Despite these limitations, it is possible to use existing data to help decide how much fiber gestation sows should consume to ensure a response. It appears that when feeding alfalfa haylage sows should consume about 450 grams of NDF/day to maximize the response in litter size at weaning. The same recommendation may also apply to alfalfa meal and hay, although that has not been critically evaluated. When oat hulls were fed to provide sows 515 grams of NDF/day, litter size was improved, but not maximized. Providing up to 380 grams of NDF/day when feeding corn gluten feed may optimize litter size. Although a dose titration study was not conducted with wheat

Table 2. Average change in litter size according to source of dietary fiber fed to the sow during gestation

Fiber source	Daily NDF intake, g[a]		No. pigs born alive	No. pigs weaned	No. litter[b]	No. references
	Control	Fiber				
Alfalfa meal	264	381	-0.4	-0.7	269	3
Alfalfa hay/haylage	246	721	+0.5	+0.8	647	6
Corn gluten feed	166	794	+0.7	+0.4	229	2
Distillers grains	139	418	-0.3	-0.4	118	2
Oat hulls/oats	260	1221	+1.8	+0.7	96	3
Wheat straw	150	368	+0.5	+0.7	699	1

[a]Average neutral detergent fiber intake by the sow consuming control and fibrous diets during gestation.
[b]Total number litters produced by sows fed control and fibrous diets.

Table 3. Estimated neutral detergent fiber (NDF) intake (g/d) by sows fed diets containing various levels of fibrous feedstuffs[a]

	Dietary level,%		
Fiber source	10	20	30
Alfalfa hay or meal	220	315	415
Corn gluten feed	185	235	295
Oats	185	235	285
Sugar beet pulp	200	265	335
Soybean hulls	235	340	455
Wheat middlings	185	230	280

[a]Alfalfa hay/meal, corn gluten feed, oats, sugar beet pulp, soybean hulls and wheat middlings assumed to contain 49, 33, 31, 40, 58 and 32% NDF, respectively. Sow ME intake = 6 Mcal/d.

straw, litter size at weaning was improved when the sows consumed 368 grams of NDF/day (Table 2). Table 3 provides estimates on the amount of NDF sows would consume if their diet contained various levels of fibrous feedstuffs.

Effect of Fiber on Sow Behavior

Recently a significant amount of attention has been given to stereotypic behavior in sows. Stereotypic behavior is repeated behavior having no apparent purpose. It is thought that stereotypic behavior is an indicator of reduced welfare of sows in individual housing systems.

Common types of stereotypic behavior observed in sows are bar-biting, sham-chewing and excessive adjunctive drinking. There are thought to be certain biological consequences to stereotypic behavior in sows including increased metabolic rate and poorer feed conversion. In addition, these sows are more prone to thin sow syndrome. It is possible that sow reproductive performance is impaired in sows prone to, or exhibiting, stereotypic behavior during gestation.

Researchers in Scotland have linked feed restriction to the development of stereotypic behavior in gestating sows. In practice, gestating sows are given quantities of feed much lower than they are capable of consuming. This leaves sows with a heightened feeding motivation which they deal with through performing stereotypic behavior.

Nutritionists may have an important role in designing feeding programs for pregnant sows to reduce the incidence of stereotypic behavior. Researchers have investigated the effect of feeding diets containing unmolassed sugar beet pulp on stereotypic behavior exhibited by gilts during the first 1.5 hours after feeding. One group of sows was fed a control diet at 4.4 pounds/day a second group was fed a diet containing 50% unmolassed sugar beet pulp at 5.1 pounds/day and a third group had ad libitum access to the 50% beet pulp diet. Results indicate the amount of time the sows spent licking the floor or trough, bar-biting or sham-chewing was reduced when the beet pulp was fed (Table 4). These results show feeding sugar beet pulp promoted satiety in gilts and reduced the incidence of stereotypies. The 50% sugar beet pulp diet fed at 5.1 pounds/day seemed as effective at reducing the incidence of stereotypies as providing gilts ad libitum access to that diet.

Table 4. Effect of dietary fiber on the incidence of oral behaviors in sows[a,b]

	Time (min) spent on[c]		
Treatment	Licking	Sham-chewing	Bar-biting
Control (4.4 lb/d)	28.1	12.1	8.8
Restricted SBP (5.1 lb/d)	6.1	0.9	0.1
Ad libitum SBP	2.6	0.0	0.3
	P < 0.03	P < 0.08	P < 0.05

[a]Brouns et al., 1994.
[b]SBP = unmolassed sugar beet pulp.
[c]During first 1.5 hr after feeding.

Diet Formulation and Feeding Management

Using fibrous feeds in sow gestation diets requires attention to some important details. A summary of key points is presented below.

- Evaluate the economics of feeding fibrous feeds by calculating **total** feed cost/sow/year (cost of feed/ton x tons/sow/year), not just feed cost/ton.
- Sows fed high-fiber diets must eat more feed to meet their energy requirements.
- Digestion coefficients for high-fiber ingredients are greater than those obtained with growing pigs.
- Dry matter, gross energy and fiber utilization of alfalfa hay is increased when particle size is reduced from .5 to 25 inches.
- Sows fed restricted quantities of a bulky diet require more time to eat their ration.

Possible Limitations to Feeding Sows Fiber

In addition to direct economic considerations, other factors may limit the ability of producers to use fibrous feeds in gestation sow diets. These include:

- Some feed mixing and handling equipment can not physically handle fibrous feed ingredients.
- Grinding certain ingredients is time consuming and dusty.
- High-fiber diets are bulky (fewer lb/ft^3) and may bridge in bulk bins and feeders.
- Costs associated with manure handling may increase due to the larger volume of solids produced.
- Handling liquid manure may be more difficult because of larger, undigested feed particles and less liquid present due to sows drinking less water.

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