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Dietary Fiber in Sow Gestation Diets - An Updated Review

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Dietary Fiber in Sow Gestation Diets — An Updated Review

Opportunities exist for pork producers to maintain or improve sow reproductive performance by using fibrous feedstuffs during gestation.

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Summary

Twenty-four published reports dating from 1975 to 2007 were examined to determine the overall effects of feeding gestation sows additional fiber. Sow and litter traits among trials were weighted by the number of litters for each treatment within each trial. Overall, sows can successfully consume high-fiber diets during gestation with few deleterious effects. Positive effects from feeding high-fiber diets were evident in litter size (0.2 to 0.6 pigs/litter) and sow lactation feed intake (0.5 to 0.8 lb/day), but they are not largely evident until the second reproductive cycle following exposure to the diet. It's possible that to ensure sow and litter performance improvements from feeding fiber, fiber must be included in the diet before mating.

Introduction

Gestating sows are excellent candidates for high-fiber diets. They 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 less energy-dense diets. Also, in contrast to growing pigs allowed ad libitum access to feed, gestation sows derive more energy from fibrous feedstuffs.

The recent increase in corn price has prompted pork producers to consider alternative, high-fiber feedstuffs in swine diets. According to literature reviews published in the *1997 Nebraska Swine Report* and in Lewis and Southern, 2000 (Swine Nutrition, 2nd ed.), the number of pigs born alive and weaned was improved by 0.4 and 0.5 pigs/litter respectively, by feeding sows additional fiber during gestation. A slight improvement in sow longevity was also observed in fiber-fed sows.

Additional research results from four reports where sows were fed high-fiber diets during gestation have appeared since those earlier reviews. In addition, fiber intake was characterized as neutral detergent fiber (NDF) earlier. Currently there's recognition that perhaps more appropriate measures of fiber are soluble fiber (SF) and insoluble fiber (IF). The objective of this paper is to summarize sow fiber feeding results in order that the role of fibrous ingredients in sow gestation diets can be further elucidated.

Materials and Methods

Twenty-four published reports dating from 1975 to 2007 were examined. Results from each comparison between control and treatment sows were evaluated to determine the number of comparisons where a decrease, no change, or an increase in response was observed from feeding high-fiber diets. Then the hypothesis of a 0.5 probability of an increase due to additional fiber was tested using the sign test (Sprent and Smeeton, 2007). Average response to dietary fiber was calculated for each sow and litter trait among trials weighted by the number of litters for each treatment within each trial. The mean difference between control and fiber of each variable and the interaction between fiber and reproductive cycle category was tested for significance using weighted analyses of variance where weights were based on the number of litters in each treatment for each trial. Computations were conducted using the NPAR1WAY and GLM procedures (SAS Inst. Inc., Cary, N.C.). Reported metabolizable energy (ME), NDF, SF and ISF intakes were recorded; otherwise, intakes were estimated from reported sow feed intakes and published composition values for the feedstuffs (Table 1).

Overall effects on reproductive performance

None of the mean responses to feeding sows additional fiber in gestation were significant ($P > 0.10$; Table 2). However, for some response variables, we determined that the likelihood sow performance changed as a result of feeding fiber rather than by chance was greater than 95 in 100. These results indicate that sows fed high-fiber diets during gestation consumed less ME/day during gestation and more feed during lactation, completed the experiments at a higher rate and farrowed more live-born pigs per litter that weighed less ($P < 0.05$; Table 2).

Despite attempts by many researchers to equalize energy intake during gestation, the net effect of feeding high-fiber diets resulted in slightly decreased sow ME intake. Errors associated with assigning an energy value to the treatment diet were often cited as contributing to the decreased energy intake. Research results from feeding sows less ME derived from a corn/soybean meal diet during gestation show a similar relationship between gestation ME intake and sow lactation feed intake as that reported in Table 2.

Table 1. Composition of corn, soybean meal, and other fibrous feedstuffs (as-fed basis).[a]

Ingredient	ME, kcal/lb	NDF, %	SF,%	ISF, %
Corn	1555	9.6	1.7	4.7
Soybean meal, 44% CP	1445	13.3	1.6	31.5
Soybean meal, 46.5% CP	1536	8.9	1.4	26.2
Alfalfa meal and hay	900	45	4.2	52.4
Alfalfa haylage (90% dry matter)	900	32.8	3.1	38.3
DDGS[b]	1559	44	0.7	42.2
Wheat shorts		35	3.3	37.7
Perennial peanut hay		40.2		
Oat hulls		71.8		
Sunflower hulls		70.6		
Corn gluten feed	1184	36.8		
Soybean hulls	950	67	8.4	75.5
Oats	1232	31.4		
Wheat straw		85	0.5	71.0
Beet pulp	1134	54	11.7	53.9
Oat bran		19.2	7.5	8.3

[a]ME = metabolizable energy NDF = neutral detergent fiber; SF = soluble fiber; ISF = insoluble fiber.
[b]Dried distillers grains with solubles.

Table 2. Summary of responses to additional fiber in sow gestation diets.[a]

	No. of comparisons exhibiting…				No. litters	
Item	Increase	No change	Decrease	Response[b]	Control	Fiber
ME intake, Mcal/d[c]	11	3	19[f]	-0.2	1,936	2,415
Gestation weight gain, lb	19	1	16	-7.7	1,970	2,458
Lactation weight loss, lb	17	1	18	-1.4	1,500	1,992
Lactation feed intake, lb/day	20	2	8[f]	0.5	1,943	2,416
Completion rate, % [d]	10	0	2[f]	10.0	773	1,080
Live pigs born/litter	29	0	11[e]	0.2	2,024	2,524
Pigs weaned/litter	19	3	12	0.3	1,520	1,988
Piglet birth weight, lb	12	7	22[e]	0.0	2,048	2,548
Piglet weaning weight, lb	16	4	18	-0.1	2,042	2,530

[a]Data from 24 reports representing 19 fiber sources; maximum number of comparisons between control and fiber diets = 41.
[b]Mean response among trials weighted by numbers of litters for each treatment within each trial.
[c]ME = metabolizable energy.
[d](Number of females that completed the study/number of females assigned to each treatment) x 100; percentage units.
[e] $P < 0.01$ (Number increase vs. number no change + number decrease).
[f] $P < 0.05$ (Number increase vs. number no change + number decrease).

The litter size responses at birth and weaning are 0.2 pigs/litter less than previously reported. Of the four research reports that were not available for the previous literature reviews, litter size response was positive in two and only slightly positive to negative in two.

One vs. multiple reproductive cycle evaluation

Consideration regarding timing of fiber-feeding is warranted when evaluating litter size information, because it's well established that nutritional interventions intended to affect litter size must be employed before mating. In gestation studies that are limited to one reproductive cycle, sows are seldom introduced to the treatment diets before mating. However, in gestation studies that extend beyond one reproductive cycle, sows can be reintroduced treatment diets at weaning. Therefore, in an attempt to better understand the role of fiber in the gestation diet, research results from Table 2 were partitioned according to whether they were obtained from sows that were fed treatment diets for one or more than one reproductive cycle.

Sows fed additional fiber during gestation in the multiple-cycle studies produced 0.5 more pigs at weaning than those fed the control diet; however, in studies that involved one reproductive cycle, fiber-fed sows produced 0.2 fewer pigs at weaning, respectively than sows fed the control diet ($P = 0.08$; Table 3). No other significant reproductive cycle category x diet interactions were observed. However, it seems that additional fiber improved the number of live-born pigs/litter and lactation feed intake more in the multiple vs. single reproductive cycle studies (0.4 vs. -0.1 pigs/litter and 0.8 vs. -0.2 lb/day, respectively).

The different response observed in litter size to feeding additional fiber between sows involved in multiple vs. single reproductive cycle studies warrants further investigation. If it is important to feed additional fiber to sows before mating to observe a litter size response, it is reasonable to expect that within the multiple cycle studies, the litter size response would be greater in the later cycles of a study than in the first. Therefore, the number of live born pigs by reproductive cycle from sows fed the control and treatment diets in each multiple-cycle study was summarized. Changes in litter size by reproductive cycle were calculated and compared to the litter size response obtained from feeding fiber to sows that were involved in one reproductive cycle (Figure 1). As expected, the average litter size response observed during the first reproductive cycle in studies that involved multiple cycles was smaller compared to that observed for the second and third cycle (0.1 vs. 0.9 and 0.5 pigs/litter, $P = 0.0008$). Moreover, the responses for the first reproductive cycle in studies that involved multiple cycles is similar to that derived for studies involving a single reproductive cycle (0.1 vs. -0.1 pigs/litter, $P = 0.49$).

These results suggest that summarizing sow fiber feeding data according to reproductive cycle number further elucidates the role of fiber in sow diets. Therefore, subsequent analyses will be limited to data from sows involved in multiple reproductive cycles. Also, it seems the results from studies where sows were fed treatment diets for more than one reproductive cycle show greater benefits from feeding high-fiber diets during gestation.

The extent that daily fiber intake

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Table 3. Summary of the effects of additional fiber in sow gestation diets when evaluated during one vs. multiple reproductive cycles.[a,b]

	No. reproductive cycles						No. litters	
	1			>1				
Item	Control	Fiber	Response	Control	Fiber	Response	1 cycle	>1 cycle
Daily intake								
ME, Mcal[c]	6.2	6.3	0.1	6.8	6.4	-0.4	1,322	3,029
NDF, g[d]	181	574	393	380	792	412	1,346	3,029
SF, g[e]	16	44	28	150	327	177	1,113	2,671
ISF g[f]	185	421	236	178	541	363	1,113	1,737
Gestation weight gain, lb	60.0	63.1	3.1	110.5	99.0	-11.5	1,297	3,131
Lactation weight loss, lb	-15.9	-19.0	3.1	-9.1	-5.2	-3.9	1,297	2,207
Lactation feed intake, lb/day	13.0	12.8	-0.2	11.6	12.4	0.8	1,287	3,073
Live pigs born/litter	10.3	10.2	-0.1	10.4	10.8	0.4	1,321	3,227
Pigs weaned/litter[g]	9.6	9.4	-0.2	8.4	8.9	0.5	1,215	2,293
Piglet birth weight, lb	3.2	3.2	0.0	3.3	3.3	0.0	1,369	3,227
Piglet weaning weight, lb	12.5	12.8	0.3	14.7	14.5	-0.2	1,345	3,227

[a]Data from 24 reports representing 19 fiber sources.
[b]Mean response among trials weighted by numbers of litters for each treatment within each trial.
[c]ME = metabolizable energy.
[d] Neutral detergent fiber.
[e]Soluble fiber.
[f]Insoluble fiber.
[g]P = 0.08 for diet x reproductive cycle category.

was improved by feeding fibrous feedstuffs may depend on the basis for characterizing fiber and on the number of reproductive cycles utilized. The inclusion of fibrous feedstuffs in the diet seemed to increase daily NDF intake to a similar extent in sows involved in multiple- vs. single-cycle studies (412 vs. 393 g/day; Table 3). In contrast, the inclusion of fibrous feedstuffs in the diet increased daily SF intake by 532% (177 vs. 28 g) in sows involved in multiple-cycle studies compared with those in single-cycle studies. Daily ISF intake was increased by 54% (363 vs. 236 g) by incorporating fibrous feedstuffs in the diet of treatment sows involved in multiple vs. single cycle studies. These results suggest that characterizing fiber as SF and ISF may be more descriptive than NDF is for feeding sows.

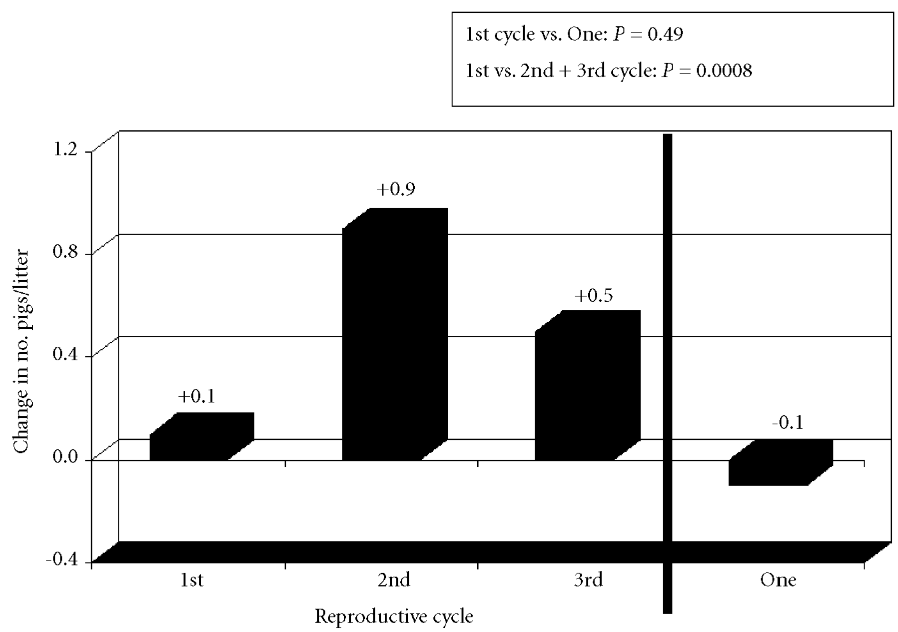

Figure 1. Change in number of live births per litter from feeding sows high-fiber diets during gestation according to reproductive cycle. Data for reproductive cycles 1 to 3 are from studies where sows were fed high-fiber diets over more than one reproductive cycle; data for One reproductive cycle are from studies where sows were fed high-fiber diets for one reproductive cycle only. Summary from 22 published reports; 14, 14, 11 and 24 control and fiber diet comparisons made for 1st, 2nd, 3rd, and One reproductive cycle category, respectively.

Evaluation of fiber additions to corn/ soybean meal-based diets

In the United States, sows are typically fed corn/soybean meal-based diets. Therefore, they would normally consume about 180, 30, and 120 g of NDF, SF and ISF per day, respectively. Sows involved in the multiple cycle studies that consumed the control diet averaged 380, 150 and 178 g of NDF, SF and ISF per day, respectively (Table 3). Assuming there is a threshold at which additional fiber in the diet does not further improve reproductive performance and given that fibrous feedstuffs would be incorporated into corn/soybean meal-based diets in the USA, it's pertinent to limit an evaluation to results from studies that utilized corn/soybean meal-based diets in control and treatment sows.

The removal of results from two studies from the data set where diets other than those based on corn/ soybean meal were provided to control

Table 4. Summary of the effects of additional fiber in corn/soybean meal-based (corn-soy) sow gestation diets when evaluated over multiple reproductive cycles.[a,b]

	Diet					No. litters	
Item	Corn-soy	Corn-soy + fiber	Response	SEM[c]	P- value	Corn-soy	Corn-soy + fiber
Daily intake							
ME, Mcal[d]	6.2	6.1	-0.1	0.1	0.56	773	987
NDF, g[e]	183	563	380	46	<0.0001	773	987
SF, g[f]	30	46	16	5	0.04	664	738
ISF g[g]	160	483	323	51	0.0005	664	738
Gestation weight gain, lb	80.9	73.2	-7.7	6.2	0.37	825	1,037
Lactation weight loss, lb	-8.0	-2.5	-5.5	3.0	0.19	830	1,042
Lactation feed intake, lb/day	11.8	12.5	0.7	0.3	0.18	791	1,013
Live pigs born/litter	10.0	10.4	0.4	0.2	0.13	873	1,085
Pigs weaned/litter	8.3	8.9	0.6	0.2	0.03	873	1,085
Piglet birth weight, lb	3.3	3.3	0.0	0.1	0.72	873	1,085
Piglet weaning weight, lb	13.3	12.8	-0.5	0.9	0.69	873	1,085

[a]Data from 11 reports representing 11 fiber sources.
[b]Mean response among trials weighted by numbers of litters for each treatment within each trial.
[c]Standard error of the mean.
[d]ME = metabolizable energy.
[e]Neutral detergent fiber.
[f]Soluble fiber.
[g]Insoluble fiber.

Table 5. Average change in litter size according to source of dietary fiber fed to the sow during gestation.[a]

Fiber source	Dietary level, %	Daily intake of treatment sows, g[b] NDF	SF	ISF	Live pigs born	Pigs weaned	No. litters	No. references
Alfalfa meal	5.0	210	33	161	-1.3	-1.1	87	1
Alfalfa hay	50.0	620	66	681	0.9	0.7	375	2
Alfalfa haylage	53.0	515	54	506	0.8	1.0	110	1
Alfalfa-orchardgrass hay	45.8	934			0.1	0.9	86	1
Corn gluten feed	93.0	830			0.9	0.6	193	1
DDGS[c]	50.0				0.8	0.3	140	1
Perennial peanut hay	79.6				-0.2	-0.4	58	1
Soybean hulls	19.1	471	67	476	-0.8	-0.7	35	1
Sunflower hulls	22.2	568			0.5	0.2	153	1
Wheat straw	14.2	429	30	368	0.5	0.7	699	1
Wheat shorts	97.5	682	65	734	0.6	1.2	96	1

[a]Control sows fed corn/soybean meal-based diets; control and treatments diets provided for >1 reproductive cycle.
[b]NDF = neutral detergent fiber; SF = soluble fiber; ISF = insoluble fiber.
[c]Dried distillers grains with solubles.

and treatment sows resulted in similar responses due to feeding additional fiber for all response variables except for SF intake (responses in Table 3 vs. Table 4). The response in daily SF intake decreased from 177 to 16 g.

The large reduction in the amount of SF provided to sows is explained by the large amount of SF sows in the two studies that were removed from the analysis consumed during gestation (457 and 806 g/day). Considering that the response in litter size did not diminish at the removal of the two studies where sows consumed a large quantity of SF, it's possible that sows do not need to consume more than about 46 g of SF per day to elicit a litter size response as long as the fiber-feeding occurs over more than one reproductive cycle.

As expected, adding fibrous ingredients to corn/soybean meal-based diets resulted in greater intakes of NDF ($P < 0.0001$), SF ($P = 0.04$) and ISF ($P = 0.0005$; Table 4). Feeding additional fiber during gestation improved litter size at weaning by 0.6 pigs/litter ($P = 0.03$). Sows fed fiber appeared to lose 5.5 lb less weight during lactation, consume 0.7 lb more feed during lactation and farrow 0.4 more pigs/litter. Overall, this analysis indicates that the addition of fiber from various sources to corn/soybean meal-based gestation diets is not likely to reduce reproductive performance; some improvement may be observed for some traits.

Effect of fiber source on litter size

The information in Table 4 may be the best available to show the effect of including fibrous feedstuffs in corn/soybean meal-based gestation diets. However, there are 11 different fiber sources represented in that summary. Does one fiber source affect sow performance more than another?

Results of a summary examining change in litter size according to source of dietary fiber when fed for

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more than one reproductive cycle are presented in Table 5. Of the 11 fiber sources shown, providing three (alfalfa meal, perennial peanut hay and soybean hulls) to gestation sows appeared to reduce litter size. Litter size improvements ranged from 0.1 to 1.2 pig per litter for the remaining sources.

Soybean hulls and alfalfa meal are generally widely available and excellent candidates for inclusion in sow gestation diets. Given the relatively few number of litters that have been produced from alfalfa meal feeding research (87) and the positive results observed from feeding high-quality alfalfa hay and haylage and alfalfa-orchard grass, producers feeding alfalfa meal to sows are not likely to observe any reduction in litter size. However, results from feeding soybean hulls to gestation sows are mixed and difficult to predict. Two, single-cycle studies, involving a total of 493 litters that were included in the overall summary (Table 1), reported changes in number of pigs born alive and weaned ranging from -0.9 to 0.1 and 0.0 to 0.2 pigs per litter, respectively due to feeding soybean hulls during gestation.

Conclusion

Despite research results that span decades, questions remain about feeding high-fiber diets to gestating sows. However, the body of data summarized for this review indicates that sows can successfully consume high-fiber diets during gestation with few deleterious effects. Positive results in litter size and lactation feed intake were observed, but they are not largely evident until the second reproductive cycle. It's possible that to ensure sow and litter performance improvements from feeding fiber, that fiber-feeding must be initiated before mating.

Based on the results of this analysis, additional research directed at feeding high-fiber diets to gestating sows could 1) entail an evaluation of the fiber source(s) for more than one reproductive cycle, 2) exam the optimum time to introduce high-fiber diets to elicit a litter size response, 3) determine the amount of additional fiber necessary to elicit a litter size response and 4) reexamine the value of soybean hulls in gestation diets.

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