Effects of Withdrawing High-Fiber Ingredients Prior to Market on Growth Performance, Carcass Characteristics, and Economics in Commercial Finishing Pigs[1,2]

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Summary

A total of 1,089 mixed-sex pigs (PIC 337 × 1050; initial BW 98.2 lb) were used in a 96-d study. The two diet types fed during the study were a corn-soybean meal control diet with low NDF (9.3%) and a high-fiber diet with high NDF (19%) that contained 30% dried distillers grains with solubles (DDGS) and 19% wheat middlings (midds). Pens of pigs were randomly allotted to 1 of 6 dietary feeding strategies with 25 to 27 pigs per pen and 7 replications per treatment. The six dietary strategies consisted of the corn-soybean meal control diet or high-fiber diet fed for the duration of the study, or the high-fiber diet fed until 24, 19, 14, or 9 d prior to harvest, at which time the pigs were switched to the corn-soybean meal control diet for the remainder of the study. Overall (d 0 to 96), pigs fed the high-fiber diet through the entire study compared with the corn-soy control diet had lower ($P < 0.01$) ADG and poorer F/G. This reduction in growth performance led to a trend for poorer ($P < 0.10$) caloric efficiency and lower ($P < 0.01$) final BW in pigs fed the high-fiber diet throughout compared to the control. For pigs fed the high-fiber diet then switched to the corn-soy control, ADG and ADFI were not different between withdrawal days, but F/G tended (linear; $P < 0.07$) to improve as withdrawal days increased from 0 to 24 d.

Pigs fed the high-fiber diet throughout had a 9.5-lb lighter ($P < 0.01$) HCW compared to those fed the corn-soy control. Neither percentage yield using the farm live weight or plant live weight were significantly influenced by withdrawal days from the high-fiber diet; however, HCW increased linearly ($P < 0.05$) as withdrawal days increased. Backfat and loin depth both decreased ($P < 0.02$) in pigs fed the high-fiber diet throughout compared with those fed the corn–soybean meal diet. Loin depth increased, then decreased (quadratic; $P < 0.04$) as high-fiber diet withdrawal time increased.

Total feed cost per pig and feed cost per lb of gain was lower ($P < 0.01$) for pigs fed the high-fiber diet until harvest, but carcass gain value per pig also decreased ($P < 0.01$) by $7.34. Total feed cost tended ($P < 0.10$) to increase and carcass gain value increased ($P < 0.05$) as high-fiber diet withdrawal time increased. Although no significant differences were observed in income over feed cost (IOFC) between treatments, switching pigs from the high-fiber diet to the corn-soybean meal diet at 14 to 19 d before market numerically increased IOFC by $1.42 to $2.30/pig over pigs fed the high-fiber diet

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continuously and $2.04 to 2.92/pig over pigs fed the corn-soybean meal diet throughout. These data indicate that much of the benefit in lower feed cost from feeding high-fiber diets can be captured while minimizing the reduction in revenue by switching pigs to a low-fiber, high-energy diet for 14 to 19 d prior to market.

Key words: finishing pig, fiber withdrawal, growth performance

Introduction

Using feed ingredients that are lower in energy and higher in fiber compared with corn is a common practice as producers and nutritionists attempt to decrease diet cost. This topic has been an active area of research; however, the effects that these ingredients have on carcass yield and ultimately carcass revenue are not fully understood. Previous research (Asmus et al., 2011[4]) reported that switching pigs from a diet high in NDF (19% NDF, 30% DDGS, and 19% wheat middlings) to a corn-soy diet (9.3% NDF) approximately 20 d prior to market restored carcass yield to levels similar to pigs fed the control diets. This result occurred partly because of the decrease in gut fill that is common with high-fiber diets; specifically, the weight of the large intestine was reduced. These data are intriguing, but the question of how much time is needed to withdraw these high-fiber ingredients prior to slaughter to minimize the negative impacts on carcass yield and maximize economic return remains.

Therefore, the objective of this study was to determine in a commercial setting the optimal time that high-fiber ingredients should be removed prior to market so growth, carcass performance and economic return can be maximized.

Procedures

The Kansas State University Institutional Animal Care and Use Committee approved the protocol used in this experiment. The study was conducted at a commercial research-finishing site in southwest Minnesota. The barn was naturally ventilated and double-curtain-sided. Each pen was equipped with a 5-hole stainless steel feeder and bowl waterer for ad libitum access to feed and water. Feed additions to each individual pen were made and recorded by a robotic feeding system (FeedPro; Feedlogic Corp., Wilmar, MN).

A total of 1,089 mixed-sex pigs (PIC 337 × 1050; initial BW 98.2 lb) were used in a 96-d study. Two diet types were fed consisting of a corn-soybean meal control diet with low NDF (9.3%) and a high-fiber diet with high NDF (19%) that contained 30% DDGS and 19% wheat midds. Diets were formulated on a standardized ileal digestible (SID) lysine basis and fed in meal form in 4 phases (Tables 1 and 2). Pens of pigs were randomly allotted to 1 of 6 dietary feeding strategies with 25 to 27 pigs per pen and 7 replications per treatment. The six dietary strategies consisted of the corn-soybean meal control diet or high-fiber diet fed for the duration of the study, or the high-fiber diet fed until 24, 19, 14, or 9 d prior to slaughter, at which time the pigs were switched to the corn-soybean meal control diet for the remainder of the study. The original design was to change pigs at d 20, 15, 10, and 5 prior to harvest; however, inclement weather led to a power outage at the processing plant and increased the original withdrawal schedule by 4 d.

[4] Asmus, M.D. et al., Swine Day 2012. Report of Progress 1074, pp. 204–207.

Samples of the DDGS and midds used in the diets were collected at the time of manufacturing and a composite sample was analyzed. Analyses included DM, CP, ether extract (fat), CF, ADF, NDF, and ash. Samples of the complete feed were taken from the feeder at the beginning and end of each phase, and composite samples for each phase and diet type were made to determine bulk density.

Pens of pigs were weighed and feeder measurements were recorded on d 0, 14, 27, 64, 72, 77, 82, 87, and 96 to calculate ADG, ADFI, F/G, and ME caloric efficiency. On d 64, the 3 heaviest pigs in each pen were weighed and sold according to standard farm procedures. After removing those pigs, pens on the high-fiber diets were realloted to withdrawal time, balancing on d 0 and 64 average BW across treatments to ensure that prior performance did not bias the performance during the last phase when pigs were withdrawn from the high-fiber diet. During the high-fiber diet withdrawal period, all pens of pigs were weighed and feeder measurements were recorded each time a treatment group switched diets. Prior to marketing, the remaining pigs were individually tattooed with a pen ID number to allow for carcass measurements to be recorded on a pen basis. On d 96, final pen weights were taken, and pigs were transported to a commercial packing plant (JBS Swift and Company, Worthington, MN) for processing and carcass data collection. Carcass measurements taken at the plant included HCW, loin depth, backfat, and percentage lean. Also, percentage carcass yield was calculated by dividing the average pen HCW by average final live weight both at the farm and plant.

At the conclusion of the study, an economic analysis was completed to determine the financial impact of withdrawing pigs from a high-fiber diet to the control diet prior to harvest. The total feed cost per pig was calculated by multiplying the ADFI by the feed cost per pound and the number of days in each respective period, then taking the sum of those values for each period. Cost per pound of gain was calculated by dividing the total feed cost per pig by the total pounds gained overall. Carcass gain value was calculated by multiplying the HCW by an assumed carcass value of $77.00/cwt, then subtracting an initial pig cost, which was determined by multiplying the initial weight by 75% and the assumed carcass value of $77.00/cwt. To calculate IOFC, total feed cost was subtracted from the value of the carcass gain.

Experimental data were analyzed as a randomized complete block design using the MIXED procedure of SAS (SAS Institute, Inc., Cary, NC) with pen as the experimental unit and initial BW as a blocking factor. Linear and quadratic contrast were completed to determine the effects of withdrawing the high-fiber diet prior to slaughter, as well as contrast between the continuous feeding of the corn-soy control and high-fiber diet. Hot carcass weight served as a covariate for the analysis of backfat, loin depth, and lean percentage. Results from the experiment were considered significant at $P \leq 0.05$ and a tendency between $P > 0.05$ and $P \leq 0.10$.

Results and Discussion

Proximate analysis completed on the DDGS and midds demonstrated that the nutrient values used for diet formulation were similar to the analyzed values (Table 3). As expected, diet bulk density showed that as DDGS and midds were included in the diet, bulk density was reduced (Table 4).

From day d 0 to 64, pigs fed the high-fiber diet throughout the entire study had decreased ($P < 0.02$) ADG and ADFI, as well as poorer ($P < 0.02$) F/G compared with pigs fed the corn-soy control; consequently, the high-fiber pigs weighed approximately 8 lb less than those fed the corn-soy control diet on d 64 (Table 5).

From d 64 to 96, there was no difference in ADG or ADFI between pigs fed the high-fiber or corn-soy diets throughout the study; however, F/G was worse ($P < 0.03$), and final BW was lower ($P < 0.01$) for pigs fed the high-fiber diet throughout compared with the corn-soy diet. There were no differences in ADG, ADFI, F/G, or final BW for pigs fed the high-fiber diet with different withdrawal days. The lack of significant differences may have been influenced by the daily weighing of pens the last 4 d of the experiment as we anticipated shipment each of those days, but the inclement weather prevented us from doing so. All treatments would have been influenced similarly during this time, but repeated weighing seems to have increased variation.

Overall (d 0 to 96), pigs continuously fed the high-fiber diet compared with the corn-soy control diet had lower ($P < 0.01$) ADG and poorer F/G, but ADFI was not affected. This reduction in growth performance led to decreased ($P < 0.01$) final BW and a tendency for poorer ($P < 0.10$) caloric efficiency for pigs fed the high-fiber diet throughout compared with the control. For pigs initially fed the high-fiber diet then switched to the corn-soybean meal control, ADG and ADFI were not different between withdrawal days; however, F/G tended (linear; $P < 0.07$) to improve as withdrawal days increased from 0 to 24 d, with the pigs withdrawn 19 and 24 days prior to harvest being the most efficient. Final BW and caloric efficiency were unaffected by withdrawal days.

For carcass characteristics, pigs fed the high-fiber diet throughout had a 9.5-lb lighter ($P < 0.01$) HCW compared with pigs fed the corn-soy control (Table 6). Percentage yield was unaffected by dietary treatment, but daily weighing of pigs the last 4 d of the study may have reduced the potential to find a difference. Nevertheless, pigs withdrawn from the high-fiber diet had heavier HCW (linear; $P < 0.05$) as withdrawal days increased. Backfat and loin depth were both reduced ($P < 0.02$) in pigs continuously fed the high-fiber diet. Loin depth increased (quadratic; $P < 0.04$) as withdrawal time increased.

Total feed cost per pig and feed cost per lb of gain were lower ($P < 0.01$) for pigs fed the high-fiber diet until harvest. The value of the carcass gain was reduced ($P < 0.01$) by $7.34 in pigs fed the high-fiber diets throughout the entire study. Total feed cost tended ($P < 0.10$) to increase and carcass gain value increased ($P < 0.05$) as withdrawal time increased. Although we observed no significant differences in IOFC between treatments, switching pigs from the high-fiber diet to the corn-soybean meal diet at 15 to 19 d before market numerically increased IOFC by $1.42 to $2.30/pig over pigs continuously fed the high-fiber diet and $2.04 to 2.92/pig over pigs fed the corn-soybean meal diet throughout.

In summary, feeding diets higher in fiber has been and will continue to be a viable option to producers and nutritionist to decrease feed cost and reduce cost of gain. However, this practice is also associated with the consequences of reduced yield and HCW. These data indicate that much of the benefit in lower feed cost from feeding high-fiber diets can be captured while minimizing the loss of carcass value by switching pigs to a lower fiber, higher energy diet for 14 to 19 d prior to market.

Table 1. Phase 1 and 2 diet composition (as-fed basis)[1]

	Phase 1		Phase 2	
Item	Control	High-fiber	Control	High-fiber
Ingredient, %				
Corn	73.15	34.18	76.85	37.83
Soybean meal , 46.5% CP	24.55	14.68	20.97	11.10
DDGS[2]	---	30.00	---	30.00
Wheat middlings	---	19.00	---	19.00
Monocalcium P, 21%	0.60	---	0.55	---
Limestone	0.95	1.25	0.93	1.20
Salt	0.35	0.35	0.35	0.35
Vitamin and trace mineral premix[3]	0.10	0.10	0.10	0.10
L-lysine sulfate[4]	0.27	0.44	0.25	0.42
L-threonine	0.02	---	0.01	---
MHA[5]	0.01	---	---	---
Phytase[6]	0.01	0.01	0.01	0.01
Total	100.00	100.00	100.00	100.00
Calculated analysis				
Standardized ileal digestible (SID) amino acids, %				
Lysine	0.95	0.95	0.85	0.85
Isoleucine:lysine	69	74	70	75
Leucine:lysine	155	189	163	202
Methionine:lysine	28	35	29	37
Met & Cys:lysine	58	66	60	70
Threonine:lysine	62	65	62	67
Tryptophan:lysine	19.0	19.0	19.0	19.0
Valine:lysine	78	90	80	93
SID lysine:ME, g/Mcal	2.84	2.90	2.54	2.59
ME, kcal/lb	1,517	1,486	1,518	1,488
Total lysine, %	1.07	1.13	0.96	1.02
CP, %	17.8	21.3	16.5	19.9
Ca, %	0.58	0.58	0.55	0.55
P, %	0.50	0.55	0.48	0.54
Available P, %	0.26	0.31	0.25	0.31
Crude fiber, %	2.6	5.3	3.3	5.1
NDF, %	9.2	20.5	9.2	20.5
Diet cost, $/ton	280.23	262.08	271.16	253.93

[1] Phase 1 diets were fed from approximately 98 to 127 lb; Phase 2 diets were fed from 127 to 175 lb.
[2] Dried distillers grains with solubles.
[3] Provided 2,043 IU/lb vitamin A, 318 IU/lb vitamin D, 11 IU/lb vitamin E, 1.4 ppm vitamin K, 3 ppm vitamin B_2, 18 ppm niacin, 12 ppm pantothenic acid, 40 ppm Mn, 100 ppm Zn, 90 ppm Fe, 10 ppm Cu, 0.3 ppm Se, and 0.5 ppm I to the complete diet.
[4] L-lysine sulfate provided by Biolys (Evonik Corporation, Kennesaw, GA).
[5] Methionine source (Novus International, St. Charles, MO).
[6] Optiphos 2000 (Enzyvia LLC, Sheridan, IN) provided 227 phytase units (FTU)/lb, with a release of 0.07% available P.

Table 2. Phase 3 and 4 diet composition (as-fed basis)[1]

	Phase 3		Phase 4	
Item	Control	High-fiber	Control	High-fiber
Ingredient, %				
Corn	80.16	41.17	83.10	43.99
Soybean meal, 46.5% CP	17.78	7.82	14.90	5.04
DDGS[2]	---	30.00	---	30.00
Wheat middlings	---	19.00	---	19.00
Monocalcium P, 21%	0.45	---	0.40	---
Limestone	0.95	1.18	0.95	1.15
Salt	0.35	0.35	0.35	0.35
Vitamin and trace mineral premix[3]	0.08	0.08	0.08	0.08
L-lysine sulfate[4]	0.23	0.40	0.21	0.38
L-threonine	---	---	0.01	---
Phytase[5]	0.01	0.01	0.01	0.01
Total	100.00	100.00	100.00	100.00
Calculated analysis				
Standardized ileal digestible (SID) amino acids, %				
Lysine	0.76	0.76	0.68	0.68
Isoleucine:lysine	71	77	72	79
Leucine:lysine	172	216	183	231
Methionine:lysine	30	39	32	42
Met & Cys:lysine	63	75	66	80
Threonine:lysine	63	69	65	71
Tryptophan:lysine	19.0	19.0	19.0	19.0
Valine:lysine	83	97	85	102
SID lysine:ME, g/Mcal	2.27	2.32	2.03	2.07
ME, kcal/lb	1,520	1,489	1,522	1,490
Total lysine, %	0.86	0.92	0.77	0.84
CP, %	15.3	18.7	14.2	17.6
Ca, %	0.53	0.53	0.51	0.51
P, %	0.44	0.53	0.42	0.52
Available P, %	0.22	0.31	0.21	0.30
Crude fiber, %	2.5	5.2	2.4	5.2
NDF, %	9.3	20.6	9.3	20.6
Diet cost, $/ton	262.88	246.12	256.16	239.17

[1] Phase 3 diets were fed from approximately 175 to 225 lb; Phase 4 diets were fed from 225 to 286 lb.
[2] Dried distillers grains with solubles.
[3] Provided 2,043 IU/lb vitamin A, 318 IU/lb vitamin D, 11 IU/lb vitamin E, 1.4 ppm vitamin K, 3 ppm vitamin B_2, 18 ppm niacin, 12 ppm pantothenic acid, 40 ppm Mn, 100 ppm Zn, 90 ppm Fe, 10 ppm Cu, 0.3 ppm Se, and 0.5 ppm I to the complete diet.
[4] L-lysine sulfate provided by Biolys (Evonik Corporation, Kennesaw, GA).
[5] Optiphos 2000 (Enzyvia LLC, Sheridan, IN) provided 227 phytase units (FTU)/lb, with a release of 0.07% available P.

Table 3. Chemical analysis of dried distillers grains with solubles (DDGS) and wheat middlings (midds); (as-fed basis)

Nutrient, %	DDGS	Midds
DM	90.35	90.72
CP	29.4 (27.3)[1]	15.5 (15.9)
Ether extract (fat)	11.2	4.4
Crude fiber	7.4 (8.9)	8.4 (7.0)
ADF	9.1 (12.0)	11.9 (10.7)
NDF	22.4 (30.4)	34.6 (35.6)
Ash	3.89	4.97

[1] Values in parentheses indicate those used in diet formulation.

Table 4. Bulk density of experimental diets (as-fed basis)[1,2]

Bulk density, lb/bu	Control	High-fiber
Phase 1	45.6	38.2
Phase 2	45.4	40.0
Phase 3	44.3	35.6
Phase 4	44.8	35.1

[1] Diet samples were collected at the beginning and end of each phase from the feeder.
[2] Phase 1 was fed from d 0 to 14 ; Phase 2 from d 14 to 37; Phase 3 from d 37 to 64; Phase 4 from d 64 to 96.

Table 5. Effects of high-fiber withdrawal prior to market on growth performance of finishing pigs[1]

		High-fiber withdrawal prior to market, d						Probability, $P <$		
								Control vs.	Duration	
Item	Control	24	19	14	9	0	SEM	0 withdrawal	Linear	Quadratic
Weight, lb										
d 0	98.2	98.0	98.1	98.2	98.2	98.2	2.07	1.00	0.88	0.92
d 64	232.1	224.3	223.8	224.2	224.0	224.5	3.24	0.01	0.85	0.73
d 96	292.0	285.1	285.5	284.7	283.0	282.7	3.48	0.01	0.23	0.80
d 0 to 64										
ADG, lb	2.09	1.97	1.96	1.97	1.97	1.97	0.028	0.01	--	--
ADFI, lb	5.63	5.38	5.38	5.40	5.41	5.48	0.069	0.02	--	--
F/G	2.69	2.73	2.74	2.75	2.75	2.79	0.028	0.02	--	--
d 64 to 96										
ADG, lb	1.88	1.91	1.90	1.91	1.82	1.86	0.041	0.72	0.20	0.98
ADFI, lb	6.24	6.54	6.44	6.55	6.43	6.46	0.122	0.19	0.61	0.95
F/G	3.31	3.43	3.40	3.43	3.53	3.48	0.059	0.03	0.17	0.85
d 0 to 96										
ADG, lb	2.03	1.95	1.94	1.95	1.92	1.94	0.021	0.01	0.28	0.79
ADFI, lb	5.82	5.74	5.71	5.76	5.73	5.79	0.077	0.68	0.53	0.66
F/G	2.87	2.94	2.94	2.95	2.98	2.99	0.024	0.01	0.07	0.79
Caloric efficiency[2]										
ME	4,364	4,401	4,400	4,411	4,452	4,448	35.12	0.10	0.19	0.86

[1] A total of 1,089 pigs (PIC 337 × 1050, initial BW= 98.2 lb) were used in a 96-d study with 7 replications per treatment. [2] Caloric efficiency is expressed as ME kcal/lb gain.

Table 6. Effects of high-fiber withdrawal prior to market of finishing pigs on carcass characteristics and economics

		High-fiber withdrawal prior to market, d						Probability, P <		
								Control vs.	Duration	
Item	Control	24	19	14	9	0	SEM	0 withdrawal	Linear	Quadratic
Carcass characteristics										
HCW, lb	218.5	211.2	212.9	212.2	210.6	209.0	2.00	0.01	0.05	0.08
Yield, %[2]										
Farm	74.85	74.10	74.62	74.54	74.43	73.93	0.496	0.19	0.73	0.27
Plant	75.35	74.28	74.59	75.14	74.95	74.52	0.705	0.39	0.69	0.37
Backfat, in.[3]	0.704	0.659	0.673	0.654	0.641	0.645	0.016	0.02	0.21	0.79
Loin depth, in.[3]	2.619	2.556	2.582	2.580	2.595	2.515	0.030	0.02	0.39	0.04
Lean, %[3]	55.90	56.45	56.32	56.57	56.87	56.55	0.296	0.14	0.39	0.75
Economics, $/pig										
Feed cost	85.58	79.30	78.36	78.65	77.69	77.62	1.061	0.01	0.10	0.86
Feed cost/lb gain	0.440	0.423	0.420	0.420	0.422	0.418	0.003	0.01	0.34	0.95
Carcass gain value[4]	111.54	105.95	107.25	106.65	105.44	104.20	1.543	0.01	0.05	0.08
IOFC[5]	25.96	26.64	28.88	28.00	27.75	26.58	1.261	0.71	0.73	0.17

[1] A total of 1,089 pigs (PIC 337 × 1050, initial BW= 98.2 lb) were used in a 96-d study with 7 replications per treatment.

[2] Percentage yield was calculated by dividing HCW by pen live weight obtained at the farm before transport to the packing plant as well as the pen live weight obtained at the plant.

[3] Carcass characteristics were adjusted by using HCW as a covariate.

[4] Carcass gain value is calculated as $77.00/cwt of final carcass wt. minus (initial weight x 75% assumed yield x $77.00/cwt).

[5] Income over feed cost = carcass gain value – feed cost.