Effects of Increasing Dietary Bakery By-Product on Growing-Finishing Pig Growth Performance and Carcass Quality[1]

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Summary

A total of 1,263 pigs (PIC 337 × 1050; initially 77.8 lb) were used in a 102-d study to determine the effects of dietary bakery by-product on pig growth performance and carcass quality. Pigs were randomly assigned to pens based on gender (14 barrow pens, 11 gilt pens, and 23 mixed-gender pens). Pens of pigs were allotted to 1 of 3 dietary treatments in a completely randomized design while balancing for initial BW and gender. Dietary treatments included 0, 7.5, and 15% bakery by-product. On d 84, the 5 heaviest pigs from each pen (determined visually) were sold according to the normal marketing procedure of the farm. On d 102, the remaining pigs were individually tattooed by pen number and sent to harvest to allow for collection of carcass data. On d 84 and d 102, the median weight market pig from every pen was selected (determined visually) for collection of carcass quality measurements.

Overall (d 0 to 102), increasing bakery by-product worsened (linear, $P < 0.02$) F/G and caloric efficiency on a ME basis and pigs fed diets containing 7.5% bakery by-product tended to have the lowest (quadratic, $P < 0.07$) ADG. For pigs marketed on d 102, no differences ($P > 0.21$) were observed in carcass characteristics. For pigs subsampled on d 84, loin color score increased (linear; $P < 0.02$) and belly fat iodine value (IV) increased numerically (linear, $P < 0.09$) as the amount of bakery by-product increased. Pigs subsampled on d 102 had decreased (linear, $P < 0.04$) middle and edge belly thickness, increased (linear, $P < 0.001$; quadratic, $P < 0.07$) IV, and numerically lower (linear, $P < 0.09$) kill floor pH and belly weight as the amount of dietary bakery by-product increased. Pigs fed 15% bakery by-product had the lowest (quadratic, $P < 0.05$) belly temperature and belly firmness score. With the exception of belly fat IV, bakery by-products had few negative effects on carcass quality.

The negative effects of bakery by-product on feed efficiency, caloric efficiency on an ME basis, and belly fat IV should be taken into consideration when using bakery by-product in diet formulation.

Key words: bakery by-product, carcass quality, finishing pig

[1] Appreciation is expressed to New Horizon Farms for use of pigs and facilities and to Richard Brobjorg, Scott Heidebrink, and Marty Heintz for technical assistance.

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Introduction

With the continuous increase in corn prices, swine producers are utilizing alternative feed ingredients to reduce diet cost. One option for producers to consider is a by-product of the baking and cereal industries. Bakery by-products have been reported to have higher dietary energy (corn ME = 1,551 kcal/lb; bakery by-product ME = 1,678 kcal/lb), CP (corn CP = 8.3%; bakery by-product CP = 10.8%), and fat (corn fat = 3.9%; bakery by-product = 11.3%; NRC, 1998[4]) than corn. Although bakery by-product can be a valuable energy source, its high levels of fat can have negative effects on carcass quality, and the nutrient values can vary greatly depending on the source of the bakery by-product and source and level of other ingredients added to improve flowability. The objective of this experiment was to determine the effects of increasing dietary bakery by-product on growth performance and carcass quality of growing-finishing pigs.

Procedures

This study was approved by and conducted in accordance with the guidelines of the Kansas State University Institutional Animal Care and Use Committee. The experiment was conducted in a commercial research finishing barn in Southwestern Minnesota. The barn was naturally ventilated and double-curtain-sided. Pens had completely slatted flooring and deep pits for manure storage. Each pen was equipped with a 5-hole stainless steel dry self-feeder (STACO, Inc., Schaefferstown, PA) and a cup waterer for ad libitum access to feed and water. Daily feed additions to each pen were accomplished through a robotic feeding system (FeedPro; Feedlogic Corp., Willmar, MN) capable of providing and measuring feed amounts for individual pens.

A total of 1,263 pigs (PIC 337 × 1050; initially 77.8 lb) were used in a 102-d study. Pigs were randomly assigned to pens based on gender (14 barrow pens, 11 gilt pens, and 23 mixed-gender pens), with 25 to 28 pigs per pen. Pens of pigs were allotted to 1 of 3 dietary treatments in a completely randomized design while balancing for initial BW and gender. There were 16 pens per treatment. Treatments included 0, 7.5, and 15% bakery by-product in place of corn and soybean meal. Diets were not balanced for energy; thus, as bakery by-product increased, the energy content of the diet increased. Dietary treatments were fed in 5 phases, with phases from 78 to 137 lb, 137 to 175 lb, 175 to 203 lb, 203 to 225 lb, and 225 to 283 lb BW (Tables 1 and 2). In the last phase, 5 ppm of Ractopamine HCl (Paylean; Elanco Animal Health, Greenfield, IN) was added to the diet, and half of the pens from each of the bakery treatments were assigned to diets with and without zinc oxide (ZnO) so average weight was similar for the ZnO treatments within bakery by-product treatment. The main effects of the addition of Zn to diets containing Ractopamine HCl are reported in another report (see Paulk et al., “Effects of Added Zn in Diets with Ractopamine HCl on Growth Performance and Carcass Quality of Finishing Pigs in a Commercial Environment,” p. 356).

Bakery by-product samples were collected at the time of feed manufacturing, and 3 composite samples were submitted for proximate analysis (Ward laboratories, Inc., Kearney, NE; Table 3). Feed samples were also collected from each feeder during each phase and combined for a single composite sample for each treatment in each phase to be analyzed for proximate analysis (Ward laboratories, Inc., Kearney, NE; Table 4).

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

Pigs and feeders were weighed on d 0, 14, 30, 50, 64, 75, 84, 91, and 102 to determine ADG, ADFI, F/G, and caloric efficiency on both an ME and NE basis. Caloric efficiency is a method to measure the efficiency of energy usage, or the ME or NE required per pound of gain. Metabolizable energy values of the feed ingredients and the NE value of bakery by-product were derived from NRC (1998). Net energy values of all feed ingredients except bakery by-product were derived from INRA (2004[5]). On d 84, the 5 heaviest pigs from each pen (determined visually) were sold according to the normal marketing procedure of the farm. The median weight pig from the 5 selected pigs was tattooed by pen and used for collection of carcass quality measurements (live weight at the plant, HCW, backfat thickness, lean percentage, loin depth, kill floor pH, 4-h pH, belly temperature, belly weight, middle belly thickness, edge belly thickness, belly firmness, belly fat iodine value (IV), loin pH, loin color, and marbling. Percentage lean was calculated by dividing the standardized fat-free lean (SFFL) by HCW. The following equation was used for calculation of SFFL (NPPC, 2001[6]):

Lb. SFFL = 15.31 + 0.51 × (HCW, lb)-31.277 × (last-rib backfat thickness, in.) + 3.813 × (loin muscle depth, in.)

Belly firmness was determined using a subjective measurement taken by picking the belly up at mid-point and estimating the amount of bend. The firmness scale was 1 = none to very little bend, 2 = moderate or 50% bend, and 3 = belly ends touched. Loin color and marbling were taken on the exposed lean of the boneless loin (NPPC, 1999[7]). The loin color scale was from 1 to 6, with 1 = pale and 6 = dark. The marbling scores correspond to intramuscular lipid content, with 1 = very little to no intramuscular lipid content and 10 = extreme amounts.

On d 102, the remaining pigs were individually tattooed by pen number and sent to harvest to allow for collection of carcass data, including HCW, percentage yield at the farm and packing plant, backfat thickness, loin depth, and percentage lean. The median weight pig from each pen was selected for carcass quality measurements. The selection of either a barrow or gilt from mixed-sex pens was balanced across treatments for determination of carcass quality.

Data were analyzed using the PROC MIXED procedure in SAS (SAS Institute, Inc., Cary, NC) with pen as the experimental unit. In addition to dietary treatment, the effects of gender (barrow, gilt, or mixed gender) were included as a fixed effect. Added Zn and interaction effects of increasing dietary bakery by-product and added Zn were tested for d 75 to 102 and carcass measurements. The interaction effect was not significant; therefore, it was removed from the model. The effects of increasing dietary bakery by-product level on performance criteria were determined by linear and quadratic polynomial contrasts. Hot carcass weight was used as a covariate for analyses of backfat

[5] INRA (Institut National de la Recherche Agronomique). 2004. Tables of composition and nutritional value of feed materials, Sauvant, D., J-M. Perez and G. Tran, Eds. Wageningen Academic Publishers, The Netherlands and INRA, Paris, France.

[6] NPPC 2001. Procedures for Estimating Pork Carcass Composition. Natl. Pork Prod. Counc., Des Moines, IA.

[7] NPPC 1999. Composition and Quality Assessment Procedures. Natl. Pork Prod. Counc., Des Moines, IA

thickness, loin depth, and lean percentage. Statistical significance was claimed at $P < 0.05$ and trends at $P < 0.10$.

Results and Discussion

The chemical analysis of the bakery by-product (Table 3) revealed that CP levels were higher and fat levels were lower than the formulated values.

From d 0 to 75, pigs fed 7.5% bakery by-product had decreased (quadratic, $P < 0.02$; Table 5) ADG. Pigs fed diets with up to 15% dietary bakery by-product had numerically poorer (linear, $P < 0.07$) F/G and had poorer (linear, $P < 0.01$) caloric efficiency on a ME basis.

From d 75 to 102, no differences were observed in ADG and ADFI (P > 0.17) as bakery by-product increased; however, F/G and caloric efficiency on a ME basis were poorer (linear, $P < 0.03$) as bakery by-product increased.

Overall (d 0 to 102), as dietary bakery by-product increased, F/G and caloric efficiency on a ME basis became poorer (linear, $P < 0.02$), and pigs fed diets with 7.5% bakery by-product tended to have the lowest (quadratic, $P < 0.07$) ADG. No differences ($P > 0.21$) were observed in carcass characteristics of pigs harvested on d 102.

For carcass quality measurements, pigs subsampled on d 84 had increased (linear; $P < 0.02$) loin color score and numerically increased (linear, $P < 0.09$) belly fat IV as the amount of dietary bakery by-product increased (Table 6). Pigs subsampled on d 102 had decreased (linear, $P < 0.04$) middle and edge belly thickness, increased (linear, $P < 0.001$; quadratic, $P < 0.07$) IV, and numerically lower (linear, $P < 0.09$) kill floor pH and belly weight as the amount of dietary bakery by-product increased. Pigs fed the 15% bakery by-product diets had the lowest (quadratic, $P < 0.05$) belly temperature and belly firmness score.

The addition of up to 15% dietary bakery by-product resulted in poorer feed efficiency and caloric efficiency on a ME basis. Poorer ME caloric efficiency suggests that the ME value for dietary bakery by-product used was overestimated for the product used in this study. This would be supported by the proximate analysis that showed a lower fat percentage (6.4 vs. 11.3%) in the analyzed bakery by-product samples compared with the expected fat percentage used in diet formulation.

The belly fat IV was increased at a greater rate when increasing the amount of added bakery by-product from 7.5 to 15% compared with the increase from 0 to 7.5%. With the exception of belly fat IV, bakery by-product had few negative effects on the carcass quality parameters measured.

Table 1. Composition of diets (Phases 1, 2, and 3; as-fed basis)[1]

	Bakery by-product, %								
	Phase 1			Phase 2			Phase 3		
	0	7.5	15	0	7.5	15	0	7.5	15
Ingredient,%									
Corn	31.81	24.84	17.78	34.69	27.62	20.65	54.62	47.56	40.59
Soybean meal (46.5% CP)	16.68	16.15	15.73	11.43	11.00	10.48	12.25	11.83	11.30
Bakery by-product	—	7.50	15.00	—	7.50	15.00	—	7.50	15.00
DDGS[2]	47.50	47.50	47.50	50.00	50.00	50.00	30.00	30.00	30.00
Choice white grease	1.45	1.45	1.45	1.35	1.35	1.35	0.95	0.95	0.95
Monocalcium P, (21% P)	—	—	—	—	—	—	—	—	—
Limestone	1.57	1.54	1.51	1.58	1.55	1.52	1.31	1.28	1.25
Salt	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
Vitamin and trace mineral premix	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
L-lysine[3]	0.54	0.56	0.58	0.51	0.53	0.55	0.42	0.44	0.46
L-threonine	—	—	—	—	—	—	—	—	—
Phytase[4]	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
Ractopamine HCl[5]	—	—	—	—	—	—	—	—	—
Total	100	100	100	100	100	100	100	100	100
Calculated analysis									
Standardized ileal digestible amino acids, %									
Lysine	1.02	1.02	1.02	0.88	0.88	0.88	0.80	0.80	0.80
Isoleucine:lysine	75	74	74	78	78	78	75	75	74
Leucine:lysine	205	203	200	229	226	223	212	209	206
Methionine:lysine	37	37	37	41	41	41	38	38	37
Met & Cys:lysine	66	66	66	72	72	72	69	69	69
Threonine:lysine	69	68	68	73	73	72	69	69	68
Tryptophan:lysine	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
Valine:lysine	90	90	90	97	97	96	92	92	91
Total lysine	1.23	1.23	1.23	1.08	1.08	1.08	0.96	0.96	0.95
CP, %	23.8	23.8	23.8	22.2	22.3	22.3	18.8	18.8	18.8
ME, kcal/lb[6]	1,549	1,559	1,569	1,547	1,557	1,568	1,543	1,553	1,563
NE, kcal/lb[7]	1,159	1,153	1,147	1,172	1,166	1,160	1,165	1,159	1,152
Ca, %	0.68	0.67	0.67	0.66	0.66	0.65	0.56	0.56	0.55
P, %	0.54	0.54	0.53	0.53	0.53	0.52	0.45	0.45	0.44
Available P, %	0.37	0.37	0.37	0.37	0.37	0.37	0.27	0.27	0.27

[1] Phase 1, 2, and 3 diets were fed from 78 to 137 lb, 137 to 175 lb, and 175 to 203 lb BW, respectively.
[2] DDGS: dried distillers grains with solubles from Valero (Aurora, SD).
[3] Biolys (50.7% L-lys; Evonik Degussa Corporation, Kennesaw, GA).
[4] OptiPhos 2000 (Enzyvla LLC, Sheridan, NJ), which provided 0.07% available P.
[5] Provided 9 g/lb of Ractopamine HCl (Paylean; Elanco Animal Health, Greenfield, IN).
[6] ME values for ingredients were derived from NRC (1998).
[7] NE values for all ingredients except bakery by-product were derived from INRA (2004). Bakery by-product NE value was derived from NRC (1998).

Table 2. Composition of diets (Phases 4 and 5; as-fed basis)[1]

	Bakery by-product, %					
	Phase 4			Phase 5		
	0	7.5	15	0	7.5	15
Ingredient, %						
Corn	69.67	62.60	55.64	63.25	56.29	49.23
Soybean meal (46.5% CP)	13.28	12.85	12.32	18.99	18.46	18.03
Bakery by-product	—	7.50	15.00	—	7.50	15.00
DDGS[2]	15.00	15.00	15.00	15.00	15.00	15.00
Choice white grease	—	—	—	0.70	0.70	0.70
Monocalcium P, (21% P)	0.13	0.13	0.13	—	—	—
Limestone	1.13	1.10	1.07	1.15	1.12	1.09
Salt	0.35	0.35	0.35	0.35	0.35	0.35
Vitamin and trace mineral premix	0.10	0.10	0.10	0.08	0.08	0.08
L-lysine[3]	0.35	0.37	0.39	0.40	0.43	0.45
L-threonine	—	—	—	0.05	0.05	0.05
Phytase[4]	0.005	0.005	0.005	0.007	0.007	0.007
Ractopamine HCl[5]	—	—	—	0.025	0.025	0.025
Total	100	100	100	100	100	100
Calculated analysis						
Standardized ileal digestible (SID) amino acids, %						
Lysine	0.75	0.75	0.75	0.92	0.92	0.92
Isoleucine:lysine	72	72	72	69	69	69
Leucine:lysine	195	192	189	173	171	168
Methionine:lysine	35	34	34	31	31	31
Met & Cys:lysine	67	67	67	60	60	60
Threonine:lysine	66	65	65	67	67	66
Tryptophan:lysine	18.0	18.1	18.0	18.0	18.0	18.0
Valine:lysine	87	87	86	81	81	81
Total lysine	0.87	0.87	0.87	1.06	1.06	1.06
CP, %	16.4	16.5	16.5	18.6	18.6	18.6
ME, kcal/lb[6]	1,524	1,534	1,544	1,539	1,549	1,559
NE, kcal/lb[7]	1,143	1,137	1,131	1,142	1,136	1,130
SID lysine: ME/Mcal	2.23	2.22	2.20	2.71	2.69	2.68
Ca, %	0.52	0.52	0.51	0.53	0.52	0.51
P, %	0.42	0.42	0.41	0.42	0.41	0.41
Available P, %	0.22	0.22	0.22	0.22	0.22	0.22

[1] Phases 4 and 5 were fed from 203 to 225 lb and 225 to 283 lb BW, respectively.
[2] Dried distillers grains with solubles from Valero (Aurora, SD).
[3] Biolys (50.7% L-lys; Evonik Degussa Corporation, Kennesaw, GA)
[4] OptiPhos 2000 (Enzyvla LLC, Sheridan, NJ), which provided 0.07 and 0.08% available P in Phases 4 and 5, respectively.
[5] Provided 9 g/lb of Ractopamine HCl (Paylean; Elanco Animal Health, Greenfield, IN).
[6] ME values for ingredients were derived from NRC (1998).
[7] NE values for all ingredients except bakery by-product were derived from INRA (2004). Bakery by-product NE value was derived from NRC (1998).

Table 3. Analyzed nutrient composition of bakery by-product[1]

Item	As-fed basis	Dry matter basis
Moisture, %	8.17	---
DM, %	91.83	100.00
CP, %	13.97 (10.8)	15.23
ADF, %	8.10	8.80
NDF, %	19.00	20.70
Fat (oil), %	6.43 (11.3)	6.97
Ash, %	5.28	5.74

[1] Proximate analysis was analyzed by Ward Laboratories, Inc. (Kearney, NE) and presented as the mean of 3 composite samples. The values in parentheses were values that used in the formulation.

Table 4. Chemical analysis of complete diets (as-fed basis)[1,2]

	Bakery by-product, %														
	Phase 1			Phase 2			Phase 3			Phase 4			Phase 5		
Nutrient,%	0	7.5	15	0	7.5	15	0	7.5	15	0	7.5	15	0	7.5	15
DM	89.3	89.8	89.8	89.3	89.9	89.7	89.7	89.8	90.0	88.7	89.2	88.9	88.8	88.9	74.4
CP	21.4	22.1	22.0	19.2	16.9	21.6	18.4	18.2	20.8	15.2	16.7	15.5	16.9	18.0	17.6
Fat (oil)	6.1	7.2	7.7	5.3	5.7	7.8	5.5	6.1	7.9	4.1	4.2	4.5	4.3	4.6	5.0
Crude fiber	5.6	6.2	6.3	4.1	4.3	6.2	4.1	4.5	6.6	3.6	3.45	3.4	3.0	3.3	3.6
ADF	7.2	8.2	8.0	5.8	5.6	8.3	6.0	6.3	8.5	5.6	5.9	5.9	5.2	5.7	6.2
NDF	16.4	18.9	17.5	13.4	14.1	17.8	16.1	14.9	18.4	13.4	12.9	12.9	11.9	13.2	13.7
Ash	5.1	4.9	5.5	3.8	4.0	4.7	3.8	4.1	4.8	3.6	4.1	3.9	4.0	3.9	4.3

[1] Phase 1, 2, 3, 4, and 5 diets were fed from 78 to 137 lb,137 to 175 lb, 175 to 203 lb, 203 to 225 lb, and 225 to 282 lb BW, respectively.

[2] Proximate analysis was analyzed by Ward laboratories, Inc., Kearney, NE.

Table 5. Effects of bakery by-product on growth performance and carcass characteristics of growing and finishing pigs[1]

	Bakery by-product,%				Probability, $P<$	
Item	0	7.5	15	SEM	Linear	Quadratic
d 0 to 75						
ADG, lb	1.96	1.91	1.96	0.02	0.99	0.02
ADFI, lb	5.02	4.99	5.15	0.06	0.14	0.20
F/G	2.57	2.62	2.63	0.03	0.07	0.58
Caloric efficiency[2]						
ME	3,961	4,064	4,117	41	0.01	0.60
NE	2,981	3,022	3,025	30	0.28	0.59
d 75 to 102						
ADG, lb	2.39	2.39	2.34	0.03	0.17	0.48
ADFI, lb	6.67	6.79	6.75	0.07	0.38	0.27
F/G	2.79	2.85	2.88	0.03	0.03	0.67
Caloric efficiency[2]						
ME	4,297	4,418	4,495	45.34	0.01	0.68
NE	3,189	3,240	3,258	33.36	0.13	0.67
d 0 to 102						
ADG, lb	2.06	2.02	2.05	0.01	0.57	0.07
ADFI, lb	5.41	5.42	5.53	0.06	0.15	0.47
F/G	2.63	2.68	2.70	0.02	0.02	0.50
Caloric efficiency[2]						
ME	4,052	4,160	4,218	34	0.001	0.52
NE	3,037	3,081	3,088	25	0.14	0.52
Avg. weight, lb						
d 0	77.9	78.1	77.4	1.30	0.78	0.79
d 75	226.0	222.8	225.1	2.0	0.7	0.2
d 102	284.7	281.5	282.3	2.3	0.44	0.46
d 103[3]	282.9	280.0	282.2	2.3	0.82	0.33
Carcass characteristics[4]						
HCW	213.8	212.3	212.6	1.6	0.60	0.63
Yield (farm), %[5]	75.1	75.4	75.3	0.28	0.55	0.54
Yield (plant), %[6]	75.6	75.8	75.3	0.26	0.53	0.21
Backfat thickness[7]	0.62	0.63	0.61	0.01	0.37	0.33
Loin depth, in.[7]	2.78	2.78	2.79	0.02	0.70	0.89
Lean, %[7,8]	54.0	54.0	54.2	0.1	0.41	0.40

[1] A total of 1,263 pigs (PIC 337 × 1050; initially 77.8 lb) were used in 102-d study, with 25 to 28 pigs per pen and 16 pens per treatment. Five pigs per pen were sold as tops on d 84 of the experiment.
[2] Caloric efficiency is expressed as kcal/lb gain.
[3] Final weight taken at the packing plant prior to harvest.
[4] On d 102, the remaining pigs were individually tattooed by pen number and sent to harvest to allow for collection of carcass data.
[5] Percentage yield was calculated by dividing HCW by live weight obtained at the farm before transport to the packing plant.
[6] Percentage yield was calculated by dividing HCW by live weight obtained at the packing plant prior to harvest.
[7] Adjusted using HCW as a covariate.
[8] Calculated using NPPC (2001) equation.

Table 6. Effects of bakery by-product on carcass quality[1]

	Bakery by-product				Probability, $P<$	
Item	0%	7.5%	15%	SEM	Linear	Quadratic
d 84[2]						
HCW	200.6	195.4	198.6	2.7	0.59	0.20
Backfat, in.[3]	0.62	0.67	0.70	0.04	0.12	0.87
Lean, %[3,4]	53.2	52.8	52.2	0.6	0.32	0.94
Loin depth, in.[3]	2.23	2.39	2.36	0.06	0.14	0.23
Kill floor, pH	6.6	6.5	6.6	0.1	0.87	0.68
4-h pH	6.6	6.6	6.6	0.1	0.73	0.47
Belly trait						
Temperature,°F	32.3	33.7	33.3	0.8	0.36	0.38
Weight, lb	14.9	14.7	15.1	0.3	0.64	0.45
Thickness, middle, in.	0.92	0.87	0.92	0.03	0.90	0.19
Thickness, edge, in.	1.07	1.08	1.13	0.04	0.25	0.64
Firmness[5]	2.6	2.7	2.7	0.1	0.51	0.53
Belly fat IV	78.7	78.6	80.2	0.6	0.09	0.25
Loin pH	5.9	5.8	5.9	0.03	0.61	0.31
Loin color[6]	3.3	3.5	3.7	0.1	0.02	0.67
Marbling[7]	1.5	1.6	1.6	0.1	0.20	0.50

continued

Table 6. Effects of bakery by-product on carcass quality[1]

	Bakery by-product				Probability, $P<$	
Item	0%	7.5%	15%	SEM	Linear	Quadratic
d 102[8]						
HCW	209.1	203.3	210.9	3.2	0.69	0.08
Backfat, in.[3]	0.64	0.61	0.60	0.02	0.21	0.77
Lean, %[3,4]	53.8	54.4	54.5	0.39	0.20	0.60
Loin depth, in.[3]	2.78	2.86	2.83	0.06	0.48	0.46
Kill floor, pH	6.7	6.5	6.5	0.1	0.09	0.45
4-h pH	6.5	6.5	6.5	0.05	0.65	0.63
Belly trait						
Temperature,°F	33.6	31.1	32.0	0.7	0.13	0.05
Weight, lb	16.7	15.7	15.9	0.3	0.09	0.15
Thickness, middle, in.	1.08	1.07	0.99	0.03	0.04	0.38
Thickness, edged, in.	1.20	1.16	1.09	0.03	0.01	0.73
Firmness[5]	2.1	1.8	2.1	0.1	0.79	0.03
Belly fat IV	75.2	76.0	81.1	1.0	0.001	0.07
Loin pH	5.8	5.8	5.8	0.03	0.74	0.46
Loin color[6]	3.5	3.3	3.4	0.2	0.71	0.65
Marbling[7]	1.7	1.4	1.5	0.1	0.24	0.19

[1] A total of 1263 pigs (PIC 337 × 1050; initially 77.8 lb) were used in a 102-d study with 25 to 28 pigs per pen and 16 pens per treatment.

[2] Five pigs per pen were sold as tops on d 84 of the experiment. The median-weight pig was subsampled for collection of carcass quality measurements. Values represent the treatment means with 1 pig per pen.

[3] Adjusted using HCW as a covariate.

[4] Calculated using NPPC (2001) equation.

[5] Scored on scale: 1 = none to very little bend, 2 = moderate or 50% bend, 3 = belly ends touched.

[6] Scored on a scale from 1 to 6, with 1 = pale and 6 = dark.

[7] Scored on scale from 1 to 10, with 1 = very little to no intramuscular lipid content and 10 = extreme amounts.

[8] The middle-weight pig of the remaining pigs in the pen was subsample for collection of carcass quality measurements. Values represent the treatment means with 1 pig per pen.