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Effects of Added Zn in Diets with Ractopamine HCl on Growth Performance and Carcass Quality of Finishing Pigs in a Commercial Environment[1]

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Summary
The experiment was conducted in a commercial facility to determine the effects of added Zn on the performance of finishing pigs fed Ractopamine HCl (RAC; Paylean®; Elanco Animal Health, Greenfield, IN). 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. Previously, pens of pigs were assigned to treatments containing 0, 7.5, or 15% bakery by-product in a completely randomized design while balancing for initial BW and gender. On d 75, treatments were implemented to determine the effects of adding 50 ppm Zn from ZnO on finishing pig performance. A total of 1,234 pigs (PIC 337 × 1050; average BW 224.6 lb) were used in a 28-d study. Pens of pigs were randomly assigned to diets with and without 50 ppm added Zn from zinc oxide (ZnO) and balanced by BW, bakery by-product, and gender. All diets contained 5 ppm RAC and 83 ppm Zn from ZnO provided by the trace mineral premix. There were 24 pens per treatment.

Overall (d 75 to 102), no differences ($P > 0.22$) in growth performance or carcass characteristics were observed when pigs were fed diets with 50 ppm added Zn compared with the RAC control. For pigs subsampled on d 84, pigs fed diets with 50 ppm added Zn had decreased ($P < 0.05$) edge belly thickness compared with pigs fed the control. For pigs subsampled on d 102, pigs fed diets with 50 ppm added Zn had decreased ($P < 0.02$) backfat thickness, belly weight, and edge belly thickness; a tendency for decreased ($P < 0.07$) middle belly thickness; and increased ($P < 0.01$) percentage lean compared with pigs fed the RAC control. In contrast with our previous research, these data indicate that adding 50 ppm Zn from ZnO to finishing pig diets containing RAC did not improve overall performance. Consistent with the earlier research, income over feed cost (IOFC) was numerically increased with the addition of Zn.

Key words: finishing pig, Ractopamine HCl, zinc

Introduction
Ractopamine HCl (RAC; Paylean®; Elanco Animal Health, Greenfield, IN) is frequently added to finishing pig diets to improve growth performance and carcass

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leanness. When adding RAC to finishing diets, amino acid concentrations are generally increased approximately 30% to maximize growth and carcass lean based on growth modeling results and several research trial data sets. In contrast, little research has been conducted to determine the effects of trace mineral concentrations on the response to RAC; however, recent research has observed that added Zn can increase the response to RAC (Akey, 2011[4], Patience, 2011[5]). We designed an experiment to determine the effects of adding zinc from ZnO on growth performance and carcass quality of finishing pigs supplemented RAC.

Procedures

The Kansas State University Institutional Animal Care and Use Committee approved the protocol used in this experiment. The experiment was conducted in a commercial research-finishing barn in southwestern Minnesota. The barns were 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.

The experiment was implemented on d 75 of a 102-d study designed to determine the effects of 0, 7.5, and 15% dietary bakery by-product on performance of finishing pigs. The procedures are described in another report (see Paulk et al., "Effects of Increasing Dietary Bakery By-Product on Growing-Finishing Pig Growth Performance and Carcass Quality," p. 155).

On d 75, a total of 1,234 pigs (PIC 337 × 1050; average BW 224.6 lb) were used in a 28-d study. Pens of pigs were randomly assigned to diets (Table 1) with and without 50 ppm added Zn from ZnO and balanced by BW, bakery by-product level, and gender. All diets contained 5 ppm RAC and 83 ppm Zn from ZnO provided by the trace mineral premix. There were 24 pens per treatment.

To determine the effects of 50 ppm added Zn, pigs and feeders were weighed on d 75, 84, 91, and 102 to determine ADG, ADFI, F/G, IOFC, and caloric efficiency on 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 NE value of bakery by-product were derived from the NRC (1998) and NE values of the feed ingredients, except dietary bakery by-product, were derived from INRA (2004[6]). Income over feed cost, a method to measure an economic value, was also calculated and assumed that other costs, such as utility and labor, are equal, and the only variables are ADG and feed usage for the experimental period. Corn was valued at \$220/ton, soybean meal at \$400/ton, dried distillers grains with solubles (DDGS) at

[4] Akey. 2011. Effects of Zinc Source and Level in Paylean Diets on Pig Performance and Carcass Characteristics. Akey Swine Newsletter.

[5] Patience, J. P. 2011. Impact of Zinc Source and Timing of Implementation on Grow-finish Performance, Carcass Composition, and Locomotion Score. IA St. Univ. Anim. Ind. Rep.

[6] 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.

$210/ton, bakery by-product at $232/ton, Biolys at $0.70/lb, Optiphos 2000 at $2.65/lb, RAC at $35.26/lb, zinc oxide at $0.86/lb, and pig price at $0.61/lb.

On d 84, the 5 heaviest pigs from each pen (determined visually) were sold according to the normal marketing procedure of the farm. The middle weight pig from each of the 5 selected pigs was tattooed by pen and used for collection of carcass quality measurements; i.e., live weight at the plant, HCW, percentage carcass yield, backfat thickness, lean percentage, loin depth, kill floor pH, 4-hr 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[7]):

$$\text{Lb. SFFL} = 15.31 + 0.51 \times (\text{HCW, lb}) - 31.277 \times (\text{last-rib backfat thickness, in.}) + 3.813 \times (\text{loin muscle depth, in.})$$

Belly firmness was determined using a subjective measurement taken by picking the belly up at its mid-point and estimating the amount of bend. The firmness scale was 1 = 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[8]). 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. The selection of either a barrow or gilt from mixed-sex pens was balanced across treatments for determination of carcass quality. On d 102, the remaining pigs were individually tattooed by pen number and sent to harvest to allow for collection of carcass data. The middle-weight pig from each pen was selected for carcass quality measurements.

Data were analyzed using the PROC MIXED procedure in SAS (SAS Institute, Inc., Cary, NC) with pen as the experimental unit. The interaction effects of increasing dietary bakery by-product and added Zn were tested. In addition to dietary treatment, the effects of gender and bakery by-product (barrow, gilt, or mixed gender) were included as fixed effects in the model. Hot carcass weight was used as a covariate for analyses of backfat thickness, loin depth, and percentage lean. Statistical significance was claimed at $P < 0.05$ and trends at $P < 0.10$.

Results and Discussion

From d 75 to 84, a bakery by-product × added Zn interaction ($P < 0.03$) occurred. Pigs fed diets with 50 ppm added Zn had a tendency for an increase (quadratic, $P < 0.1$) in ADG as dietary bakery by-product was increased from 0 to 7.5%, whereas pigs fed diets without 50 ppm added Zn had decreased ($P < 0.001$) ADG as dietary bakery by-product increased up to 15%. Although the interaction was significant for d 75 to 84, no interaction ($P > 0.15$) was observed for the overall period.

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

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

From d 75 to 84, pigs fed diets with 50 ppm added Zn from ZnO had decreased ($P < 0.03$) ADFI compared with the RAC control diet (Table 2); however, no differences ($P > 0.24$) occurred in ADG or F/G. From d 84 to 102, pigs fed diets containing 50 ppm added Zn had a tendency for increased ($P < 0.09$) ADG compared with those fed the RAC control diet. Overall (d 75 to 102), no differences ($P > 0.22$) in growth performance or carcass characteristics were observed when pigs were fed diets with 50 ppm added Zn compared with the RAC control (Table 3).

For pigs subsampled on d 84, pigs fed diets with 50 ppm added Zn had decreased ($P < 0.05$) belly edge thickness compared with those fed the RAC control (Table 4). For pigs subsampled on d 102, those fed diets with 50 ppm added Zn had decreased ($P < 0.02$) backfat thickness, belly weight, belly edge thickness, a tendency for decreased ($P < 0.07$) belly middle thickness, and increased ($P < 0.01$) percentage lean compared with pigs fed the RAC control.

Pigs fed RAC diets with 50 ppm added Zn tended to exhibit a 3% increase in ADG from d 84 to 102; however, the addition of 50 ppm Zn from ZnO did not improve overall performance. The increased growth rate during the d 84 to 102 period resulted in a numeric increase in IOFC of $0.47 per pig. Although the response to added Zn is not consistent, little improvement in performance is needed to cover the cost.

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

	No added Zn			50 ppm added Zn from ZnO		
Bakery, %	0	7.5	15	0	7.5	15
Ingredient,%						
Corn	63.25	56.28	49.22	63.24	56.27	49.21
Soybean meal (46.5% CP)	18.99	18.46	18.03	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	0.70	0.70	0.70
Limestone	1.15	1.12	1.09	1.15	1.12	1.09
Salt	0.35	0.35	0.35	0.35	0.35	0.35
Vitamin and trace mineral premix	0.08	0.08	0.08	0.08	0.08	0.08
L-threonine	0.05	0.05	0.05	0.05	0.05	0.05
L-lysine[3]	0.40	0.43	0.45	0.40	0.43	0.45
Phytase[4]	0.007	0.007	0.007	0.007	0.007	0.007
Ractopamine HCl[5]	0.025	0.025	0.025	0.025	0.025	0.025
ZnO	—	—	—	0.007	0.007	0.007
Total	100	100	100	100	100	100
Zinc, ppm						
Calculated analysis						
Trace mineral premix	80	80	80	80	80	80
Added ZnO	0	0	0	50	50	50
Total	114	114	114	164	164	164
Analyzed values						
Total	103	109	124	150	190	148

[1] Dietary treatments were obtained by replacing corn in diets to achieve 50 ppm added Zn from zinc oxide (ZnO).
[2] DDGS: dried distillers grains with solubles.
[3] Biolys (50.7% L-Lys; Evonik Degussa Corporation, Kennesaw, GA).
[4] OptiPhos 2000 (Enzyvla LLC, Sheridan, NJ).
[5] Provided 9 g/lb Ractopamine HCl (Paylean, Elanco Animal Health, Greenfield, IN).

Table 2. Effects of added zinc on growth performance of finishing pigs fed Ractopamine HCl[1]

Item	Control	50 ppm added Zn	SEM	*P*<
d 75 to 84				
ADG, lb	2.47	2.40	0.04	0.24
ADFI, lb	6.81	6.60	0.07	0.03
F/G	2.77	2.76	0.04	0.77
IOFC, $/pig[2]	4.65	4.56	0.18	0.70
Caloric efficiency[3]				
ME	4,294	4,272	55	0.77
NE	3,148	3,131	40	0.77
d 84 to 102				
ADG, lb	2.30	2.37	0.03	0.09
ADFI, lb	6.72	6.79	0.06	0.41
F/G	2.93	2.87	0.03	0.21
IOFC, $/pig[2]	7.68	8.24	0.28	0.14
Caloric efficiency[3]				
ME	4,539	4,450	51	0.21
NE	3,329	3,263	38	0.20
d 75 to 102				
ADG, lb	2.36	2.38	0.02	0.55
ADFI, lb	6.75	6.72	0.05	0.61
F/G	2.86	2.82	0.02	0.23
IOFC, $/pig[2]	12.33	12.80	0.29	0.25
Caloric efficiency[3]				
ME	4,434	4,374	36	0.23
NE	3,251	3,206	27	0.22
Weight, lb				
d 75	224.8	224.4	1.6	0.85
d 84 (before tops)	247.1	246.0	1.7	0.63
d 84 (tops)	274.4	269.8	2.3	0.14
d 102	282.0	283.6	1.8	0.53
d 103[4]	280.9	282.5	1.8	0.55

[1] A total of 1,263 pigs (PIC 337 × 1050; initially 224.6 lb) were used in a 28-d study with 25 to 27 pigs per pen and 24 pens per treatment.
[2] IOFC: income over feed cost. Corn was valued at $220/ton, soybean meal at $400/ton, dried distillers grains with solubles at $210/ton, bakery by-product at $232/ton, Biolys at $0.70/lb, Optiphos 2000 at $2.65/lb, Ractopamine HCL at $35.26/lb, zinc oxide at $0.86/lb, and pig price at $0.61/lb.
[3] Expressed as kcal per pound of gain.
[4] Final BW collected at JBS Swift and Company (Worthington, MN) prior to harvest.

Table 3. Effects of added zinc on carcass characteristics of finishing pigs fed Ractopamine HCL[1]

Item	Control	50 ppm added Zn	SEM	*P*<
Weight, lb				
d 102	282.0	283.6	1.8	0.53
d 103[2]	280.9	282.5	1.8	0.55
Carcass characteristics				
HCW, lb	212.4	213.4	1.3	0.57
Farm yield, %[3]	75.31	75.24	0.22	0.83
Packing plant yield, %[4]	75.60	75.55	0.20	0.87
Backfat thickness, in.[5]	0.62	0.62	0.01	0.47
Loin depth, in.[5]	2.77	2.79	0.01	0.19
Lean, %[5,6]	54.00	54.15	0.11	0.32

[1] 1,263 pigs (PIC 337 × 1050; initially 224.6 lb) were used in a 28-d study with 25 to 27 pigs per pen and 24 pens per treatment.
[2] Final BW collected at JBS Swift and Company (Worthington, MN) prior to harvest.
[3] Percentage yield was calculated by dividing HCW by live weight obtained at the farm before transport to the packing plant.
[4] Percentage yield was calculated by dividing HCW by live weight obtained at the packing plant prior to harvest.
[5] Adjusted using HCW as a covariate.
[6] Calculated using NPPC (2001) equation: (15.31 + 0.51 × (HCW, lb)-31.277 × (last rib backfat thickness,in.) + 3.813 × (loin muscle depth, in.)) / HCW × 100.

Table 4. Effects of added zinc on carcass quality of finishing pigs fed Ractopamine HCL[1]

Item	Control	50 ppm Zn	SEM	Probability *P*<
d 84[2]				
HCW	199.7	196.7	2.2	0.33
Backfat, in.[3]	0.68	0.65	0.03	0.53
Loin depth, in.[3]	2.33	2.32	0.05	0.88
Lean, %[3,4]	52.52	52.92	0.50	0.59
Kill floor pH	6.58	6.57	0.06	0.93
4-h pH	6.58	6.63	0.04	0.40
Belly trait				
Temperature, °F	33.3	32.9	0.6	0.67
Weight	15.03	14.79	0.28	0.55
Thickness middle, in.	0.91	0.90	0.02	0.81
Thickness edged, in.	1.14	1.05	0.03	0.05
Firmness[5]	2.61	2.66	0.09	0.68
Fat iodine value (IV)	79.21	79.12	0.51	0.90
Loin ph	5.86	5.86	0.02	0.82
Loin color[6]	3.43	3.55	0.10	0.39
Marbling[7]	1.55	1.60	0.08	0.67

continued

Table 4. Effects of added zinc on carcass quality of finishing pigs fed Ractopamine HCL[1]

Item	Control	50 ppm Zn	SEM	Probability *P*<
d 102[8]				
HCW	208.1	207.4	2.6	0.86
Backfat, in.[3]	0.65	0.58	0.02	0.01
Loin depth, in.[3]	2.80	2.84	0.05	0.50
Lean, %[3,4]	53.65	54.89	0.32	0.01
Kill floor pH	6.56	6.51	0.07	0.65
4-h pH	6.54	6.47	0.04	0.23
Belly trait				
Temperature, °F	32.7	31.8	0.6	0.22
Weight	16.55	15.64	0.27	0.02
Thickness middle, in.	1.08	1.02	0.03	0.07
Thickness edged, in.	1.19	1.11	0.03	0.02
Firmness[5]	1.89	2.11	0.11	0.16
Fat IV	77.32	77.56	0.81	0.83
Loin pH	5.80	5.81	0.02	0.93
Loin color[6]	3.41	3.34	0.14	0.75
Marbling[7]	1.63	1.45	0.11	0.22

[1]A total of 1263 pigs (PIC 337 × 1050; initially 77.8 lb) were used in 102-d study with 25 to 27 pigs per pen and 16 pens per treatment. There were 14 barrow pens, 11 gilt pens, and 23 mixed-sex pens.

[2] Five pigs per pen were sold as tops on d 84 of the experiment. The middle-weight pig was subsampled for collection of carcass quality measurements.

[3]Adjusted using HCW as a covariate.

[4] Calculated using NPPC (2001) equation: (15.31 + 0.51 × (HCW, lb) - 31.277 × (last rib backfat thickness, in.) + 3.813 × (loin muscle depth, in.)) / HCW

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

[6] Scored on 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.