Effect of Dietary Fiber Source on Growth Performance, Carcass Characteristics, and Economic Return of Finishing Pigs[1]

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Summary

A total of 287 pigs (DNA 600 × 241; initially 111.8 lb) were used in an 86-d experiment to determine the effect of dietary fiber source on finishing pig growth performance and carcass characteristics. There were 12 pens per treatment with 7 or 8 pigs per pen. Pens were randomly assigned to 1 of 3 dietary treatments consisting of a control (8.7% neutral detergent fiber; NDF), 20% dried distillers grains with solubles (DDGS; 13.6% NDF), or 14.5% sugar beet pulp (SBP; 13.6% NDF). Experimental diets were fed from d 0 to 86 in 3 phases; d 0 to 18, d 18 to 39, and d 39 to 86. From d 0 to 86, there was no evidence for treatment difference in ADG or ADFI. Pigs fed DDGS had marginally poorer F/G than the control or 14.5% SBP diets ($P < 0.10$). Caloric efficiency of net energy (NE) in kcal per lb of live gain was marginally poorer ($P < 0.10$) in pigs fed DDGS compared to those fed control and SBP. There was a decrease ($P < 0.10$) in hot carcass weight (HCW) and carcass yield ($P < .0.05$) in pigs fed DDGS and SBP compared to those fed the control diet. Loin depth marginally decreased ($P < 0.10$) in pigs fed SBP compared to the control, with those fed DDGS intermediate. Feed cost per pig was greatest ($P < 0.05$) for pigs fed SBP, followed by DDGS, with those fed the control diet having the least. Feed cost per lb of gain increased ($P < 0.05$) in pigs fed SBP, followed by DDGS, with those fed the control having the least. Gain value decreased ($P < 0.05$) in pigs fed SBP compared to the control, with those fed DDGS intermediate. Income over feed cost was poorest ($P < 0.05$) in pigs fed SBP, followed by DDGS, with those fed the control diet being the greatest. In conclusion, pigs fed DDGS tended to have poorer F/G compared to those fed the control diet or SBP. This can be explained by the overestimation of NE of the diet as demonstrated by an increase in caloric efficiency. Increasing dietary NDF reduced carcass yield and economic return.

Introduction

Utilizing alternative feedstuffs in place of corn and soybean meal has become a common practice in the swine industry. Dried distillers grains with solubles (DDGS) and sugar beet pulp (SBP) are two ingredients available for use in swine diets. Dried distillers

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grains with solubles are a common co-product of ethanol production, while SBP is a co-product of sugar beet processing. When formulating diets using DDGS and SBP, nutritionists need to consider the decreased metabolizable energy (ME) and net energy (NE) content of these ingredients. This decrease in ME and NE is attributed to the increase in fiber content of DDGS and SBP. Dried distillers grains with solubles and SBP contain approximately 12.0% and 23.5% acid detergent fiber (ADF) and 30.5% and 44.9% neutral detergent fiber (NDF), respectively.

Dietary fiber utilization takes place in the large intestine via microbial fermentation, contributing energy through the synthesis and absorption of volatile fatty acids (VFAs).[3] High dietary fiber content is also commonly associated with decreased nutrient utilization, low NE values, and reduced carcass yield.[4] However, the chemical and physical characteristics of dietary fiber determine the rate of fermentation and VFA absorption.[5] The negative impact of dietary fiber can vary considerably between fiber sources. While both are considered fibrous ingredients, the fiber in DDGS and SBP are primarily insoluble and soluble, respectively, which has a major impact on fermentation and digesta viscosity. With this in mind, the evaluation of the differences among fiber sources can also be evaluated by balancing diets for energy. Further investigation about including various fiber sources in finishing pig diets is needed to determine their influence on growth performance and economics. Therefore, the objective of this study was to determine the effect of dietary fiber source on finishing pig growth performance and carcass characteristics.

Procedures

The Kansas State University Institutional Animal Care and Use Committee approved the protocol used in this experiment. This study was conducted at the Kansas State University Swine Teaching and Research Center, Manhattan, KS.

Pigs were housed in a fully enclosed, environmentally regulated barn containing 36 pens. Pens were equipped with a dry, two-space, single-sided feeder (Farmweld, Teutopolis, IL) and a cup waterer. Pigs were allowed *ad libitum* access to feed and water. Floor space allowance per pig was maintained at 7.83 ft^2. Pens were housed on a completely slatted concrete floor with a 4-ft pit underneath for manure storage. An automatic feeding system (FeedPro; Feedlogic Corp., Wilmar, MN) was used to deliver and record daily feed additions to each pen.

A total of 287 pigs (DNA 600 × 241; initially 111.8 lb) were used in an 86-d experiment. There were 12 pens per treatment with 7 or 8 pigs per pen with an equal number of barrows and gilts per pen. Pens were randomly assigned to 1 of 3 dietary treatments consisting of a control (8.7% NDF), 20% DDGS (13.6% NDF), or 14.5% sugar beet pulp (13.6% NDF). Diets were balanced on NE and standardized ileal digestible lysine, and the DDGS and SBP treatments were balanced for NDF. Energy values for all ingre-

[3]Urriola, P. E., S. K. Cervantes-Pahm, and H. H. Stein. 2013. "Fiber in swine nutrition." Sustainable swine nutrition. 255–276. Chiba, L. I., ed. John Wiley & Sons, Inc., Ames, IA.
[4]Lindberg, J. E. 2014. Fiber effects in nutrition and gut health in pigs. J Animal Sci Biotechnol 5: 15.
[5]Navarro, D. M. D. L, E. M. A. M. Bruininx, L. de Jong, H. H. Stein. 2018. Effects of physicochemical characteristics of feed ingredients on the apparent total tract digestibility of energy, DM, and nutrients by growing pigs. J. Anim. Sci. 96: 2265–2277.

dients were from National Research Council (NRC),[6] except for DDGS, where energy was estimated using the equation of Graham et al.[7] All amino acids were at or above minimum recommended ratios relative to lysine. Experimental diets were fed from d 0 to 86 in 3 phases; d 0 to 18, d 18 to 39, and d 39 to 86.

Pigs and feeders were weighed to determine average daily gain (ADG), average daily feed intake (ADFI), and feed efficiency (F/G). Caloric efficiency was determined on both an ME and NE basis. Caloric efficiency was calculated by multiplying total feed intake by energy in the diet (kcal/lb) and dividing by total gain. At d 86, pigs were individually ear tagged with a unique radio frequency identification device number for carcass measurements to be recorded on a pig basis. On d 86, final pen weights and individual weights were taken, and pigs were transported to a commercial packing plant (Triumph, St. Joseph, MO) for processing and carcass data collection. Data collected included hot carcass weight (HCW), backfat thickness, loin depth, and percent lean. Carcass yield was calculated as HCW divided by final live weight taken at the farm.

Sugar beet pulp pellets were received and ground through a roller mill (RMS Model #924, Sioux Falls, SD) to be mixed for complete feed. Individual ingredient and complete feed samples were collected and analyzed for dry matter (DM), crude protein (CP), crude fiber (CF), acid detergent fiber (ADF), neutral detergent fiber (NDF), ether extract (EE), nitrogen free extract (NFE), and ash (Table 1; Ward Laboratories, Inc., Kearney, NE).

For the economic evaluation, total feed cost per pig, cost per pound of gain, gain value, and income over feed cost (IOFC) were calculated. The total feed cost per pig was calculated by multiplying the total feed consumed by the cost per pound of feed. Ingredient prices used were: corn at $3.81/bu ($136/ton), DDGS at $250/ton, soybean meal at $410/ton, and sugar beet pulp at $678/ton. Cost per pound of gain was calculated by dividing the total feed cost per pig by overall pounds gained. Gain value per pig was calculated by multiplying the total carcass gain by the assumed carcass price of $73.52 per cwt. Carcass gain was calculated using the carcass weight minus the initial live weight multiplied by an assumed yield of 75%. To calculate IOFC, total feed cost was subtracted from gain value.

Data were analyzed using the PROC MIXED procedure of SAS version 9.4 (SAS Institute, Inc., Cary, NC) with pen serving as the experimental unit. Results were considered significant $P \leq 0.05$ and marginally significant at $P \leq 0.10$.

Results

For DDGS, nutrient values used in diet formulation were 12.0% ADF and 30.5% NDF and analyzed values were 12.0% ADF and 27.9% NDF (Table 1). For SBP, values used in formulation were 23.5% ADF and 44.9% NDF and analyzed values were 27.8% and 33.5% (Table 1).[7] Diets containing DDGS and SBP were formulated to 13.6% NDF, while analyzed values were 10.9% for each (Table 2).

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[6]NRC, 2012. Nutrient Requirements of Swine, 11th ed. Natl. Acad. Press, Washington, DC.
[7]Graham, A. B., R. D. Goodband, M. D. Tokach, S. S. Dritz, J. M. DeRouchey, S. Nitikanchana, J. J Updike. 2014. The effects of low-, medium-, and high-oil distillers dried grains with solubles on growth performance, nutrient digestibility, and fat quality in finishing pigs. J. Anim. Sci. 92: 3610–3623.

From d 0 to 86, there was no evidence of treatment difference for ADG, ADFI, and final BW. Pigs fed DDGS had marginally significant poorer ($P < 0.10$) F/G compared to those fed the control or SBP diets. Caloric efficiency of ME in kcal per lb of live gain was not different for pigs fed different dietary treatments. Caloric efficiency of NE in kcal per lb of live gain tended to be poorer ($P < 0.10$) in pigs fed DDGS compared to those fed control and SBP diets. The poorer caloric efficiency for DDGS diets indicates that the NE value of the diet was overestimated in diet formulation.

For carcass characteristics, there was a marginally significant decrease ($P < 0.10$) in HCW for pigs fed DDGS and SBP compared to those fed the control diet. Carcass yield decreased ($P < 0.05$) in pigs fed DDGS and SBP compared to those fed the control diet. This is consistent with previous research in that high fiber diets result in increased gut fill and decreased carcass yield.[8] Loin depth tended to decrease ($P < 0.10$) in pigs fed SBP compared to the control, with those fed DDGS intermediate. No differences were observed in backfat depth or percentage lean.

For economic value per pig, feed cost per pig was greatest ($P < 0.05$) for pigs fed SBP, followed by DDGS, and those fed the control diet having the least. Feed cost per lb of gain was greatest ($P < 0.05$) in pigs fed SBP, followed by DDGS, with those fed the control diet having the least. Gain value decreased ($P < 0.05$) in pigs fed SBP compared to the control, with those fed DDGS intermediate. Income over feed cost was poorest ($P < 0.05$) in pigs fed SBP, followed by DDGS, with those fed the control diet being the greatest.

In conclusion, pigs fed DDGS tended to have poorer F/G compared to those fed the control or SBP. This can be explained by the overestimation of NE of the diet as demonstrated by an increase in caloric efficiency. Increasing dietary NDF reduced carcass yield and economic return. Therefore, ingredient cost and energy content must be evaluated when considering the use of fibrous ingredients.

[8] Asmus M. D., J. M. DeRouchey, M. D. Tokach, S. S. Dritz, T. A. Houser, J. L. Nelssen, and R. D. Goodband. 2014. Effects of lowering dietary fiber before marketing on finishing pig growth performance, carcass characteristics, carcass fat quality, and intestinal weights. J. Anim. Sci. 92:119–128.

Table 1. Chemical analysis of ingredients (as-fed basis)[1]

Item, %	DDGS[2]	SBP[3]
Dry matter	90.2	92.0
Crude protein	31.1	7.9
Crude fat	6.9	1.0
Crude fiber	8.5	17.9
Acid detergent fiber	12.0	27.8
Neutral detergent fiber	27.9	33.5
Nitrogen free extract	38.8	56.7
Ash	5.25	10.4

[1]Analysis of individual ingredients was performed at Ward Laboratories, Inc. (Kearney, NE).
[2]DDGS = dried distillers grain with solubles.
[3]SBP = sugar beet pulp.

Table 2. Chemical analysis of experimental diets (as-fed basis)[1,2]

	Phase 1			Phase 2			Phase 3		
Item, %	Control	DDGS[3]	SBP[4]	Control	DDGS	SBP	Control	DDGS	SBP
Dry matter	88.9	89.8	89.9	89.2	90.4	90.4	88.4	89.4	89.0
Crude protein	17.4	18.7	16.7	14.3	16.4	14.3	12.6	15.3	12.3
Crude fat	2.6	4.0	5.6	2.9	4.5	5.8	2.9	4.0	4.8
Crude fiber	1.8	2.4	4.4	2.0	3.1	4.2	1.6	2.3	4.5
Acid detergent fiber	3.0	3.8	7.3	3.5	4.4	6.8	2.5	3.9	7.6
Neutral detergent fiber	6.8	10.6	11.1	7.8	12.6	11.3	6.7	9.6	10.4
Nitrogen free extract	63.7	60.2	59.0	66.7	62.4	61.4	68.0	63.9	63.1
Ash	3.8	4.4	4.8	3.5	4.2	5.1	3.4	3.7	4.4

[1]Analysis was performed by Ward Laboratories, Inc. (Kearney, NE) on pooled diet samples.
[2]Experimental diets were fed in 3 phases from d 0 to 18, d 18 to 39 and d 39 to 86, respectively.
[3]DDGS = diets containing dried distillers grain with solubles.
[4]SBP = diets containing sugar beet pulp.

Table 3. Diet composition (as-fed basis)[1]

	Phase 1			Phase 2			Phase 3		
Ingredient, %	Control	DDGS[2]	SBP[3]	Control	DDGS	SBP	Control	DDGS	SBP
Corn	75.46	62.56	58.65	81.82	68.83	64.97	85.19	70.56	68.48
DDGS[2]	---	20.00	---	---	20.00	---	---	20.00	---
Sugar beet pulp	---	---	14.50	---	---	14.50	---	---	14.50
Soybean meal, 47% crude protein	21.79	14.53	21.42	15.65	8.40	15.29	12.37	6.73	12.00
Choice white grease	---	0.20	2.80	---	0.25	2.85	---	0.40	2.75
Calcium carbonate	0.93	1.05	0.60	0.93	1.08	0.63	0.93	1.08	0.63
Monocalcium P, (21% P)	0.55	0.25	0.63	0.40	0.10	0.45	0.35	---	0.38
Sodium chloride	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
L-lysine-HCl	0.30	0.45	0.30	0.30	0.45	0.30	0.30	0.40	0.30
DL-methionine	0.07	0.03	0.11	0.03	---	0.08	0.02	---	0.06
L-threonine	0.09	0.09	0.12	0.10	0.10	0.13	0.11	0.09	0.14
L-tryptophan	0.01	0.03	0.02	0.02	0.04	0.02	0.02	0.03	0.03
L-valine	---	---	0.04	---	---	0.03	---	---	0.03
Trace mineral premix	0.15	0.15	0.15	0.13	0.13	0.13	0.10	0.10	0.10
Vitamin premix	0.15	0.15	0.15	0.13	0.13	0.13	0.10	0.10	0.10
Phytase[4]	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Total	100	100	100	100	100	100	100	100	100

continued

Table 3. Diet composition (as-fed basis)[1]

	Phase 1			Phase 2			Phase 3		
Ingredient, %	Control	DDGS[2]	SBP[3]	Control	DDGS	SBP	Control	DDGS	SBP
Calculated analysis									
Standardized ileal digestible SID AA, %									
Lysine	0.95	0.95	0.95	0.80	0.80	0.80	0.72	0.72	0.72
Isoleusine:lysine	62	61	60	61	60	58	60	63	57
Leucine:lysine	139	161	128	148	173	134	154	187	138
Methionine:lysine	32	31	35	31	31	34	30	33	33
Methionine and cystine:lysine	58	58	58	58	60	58	58	64	58
Threonine:lysine	63	63	63	65	65	65	68	68	68
Trptophan:lysine	19	19	19	19	19	19	19	19	19
Valine:lysine	69	72	70	70	73	70	70	78	70
Histadine:lysine	42	43	40	43	44	41	43	46	41
Metabolizable energy, kcal/lb	1,497	1,494	1,523	1,503	1,501	1,530	1,506	1,507	1,531
Net energy, kcal/lb[5]	1,128	1,128	1,128	1,147	1,147	1,147	1,156	1,156	1,156
SID lysine: net energy, g/Mcal	3.82	3.82	3.82	3.16	3.16	3.16	2.82	2.82	2.83
Total lysine, %	1.07	1.10	1.09	0.90	0.93	0.93	0.82	0.85	0.84
Crude protein, %	17.01	18.25	16.85	14.60	15.83	14.43	13.31	15.13	13.15
Calcium, %	0.59	0.59	0.59	0.54	0.54	0.54	0.51	0.51	0.51
Phosphorus, %	0.47	0.47	0.45	0.41	0.41	0.39	0.38	0.38	0.36
Standardized digestible phosphorus, %	0.33	0.33	0.33	0.28	0.28	0.28	0.26	0.26	0.26
Crude fiber, %	2.3	3.3	5.3	2.2	3.2	5.1	2.2	3.1	5.1
Neutral detergent fiber, %	8.7	13.6	13.6	8.7	13.7	13.7	8.8	13.7	13.7

[1]Diets were fed in 3 phases: d 0 to 18, d 18 to 39, and d 39 to 86, respectively.
[2]DDGS = dried distillers grains with solubles.
[3]SBP = sugar beet pulp. Sugar beet pulp pellets were ground through a roller mill (RMS Model #924, Sioux Falls, SD).
[4]HiPhos 2700 (DSM Nutritional Products, Inc., Parsippany, NJ), providing 183.7 phytase units (FTU)/lb and an estimated release of 0.09% available P.
[5]NE values for ingredients were derived from NRC (2012).

Table 4. Effect of dietary fiber source on growth performance and carcass characteristics of finishing pigs[1]

Item	Control	DDGS[2]	SBP[3]	SEM	Probability, $P<$
Body weight, lb					
d 0	111.8	111.8	111.8	1.57	1.000
d 86	291.2	287.2	288.7	1.89	0.328
d 0 to 86					
ADG, lb[4]	2.08	2.03	2.06	0.021	0.228
ADFI, lb[4]	6.15	6.11	6.05	0.074	0.625
F/G[4]	2.95[x]	3.02[y]	2.94[x]	0.025	0.096
Caloric efficiency					
ME, kcal/lb of gain[5]	4,431	4,528	4,496	38.2	0.203
NE, kcal/lb of gain[5]	3,374[x]	3,451[y]	3,365[x]	29.0	0.086
Carcass					
HCW, lb[6]	220.5[x]	215.3[y]	216.1[y]	1.669	0.071
Carcass yield, %	75.8[a]	75.0[b]	74.6[b]	0.187	0.001
Back fat, in.[7]	0.63	0.62	0.63	0.010	0.496
Loin depth, in.[7]	2.48[x]	2.46[yz]	2.42[z]	0.017	0.093
Lean, %[7]	0.54	0.54	0.54	0.001	0.329
Economics, $/pig					
Feed cost	51.86[a]	54.20[b]	77.44[c]	0.711	0.001
Feed cost/lb gain[8]	0.29[a]	0.31[b]	0.44[c]	0.002	0.001
Gain value[9]	100.49[a]	96.62[bc]	97.25[c]	1.106	0.041
IOFC[10]	48.63[a]	42.42[b]	19.81[c]	1.008	0.001

[1]A total of 287 pigs (DNA 600 × 241; initially 111.8 lb) were used in an 86-d experiment with 7 or 8 pigs per pen and 12 pens per treatment.
[2]DDGS = diets containing dried distillers grain with solubles.
[3]SBP = diets containing sugar beet pulp.
[4]ADG = average daily gain. ADFI = average daily feed intake. F/G = feed efficiency.
[5]ME = metabolizable energy, ME (kcal/lb of live gain) = ((ADFI × ME/lb) /ADG). NE = net energy, NE (kcal/lb of live gain) = ((ADFI × NE/lb) /ADG).
[6]HCW = hot carcass weight.
[7]Adjusted using HCW as a covariate.
[8]Feed cost/lb gain = total feed cost ÷ total gain per pig.
[9]Gain value = $0.7352 × [HCW – (d 0 BW × 0.75)]
[10]Income over feed cost = gain value – feed cost