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Effects of Compound Enzymes in Reduced Nutrient Density Nursery Pig Diets

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Effects of Compound Enzymes in Reduced Nutrient Density Nursery Pig Diets

Ty H. Kim, Mike D. Tokach, Joel M. DeRouchey, Jason C. Woodworth, Robert D. Goodband, Katelyn N. Gaffield, Ying Zhou,[1] Xuerong Song,[1] Xiuyi Wu,[1] and Jordan T. Gebhardt[2]

Summary

A total of 356 nursery pigs (DNA 241 × 600, initially 27.3 ± 0.48 lb BW) were used in a 35-d growth study to determine the effects of compound enzymes (Sunzyme; Wuhan Sunhy Biology Co., Ltd., Wuhan, P.R. China) on growth performance and nutrient digestibility in reduced-nutrient-density nursery pig diets. At approximately 19 d of age, pigs were weaned, randomly allotted to pens, and fed common phase 1 and 2 diets. On d 24 post-weaning, considered d 0 of the study, pigs were blocked by average pen BW and allotted to one of six dietary treatments in a randomized complete block design with four or five pigs per pen and 12 pens per treatment. Treatment diets were formulated in two dietary phases and fed from d 0 to 21 and d 21 to 35, respectively. The six treatments included a corn-soybean meal-based diet without compound enzyme (CS) and five corn-soybean meal-wheat middling-low oil DDGS-based diets (CSBP) with 0, 0.01, 0.02, or 0.03% compound enzyme 1 or 0.02% compound enzyme 2. At the conclusion of the study (d 35), fecal samples were collected from 12 pigs per treatment to determine apparent total tract digestibility (ATTD) of DM, CP, and NDF. From d 0 to 21, pigs fed the CS diet had increased ($P < 0.001$) ADG and improved ($P < 0.001$) F/G compared to pigs fed CSBP diets, but there were no treatment effects ($P > 0.10$) on ADFI. From d 21 to 35, pigs fed the CS diet had increased ($P = 0.006$) ADG and tended to have improved ($P = 0.053$) F/G compared to pigs fed CSBP diets. Overall, pigs fed the CS diet had increased ($P < 0.001$) ADG and improved ($P < 0.001$) F/G compared to pigs fed CSBP diets. For ATTD measures, pigs fed the CS diet had increased ($P < 0.05$) ATTD of DM and NDF compared to pigs fed CSBP diets. Pigs fed CSBP + 0.02% compound enzyme 1 had increased ($P < 0.05$) ATTD of DM, CP, and NDF compared to pigs fed CSBP + 0.02% compound enzyme 2. In summary, pigs fed the CS diet had increased ADG and ATTD of DM and NDF and improved F/G compared to pigs fed CSBP diets. Pigs fed CSBP + 0.02% compound enzyme 1 had increased ATTD of DM, CP, and NDF compared to pigs fed CSBP + 0.02% compound enzyme 2.

Introduction

Swine diets include plant-based ingredients containing anti-nutritional factors (ANFs) and components that are not readily digested by pigs. Exogenous enzymes can be

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included to degrade feed components resistant to endogenous enzymes, inactivate antinutritional factors, or supplement endogenous enzymes that may be present in insufficient amounts.[3]

Enzymes are substrate specific, meaning enzyme inclusion must match the substrate present in the diet to be effective.[4] Compound enzyme 1 is comprised of carbohydrases, specifically non-starch polysaccharide (NSP) degrading enzymes, such as xylanase, glucanase, mannanase, pectinase, and cellulase, which break down complex carbohydrates in the cell walls of plant-derived ingredients.[3] In addition to NSP enzymes, compound enzyme 1 contains other digestive enzymes, such as amylase, which breaks down starch.[4] Compound enzyme 2 contains xylanase and protease. However, the use of multi-enzyme products in swine diets has provided inconsistent results. As a result, new compound enzyme products must be evaluated to determine their efficacy. Therefore, the objective of this study was to determine the effects of compound enzymes on growth performance and nutrient digestibility of nursery pigs fed diets with reduced nutrient density. A second objective was to determine if pigs fed diets of reduced nutrient density with the addition of a compound enzyme could reach the same level of performance as those fed a higher-nutrient-density diet.

Materials and Methods

The protocol used in this experiment was approved by the Kansas State University Institutional Animal Care and Use Committee. The study was conducted at the Kansas State University Swine Teaching and Research Center in Manhattan, KS. Each pen contained a four-hole, dry self-feeder and nipple waterer for *ad libitum* access to feed and water.

Prior to diet formulation, representative samples of corn, SBM, DDGS, and wheat middlings were submitted for complete proximate and amino acid analysis in duplicate (University of Missouri Agricultural Experiment Station Chemical Laboratory; Table 1). Analyzed values were then used in diet formulation. Nutrient values and standardized ileal digestibility coefficients from NRC (2012) were used for all nutrients where analytical values were not available.

A total of 356 nursery pigs (DNA 241 × 600) were weaned at approximately 19 d of age, randomly allotted to pens, and fed common phase 1 and 2 diets. On d 24 post-weaning, considered d 0 of the study, pigs were blocked by average pen BW (initially 27.3 ± 0.48 lb) and allotted to one of six dietary treatments in a randomized complete block design. There were four or five pigs per pen and 12 pens per treatment. Treatment diets were formulated in two dietary phases and fed from d 0 to 21 and d 21 to 35, respectively (Tables 2 and 3). The six treatments included a corn-soybean meal-based diet without the compound enzyme (CS) and five corn-soybean meal-wheat middling-low oil DDGS based diets (CSBP) with 0 (CSBP + 0), 0.01 (CSBP + 0.01), 0.02 (CSBP + 0.02), or 0.03% (CSBP + 0.03) compound enzyme 1 or 0.02% compound enzyme 2 (CSBP2 + 0.02). Compound enzyme 1 is comprised of carbo-

[3] Thacker, P. A. 2013. Alternatives to antibiotics as growth promoters for use in swine production: A review. Journal of Animal Science and Biotechnology. 4:35-47. doi:10.1186/2049- 1891-4-35.
[4] Jacela, J Y.; DeRouchey, Joel M.; Tokach, Michael D.; Goodband, Robert D.; Nelssen, Jim L.; Renter, David G.; and Dritz, Steven S. 2009. "Feed additives for swine: Fact sheets – carcass modifiers, carbohydrate-degrading enzymes and proteases, and anthelmintics," Kansas Agricultural Experiment Station Research Reports: Vol. 0: Iss. 10. doi:10.4148/2378-5977.7070.

hydrases, such as xylanase, glucanase, mannanase, pectinase, and cellulase, as well as amylase. Compound enzyme 2 includes xylanase and protease.

The CSBP diets were formulated to achieve a targeted 72 kcal/lb decrease in NE and a 10% reduction in SID Lys compared to the CS diet. The CS diet was formulated to 1.28% SID Lys and 1,183 kcal/lb NE in phase 1 and 1.17% SID Lys and 1,179 kcal/lb NE in phase 2. The five CSBP diets were formulated to 1.15% SID Lys and 1,111 kcal/lb NE in phase 1 and 1.05% SID Lys and 1,107 kcal/lb NE in phase 2. Phase 2 diets included 0.5% titanium dioxide as an indigestible marker. During bagging, complete diet samples were collected from every fourth bag, pooled, ground to reduce particle size, and stored at -4°F.

Throughout the experiment, pig and feeder weights were collected every 7 d to determine ADG, ADFI, and F/G.

Fecal samples were collected from 12 pigs (six barrows and six gilts) per treatment on d 35 of the study to determine apparent total tract digestibility (ATTD) of DM, CP, and NDF. The pigs selected for collection were the closest to the mean BW of each pen. After collection, fecal samples were dried at 131°F in a forced air oven for 48 h, and fecal DM was determined as the ratio of dried to wet fecal weight.

Ground feed and fecal samples were dried in a 275°F drying oven for 2 h to determine percentage DM of the samples used for titanium analysis (Method 985.01).[5] Titanium dioxide concentration in dried feed and fecal samples was determined utilizing procedures outlined by Leone (1973).[6] Feed and fecal samples were analyzed for ADF and NDF (University of Missouri Agricultural Experiment Station Chemical Laboratory). Feed and fecal samples were analyzed for DM and CP (Kansas State University Swine Laboratory). The ATTD of DM, CP, and NDF were determined using the index method described by Adeola (2001)[7] using the following equation:

Statistical analysis

Growth and digestibility data were analyzed as a randomized complete block design with pen as the experimental unit, treatment as a fixed effect, and weight block as a random effect. Linear and quadratic contrasts were constructed with increasing levels of compound enzyme 1 in the CSBP diets. A pairwise comparison was conducted to determine the effect of formulation strategy by comparing the CS and CSBP diets without compound enzyme inclusion (CS vs. CSBP + 0% compound enzyme). A pairwise comparison was conducted between the CSBP diets with the same inclusion of compound enzyme 1 and compound enzyme 2 (CSBP + 0.02% compound enzyme 1 vs. CSBP + 0.02% compound enzyme 2) to test the effect of enzyme type. A pairwise comparison was conducted between the CSBP diet without compound enzyme and the CSBP diet with the compound enzyme 2 (CSBP + 0% compound enzyme vs. CSBP + 0.02% compound enzyme 2) to test the effect of compound enzyme 2. Data were analyzed using the lmer package of R (version 4.2.2 (2022-10-31), R Core Team,

[5] AOAC. 2007. Official methods of analysis AOAC international. 18th ed. Association of Official Analytical Chemists, Washington, DC.

[6] Leone, J. L. 1973. Collaborative study of the quantitative determination of titanium dioxide in cheese. AOAC. 56(3):535.

[7] Adeola, O. 2001. Digestion and balance techniques in pigs. pp. 903. Swine Nutrition, 2nd ed. A. J. Lewis and L. L. Southern ed. CRC Press, Washington, DC.

Vienna, Austria). Results were considered significant with $P \leq 0.05$ and were considered marginally significant with $P \leq 0.10$.

Results and Discussion

Throughout the study (d 0 to 21, d 21 to 35) and overall (d 0 to 35), pigs fed the CS diet had increased ($P < 0.05$; Table 4) ADG and improved ($P < 0.06$) F/G compared to pigs fed CSBP diets, but there were no treatment effects on ADFI.

Pigs fed the CS diet had increased ($P < 0.05$) ATTD of DM and NDF compared to pigs fed CSBP diets (Table 5). There was no effect of formulation strategy on ATTD of CP. Pigs fed CSBP + 0.02% compound enzyme 1 had increased ($P < 0.05$) ATTD of DM, CP, and NDF compared to pigs fed CSBP + 0.02% compound enzyme 2. Pigs fed CSBP without compound enzyme tended to have increased ($P = 0.063$) ATTD of NDF compared to pigs fed CSBP + 0.02% compound enzyme 2.

In summary, pigs fed the CS diet had increased ADG and ATTD of DM and NDF and improved F/G compared to pigs fed CSBP diets. Pigs fed CSBP + 0.02% compound enzyme 1 had increased ATTD of DM, CP, and NDF compared to pigs fed CSBP + 0.02% compound enzyme 2.

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Appreciation is expressed to Wuhan Sunhy Biology Co., Ltd. (Wuhan, P. R. China) who provided partial financial support for this project.

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Table 1. Analyzed ingredient composition (as-fed basis)[1]

Item, %	Corn	Soybean meal	Corn DDGS	Wheat middlings
DM	87.23	90.06	88.53	88.31
CP	7.42	43.90	29.13	15.74
Ether extract	2.25	1.32	4.26	3.68
Crude fiber	0.98	5.32	8.57	8.18
Ash	1.05	10.67	4.54	4.75
Essential AAs				
Arg	0.35	3.22	1.31	1.16
His	0.22	1.20	0.85	0.47
Ile	0.28	2.20	1.09	0.57
Leu	0.91	3.47	3.31	1.06
Lys	0.25	2.98	1.07	0.78
Met	0.17	0.63	0.63	0.26
Phe	0.37	2.31	1.41	0.69
Thr	0.26	1.73	1.14	0.56
Trp	0.05	0.58	0.20	0.17
Val	0.37	2.26	1.44	0.82
Non-essential AAs				
Ala	0.56	1.94	2.08	0.82
Asp	0.50	5.15	1.85	1.25
Cys	0.17	0.68	0.69	0.38
Glu	1.44	8.29	4.53	3.34
Gly	0.29	1.91	1.27	0.92
Pro	0.69	2.29	2.92	1.09
Ser	0.32	1.92	1.30	0.63
Tyr	0.23	1.59	1.05	0.42

[1]Representative ingredient samples were submitted for complete proximate and amino acid analysis in duplicate (University of Missouri Agricultural Experiment Station Chemical Laboratory; Columbia, MO). Analyzed values for corn, SBM, corn DDGS, and wheat middlings were used in diet formulation.

Table 2. Ingredient composition of experimental diets (as-fed basis)[1]

	Phase 1		Phase 2	
Ingredient, %	**CS**	**CSBP**	**CS**	**CSBP**
Corn	63.04	51.68	67.16	55.29
Soybean meal	33.47	17.24	29.03	13.29
Wheat middlings	---	17.50	---	17.50
DDGS	---	10.00	---	10.00
Calcium carbonate	0.90	1.26	0.85	1.23
Monocalcium phosphate	0.75	0.25	0.70	0.20
Sodium chloride	0.60	0.57	0.55	0.51
L-Lys-HCl	0.35	0.54	0.35	0.54
DL-Met	0.19	0.14	0.17	0.12
L-Thr	0.20	0.23	0.19	0.22
L-Trp	0.05	0.07	0.05	0.07
L-Val	0.05	0.09	0.05	0.09
L-Ile	---	0.03	---	0.04
Trace mineral premix	0.15	0.15	0.15	0.15
Vitamin premix	0.25	0.25	0.25	0.25
Phytase[2]	0.01	0.01	0.01	0.01
Compound enzyme[3]	---	-/+	---	-/+
Titanium dioxide	---	---	0.50	0.50
Total	100.00	100.00	100.00	100.00

continued

Table 2. Ingredient composition of experimental diets (as-fed basis)[1]

	Phase 1		Phase 2	
Ingredient, %	**CS**	**CSBP**	**CS**	**CSBP**
Calculated analysis				
Standardized ileal digestible (SID) amino acids, %				
Lys	1.28	1.15	1.17	1.05
Ile:Lys	63	56	62	56
Leu:Lys	119	118	121	121
Met:Lys	36	35	36	34
Met and Cys:Lys	58	58	58	58
Thr:Lys	64	64	64	64
Trp:Lys	19	19	19	19
Val:Lys	70	70	70	70
His:Lys	37	36	37	36
Total Lys, %	1.43	1.31	1.31	1.20
NE, kcal/lb	1,183	1,111	1,179	1,107
SID Lys:NE, g/Mcal	4.91	4.70	4.50	4.30
CP, %	20.0	18.0	18.4	16.5
Ca, %	0.68	0.70	0.64	0.66
STTD P, %	0.42	0.42	0.40	0.40
Ca:P	1.20	1.20	1.20	1.20
ADF, %	2.7	3.6	2.6	3.5
NDF, %	6.2	13.0	6.2	13.0
Diet cost, $/ton	224.21	201.83	215.58	194.60

[1]Phase 1 diets were fed from d 0 to 21 (approximately 27 to 57 lb BW), and phase 2 diets were fed from d 21 to 35 (approximately 57 to 86 lb BW) of the study.
[2]Sunphase HT (Wuhan Sunhy Biology Co., Ltd., Wuhan, P. R. China) included at 1,227 FTU/kg provided an estimated release of 0.11% STTD P.
[3]Corn-SBM-by-product diets (CSBP) contained 0, 0.01, 0.02, or 0.03% compound enzyme 1 or 0.02% compound enzyme 2 (Wuhan Sunhy Biology Co., Ltd., Wuhan, P. R. China) added at the expense of corn.

Table 3. Analyzed composition of experimental diets (as-fed basis)[1]

Formulation strategy:	Corn-SBM		Corn-SBM-By-product			
Enzyme product:[2]	---	---	1	1	1	2
Nutrient, % Enzyme, %:	0	0	0.01	0.02	0.03	0.02
Phase 1						
DM	89.4	89.8	89.3	89.4	89.4	89.0
CP	21.9	20.1	19.4	19.6	19.7	19.2
ADF	2.2	4.5	5.3	4.4	4.5	3.9
NDF	3.9	9.6	10.0	13.5	13.9	11.7
Phase 2						
DM	88.9	88.6	88.8	88.9	89.5	88.8
CP	20.2	18.1	18.0	18.1	17.9	17.4
ADF	2.8	4.4	4.3	4.9	4.7	4.2
NDF	6.5	13.4	13.2	14.4	13.6	13.4

[1]Complete diet samples were taken during bagging of experimental diets from every fourth bag and pooled into one homogenized sample per dietary treatment. Samples were stored at -4°F until analysis. Phase 1 and 2 samples were analyzed for ADF and NDF (University of Missouri Agricultural Experiment Station Chemical Laboratory). Phase 1 and 2 samples were analyzed for DM and CP in the Kansas State University Swine Laboratory.
[2]Sunzyme (Wuhan Sunhy Biology Co., Ltd., Wuhan, P. R. China).

Table 4. Effects of compound enzymes in reduced nutrient density diets on growth performance of nursery pigs[1]

	Formulation strategy[2]											
	CS		CSBP					*P* =				
Enzyme product:[3]	---	---	1	1	1	2		Formu-	Enzyme in CSBP			
Item Enzyme, %:	0	0	0.01	0.02	0.03	0.02	SEM	lation[4]	Linear	Quadratic	Enzyme[5]	Enzyme 2[6]
BW, lb												
d 0	27.3	27.3	27.3	27.3	27.3	27.3	0.48	0.970	0.962	0.937	0.903	1.000
d 21	60.1	56.0	55.7	56.2	56.4	56.9	0.96	< 0.001	0.595	0.727	0.511	0.400
d 35	91.2	85.0	85.1	85.3	84.1	86.5	1.32	< 0.001	0.632	0.592	0.513	0.408
d 0 to 21												
ADG, lb	1.56	1.36	1.35	1.38	1.39	1.41	0.035	< 0.001	0.552	0.713	0.486	0.355
ADFI, lb	2.21	2.17	2.14	2.15	2.20	2.20	0.054	0.570	0.650	0.420	0.522	0.708
F/G	1.42	1.60	1.59	1.57	1.59	1.56	0.018	< 0.001	0.609	0.391	0.753	0.151
d 21 to 35												
ADG, lb	2.22	2.08	2.07	2.08	2.02	2.11	0.038	0.006	0.272	0.379	0.601	0.519
ADFI, lb	3.97	3.85	3.79	3.84	3.77	3.85	0.071	0.217	0.491	0.995	0.851	0.991
F/G	1.79	1.86	1.83	1.85	1.87	1.83	0.026	0.053	0.581	0.240	0.698	0.418
d 0 to 35												
ADG, lb	1.83	1.65	1.64	1.66	1.63	1.69	0.032	< 0.001	0.837	0.827	0.490	0.371
ADFI, lb	2.91	2.84	2.79	2.83	2.81	2.86	0.058	0.352	0.794	0.733	0.648	0.827
F/G	1.60	1.73	1.71	1.70	1.72	1.69	0.016	< 0.001	0.905	0.220	0.592	0.133

[1]A total of 356 nursery pigs (DNA 241 × 600, initially 27.3 ± 0.48 lb BW) were used in a 35-d growth trial with four to five pigs per pen and 12 replications per treatment.

[2]The corn-SBM diet (CS) was corn-soybean meal based and formulated to 1.28% SID Lys and 1,183 kcal/lb NE in phase 1 and 1.17% SID Lys and 1,179 kcal/lb NE in phase 2. Corn-SBM-by-product diets (CSBP) were corn-soybean meal-wheat middling-low oil DDGS-based and formulated to 1.15% SID Lys and 1,111 kcal/lb NE in phase 1 and 1.05% SID Lys and 1,107 kcal/lb NE in phase 2.

[3]Sunzyme, Wuhan Sunhy Biology Co., Ltd., Wuhan, P. R. China.

[4]CS + 0% vs. CSBP + 0%.

[5]CSBP + 0.02% compound enzyme 1 vs. CSBP + 0.02% compound enzyme 2.

[6]CSBP + 0% vs. CSBP + 0.02% compound enzyme 2.

Table 5. Effects of compound enzymes in reduced nutrient density diets on nutrient digestibility of nursery pigs[1]

	Formulation strategy[2]							*P* =				
	CS	CSBP							Enzyme in CSBP			
Enzyme product:[3]	---	---	1	1	1	2		Formulation[4]			Enzyme[5]	Enzyme 2[6]
Item Enzyme, %:	0	0	0.01	0.02	0.03	0.02	SEM		Linear	Quadratic		
ATTD, %												
DM	82.9	76.4	76.1	77.6	77.4	75.4	0.73	< 0.001	0.147	0.993	0.025	0.313
CP	77.8	75.9	77.1	78.3	77.4	74.7	1.12	0.238	0.248	0.349	0.023	0.431
NDF	44.2	35.3	34.4	43.5	38.5	28.4	2.67	0.020	0.115	0.438	< 0.001	0.063

[1]A total of 356 nursery pigs (DNA 241 × 600, initially 27.3 ± 0.48 lb BW) were used in a 35-d growth trial with four to five pigs per pen and 12 replications per treatment. Fecal samples were collected from 12 pigs per treatment on d 35 of the study to determine ATTD of nutrients.

[2]The corn-SBM diet (CS) was corn-soybean meal based and formulated to 1.28% SID Lys and 1,183 kcal/lb NE in phase 1 and 1.17% SID Lys and 1,179 kcal/lb NE in phase 2. Corn-SBM-by-product diets (CSBP) were corn-soybean meal-wheat middling-low oil DDGS-based and formulated to 1.15% SID Lys and 1,111 kcal/lb NE in phase 1 and 1.05% SID Lys and 1,107 kcal/lb NE in phase 2.

[3]Sunzyme, Wuhan Sunhy Biology Co., Ltd., Wuhan, P. R. China.

[4]CS + 0% vs. CSBP + 0%.

[5]CSBP + 0.02% compound enzyme 1 vs. CSBP + 0.02% compound enzyme 2.

[6]CSBP + 0% vs. CSBP + 0.02% compound enzyme 2.