Effects of Xylanase in High-Co-Product Diets on Nutrient Digestibility in Finishing Pigs[1]

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Summary

A total of 36 pigs (PIC 337 × 1050; initially 185 lb BW) were used in a 14-d study to evaluate the effects of xylanase (Porzyme 9302; Danisco Animal Nutrition, St. Louis, MO) in growing-finishing diets varying in dietary fiber on nutrient digestibility. Pigs were randomly allotted to 1 of 6 dietary treatments in a 2 × 3 factorial. Main effects were increasing dried distillers grains with solubles (DDGS; 35, 42.5, and 50%) with or without xylanase (0 or 4,000 units xylanase per kilogram of diet. The 6 treatment diets were corn-soybean meal–based with 15% added wheat middlings (midds), with 6 replications per treatment. All diets were fed in meal form. Multiple enzyme × DDGS interactive effects ($P < 0.05$) were observed for digestibility of various nutrients. The majority of these interactions resulted from differences in response to increasing DDGS with and without xylanase. In diets with xylanase, apparent digestibility generally decreased as DDGS increased. In diets without xylanase, apparent digestibility decreased as DDGS increased from 35 to 42.5% but increased in diets containing 50% DDGS. Overall, despite the interactions, increasing DDGS regardless of enzyme inclusion lowered (quadratic, $P < 0.01$) apparent fecal digestibility of DM, GE, ADF, NDF, and zinc as well as fecal digestibility (linear, $P < 0.02$) of fat, Ca, and P. Despite the interactions, adding dietary xylanase did not improve digestibility in corn-soybean meal–based diets containing fibrous co-products.

Key words: DDGS, digestibility, enzyme, fiber, finishing pig

Introduction

Feed ingredients such as wheat midds and DDGS are often used as alternatives to corn and soybean meal in swine diets. The majority of the starch is removed from the kernel of DDGS and midds during the fermentation and milling process of corn and wheat, respectively. The remaining components of the kernel, such as fiber, increase in concentration, which causes most grain co-products to be low in dietary energy. Both DDGS and midds have higher crude fiber content than corn and contain more arabinoxylans. Arabinoxylans are hydrophilic non-starch polysaccharides (NSP) found in grain as minor constituents in the cell wall that act as anti-nutritional factors. Swine do not digest NSP efficiently due to their lack of fiber-specific digestive enzymes; consequently, enzymes like xylanase are viable solutions to increase nutrient availability.

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Xylanase is a carbohydrase that is able to break some insoluble bonds that monogastric animals are otherwise unable to digest (Sugimoto and Van Buren, 1970[3]). Xylanase also has been successful in increasing nutrient digestibility of swine diets (Nortey et al., 2008[4]); however, corn is more digestible and lower in fiber than wheat, which is one factor believed to contribute to xylanase's inconsistency in improving growth performance when used in corn-soy–based diets (Jacela et al., 2009[5]). Xylanase may be more beneficial in corn-soybean meal–based diets when the diets contain high levels of higher-fiber ingredients such as DDGS and midds; therefore, the objective of this study was to evaluate the effect of xylanase in corn-soybean meal–based diets with high co-product inclusion (15% wheat midds and 30, 42.5, or 50% DDGS) on dietary nutrient digestibility.

Procedures

The Institutional Animal Care and Use Committees at Kansas State University and Danisco Animal Nutrition approved the protocol used in this experiment. The study was conducted at the K-State Swine Teaching and Research Farm. Pigs were housed in an environmentally controlled finishing building with pens over a totally slatted floor that provided approximately 10 ft^2/pig. Each pen was equipped with a dry self-feeder and a nipple waterer to provide ad libitum access to feed and water. The facility was a mechanically ventilated room with a pull-plug manure storage pit.

A total of 18 barrows and 18 gilts (337 × 1050, PIC, Hendersonville, TN; initially 185 lb BW) were individually penned and used in a 14-d experiment. Prior to being assigned to treatment diets, all pigs were fed a corn-soybean meal–based diet with 30% DDGS and 10% midds. All pigs were then assigned to a pen, and treatments were balanced by gender and initial BW and randomly allotted to 1 of 6 dietary treatments with 3 replications per gender (6 replications per treatment). The 6 treatments consisted of corn-soybean meal–based diets with 15% added midds and were arranged in a 2 × 3 factorial with the main effects of xylanase (0 or 4,000 units xylanase per kilogram of diet; Porzyme 93020) and DDGS (Homeland Energy, Lawler, IA; 35%, 42.5%, or 50%). All diets were fed in meal form and manufactured at United Farmers Cooperative (Klossner, MN). In addition, all diets were formulated to contain 1,000 phytase units (FTU)/kg phytase (Table 1). Pigs were allowed ad libitum access to food and water. Diets were formulated to meet all requirements recommended by NRC (1998[6]).

Feces samples were collected on the morning and night of d 14 via rectal massage from all pigs. All diets contained 0.4% titanium dioxide (TiO^2) as the digestibility marker. Samples of feces were stored in a freezer (-4°F) until they were thawed and homogenized for each pig. Fecal samples were dried at 122°F in a forced-air oven, then ground for analysis of bomb calorimetry and TiO^2 concentration.

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[3] Sugimoto, H., and J. P. Van Buren. 1970. Removal of oligosaccharides from soy milk by an enzyme from Aspergillussaitoi. J. Food Sci. 35:655–660.

[4] Nortey, T. N., J. F. Patience, J. S. Sands, N. L. Trottier, and R. T. Zijlstra. 2008. Effects of Xylanase supplementation on the apparent digestibility and digestible content of energy, amino acids, phosphorus, and calcium in wheat and wheat by-products from dry milling fed to grower pigs. J. Anim. Sci. 86:3450–3464.

[5] Jacela et al., Swine Day 2009, Report of Progress 1020, pp. 220–224.

[6] NRC. 1998. Nutrient Requirements of Swine. 10th ed. Natl. Acad. Press, Washington, DC.

Gross energy of diets and ground fecal samples were determined with an adiabatic bomb calorimeter (Parr Instruments, Moline, IL). Diets and ground fecal samples were also analyzed for TiO^2 concentration with an atomic absorption spectrometer.

Diet samples were collected from the tops of each feeder and combined for a single composite sample by treatment to measure moisture, CP, crude fat, GE, ADF, NDF, Ca, and P at Eurofins US (Des Moines, IA). Fecal samples were also analyzed for CP, crude fat, GE, ADF, NDF, Ca, and P.

Xylanase activity was analyzed at Eurofins US (Des Moines, IA) in which 1 unit of xylanase activity (XU) is defined as the amount of xylanase that will liberate 0.5 μmol of reducing sugars (expressed as xylose equivalents) from a cross-linked oat spelt xylan substrate (at pH 5.3 and 122°F in 1 min).

Data were analyzed as a 2 × 3 factorial using the PROC MIXED procedure in SAS (SAS Institute, Inc., Cary, NC) with pig as the experimental unit. Linear and quadratic polynomial contrasts were conducted to determine effects of increasing dietary DDGS. Results were considered significant at $P \leq 0.05$ and trends at $P \leq 0.10$.

Results and Discussion

Chemical Analysis

Nutrient analyses of the treatment diets were found to be generally similar to formulation (Table 2). The only exception was the Ca level, which was much lower than anticipated in the low-DDGS with xylanase diet. We speculated that limestone was omitted from this diet during manufacturing. The other minor differences were not expected to influence the results of the experiment.

Treatment diets containing xylanase were formulated to contain 4,000 units of xylanase activity per kilogram of diet. Chemical analysis showed some variation in diet xylanase concentrations, but on average, the treatments with the enzyme had significantly higher levels of xylanase activity than those without xylanase, which indicates that xylanase was included in the correct diets.

Nutrient Digestibility

Enzyme × DDGS interactions ($P < 0.05$) were observed for all nutrient digestibility criteria tested (Table 3). The majority of these interactions were a result of differences in response to increasing DDGS with and without xylanase. In diets with xylanase, apparent digestibility generally decreased as DDGS increased. In diets without xylanase, apparent digestibility decreased as DDGS increased from 35 to 42.5% but increased in diets containing 50% DDGS. Apparent digestibility of NDF decreased ($P < 0.01$), but digestibility of Ca increased ($P < 0.001$) with the addition of dietary xylanase; however, Ca digestibility could have been artificially high due to the low level of Ca present in the treatment diet, making pigs more efficient in their utilization of Ca.

Pigs fed diets with increasing DDGS in combination with added xylanase demonstrated reduced (linear, $P < 0.02$) digestibility of DM, CP, GE, Ca, P, and fat as well as reduced (quadratic, $P < 0.01$) ADF, NDF, and Zn digestibility; however, when dietary DDGS increased without added xylanase, we observed increased (quadratic, $P < 0.05$)

digestibility of DM, CP, GE, ADF, NDF, and ADF but reduced (quadratic, $P < 0.05$) apparent fecal digestibility of Ca, P, and Zn (Table 4). This result was driven mainly by the unexplained increase in digestibility when pigs were fed 50% DDGS without the enzyme.

Increasing DDGS regardless of added xylanase also decreased (quadratic, $P < 0.01$) apparent fecal digestibility of DM, GE, ADF, NDF, and Zn and decreased (linear, $P < 0.02$) fecal digestibility of fat, Ca, and P (Table 5). In this study, adding dietary xylanase was unsuccessful at improving digestibility in corn-soybean meal–based diets containing fibrous co-products for finishing pigs.

Table 1. Diet composition (as-fed basis)

	DDGS, %[1]		
Item	35	42.5	50
Ingredient, %			
Corn	34.80	28.40	22.00
Soybean meal (46.5% CP)	11.95	10.73	9.50
DDGS	35.00	42.50	50.00
Wheat middlings	15.00	15.00	15.00
Choice white grease	1.00	1.00	1.00
Limestone	1.45	1.56	1.67
Salt	0.35	0.35	0.35
Vitamin premix	0.10	0.10	0.10
Trace mineral premix	0.10	0.10	0.10
L-lysine HCl	0.20	0.22	0.23
Phytase[2]	0.04	0.04	0.04
Xylanase[3]	---	---	---
Total	100.0	100.0	100.0
Calculated analysis			
Standardized ileal digestible (SID) AA			
Lysine, %	0.79	0.79	0.79
Methionine:lysine, %	39	41	42
Met & Cys:lysine, %	79	83	86
Threonine:lysine, %	73	75	77
Tryptophan:lysine, %	21	21	21
Total lysine, %	0.95	0.97	0.98
CP, %	20.4	21.3	22.2
SID lysine:ME, g/Mcal	2.37	2.37	2.37
ME, kcal/lb	1,512	1,511	1,509
Ca, %	0.64	0.68	0.71
Available P, %	0.47	0.52	0.56
Crude fat, %	6.9	7.4	7.9
Crude fiber, %	5.0	5.4	5.8
NDF, %	18.5	19.7	20.8
ADF, %	6.9	7.5	8.0

[1] DDGS: dried distillers grains with solubles (Homeland Energy, Lawler, IA).
[2] Phyzyme 2,500 (Danisco Animal Nutrition, St. Louis, MO) provided 1,000 phytase units (FTU)/kg phytase with a release of 0.14%.
[3] Porzyme 9302 (Danisco Animal Nutrition, St. Louis, MO) was added at the expense of corn to create the xylanase diets.

Table 2. Chemical analysis of diets (as-fed basis)

	Xylanase:[1]	-			+		
Item	DDGS, %:[2]	35	42.5	50	35	42.5	50
DM, %		90.0	90.2	90.0	89.8	89.6	89.7
CP, %		20.3	21.6	21.7	22.1	22.0	22.5
GE, kcal/lb		1,910	1,940	1,940	1,960	1,950	1,930
ADF, %		6.7	7.1	7.2	6.8	7.1	8.1
NDF, %		19.3	19.6	20.7	18.2	19.2	22.5
Fat, %		6.4	7.6	7.9	6.1	6.4	6.6
Ca, %		0.93	1.14	1.35	0.32	0.81	1.13
P, %		0.65	0.75	0.78	0.64	0.71	0.73
Zn, %		314	306	382	314	230	228
Phytase, FTU/kg[3]		1,430	2,150	2,470	1,010	1,400	1,360
Xylanase activity, U/kg[4]		330	310	420	4,700	2,700	3,700

[1] Porzyme 9302 (Danisco Animal Nutrition, St Louis, MO).
[2] DDGS: dried distillers grains with solubles (Homeland Energy, Lawler, IA).
[3] FTU: phytase units.
[4] One unit of xylanase activity is defined as amount of xylanase that will liberate 0.5 μmol of reducing sugars from a cross-linked oat spelt xylan (at pH 5.3 and 122°F) substrate in 1 min.

Table 3. Effect of dietary xylanase and dried distillers grains with solubles (DDGS) on finishing pig apparent total tract digestibility[1]

	Xylanase:[2]	-			+			
Item	DDGS, %:	35	42.5	50	35	42.5	50	SEM
DM		74.83	69.93	75.72	77.42	71.64	68.32	1.15
CP		78.74	77.64	82.11	80.72	77.81	76.56	1.21
GE		74.09	69.72	75.75	77.40	70.66	67.26	1.28
ADF		37.18	32.74	49.78	42.47	32.51	38.12	2.63
NDF		49.86	42.72	58.14	49.39	40.54	47.48	2.24
Fat		47.54	44.34	51.67	54.93	46.09	33.03	3.94
Ca		48.70	25.89	32.39	62.62	53.87	35.00	4.00
P		39.82	30.51	39.21	48.07	43.29	30.71	3.97
Zn		13.11	-18.48	12.01	15.95	-7.70	-2.62	4.28

[1] Fecal samples were collected on d 14 via rectal massage from all pigs.
[2] Porzyme 9302 (Danisco Animal Nutrition, St Louis, MO).

Table 4. Main effects of dietary xylanase and dried distillers grains with solubles (DDGS) on finishing pig apparent total tract digestibility[1]

	DDGS, %				Xylanase		
Item, %	35	42.5	50	SEM	No	Yes	SEM
DM	76.13	70.79	72.02	0.77	73.50	72.46	0.64
CP	79.73	77.72	79.34	0.81	79.50	78.60	0.67
GE	75.75	70.19	71.50	0.96	73.18	71.77	0.77
ADF	39.83	32.63	43.95	1.78	39.90	37.70	1.34
NDF	49.62	41.63	52.81	1.50	50.24	45.80	1.21
Fat	51.23	45.22	42.35	2.64	47.85	44.68	2.12
Ca	55.66	39.88	33.70	2.68	35.66	50.50	2.15
P	43.94	36.90	34.96	2.66	36.51	40.69	2.13
Zn	14.53	-13.09	4.69	3.21	2.21	1.88	2.57

[1] Fecal samples were collected on d 14 via rectal massage from all pigs.

Table 5. Effects of dietary xylanase and DDGS on finishing pig apparent total tract digestibility[1]

	Probability, *P*<							
Xylanase:[2]					-	-	+	+
Item, %	Interaction[3]	Xylanase[4]	DDGS lin.[5]	DDGS Quad[5]	DDGS lin.[6]	DDGS quad[6]	DDGS lin.[7]	DDGS quad[7]
DM	0.001	0.25	0.001	0.002	0.55	0.001	0.001	0.36
CP	0.01	0.23	0.73	0.08	0.04	0.05	0.02	0.57
GE	0.001	0.20	0.004	0.01	0.37	0.003	0.001	0.31
ADF	0.01	0.25	0.09	0.001	0.001	0.001	0.19	0.01
NDF	0.05	0.01	0.14	0.001	0.01	0.001	0.51	0.004
Fat	0.004	0.29	0.02	0.61	0.42	0.24	0.001	0.64
Ca	0.01	0.001	0.001	0.15	0.004	0.01	0.001	0.27
P	0.02	0.17	0.02	0.42	0.90	0.05	0.004	0.39
Zn	0.03	0.93	0.04	0.001	0.86	0.001	0.01	0.01

[1] Fecal samples were collected on d 14 via rectal massage from all pigs.
[2] Porzyme 9302 (Danisco Animal Nutrition, St. Louis, MO).
[3] Interactive effect (xylanase × DDGS).
[4] Main effect of xylanase inclusion (Treatments 1, 2, and 3 vs. 4, 5, and 6).
[5] Effect of DDGS regardless of xylanase inclusion (Treatments 1 & 4, 2 & 5, and 3 & 6).
[6] Effect of DDGS without xylanase (Treatments 1, 2, and 3).
[7] Effect of DDGS with xylanase (Treatments 4, 5, and 6).