Effects of Diet Mix Time on Growth Performance of Finishing Pigs Fed Ractopamine HCl

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Summary

Two experiments were conducted to determine the effects of mix uniformity for diets with Ractopamine HCl (RAC) (Paylean; Elanco Animal Health, Greenfield, IN) when fed to finishing pigs. In Exp. 1, a total of 200 pigs (PIC TR4 × 1050; average BW of 198.4 lb) were used in a 33-d growth assay arranged in a randomized complete-block design with 5 pigs per pen and 8 pens per treatment. Treatments were a corn-soybean meal-based control diet mixed for 360 sec and the mixed control diet with 9 g/ton RAC added before additional mixing for 0, 30, 120, and 360 sec. Thus, this experiment was designed to determine the effects of nutrient utilization from a thoroughly mixed diet with a potential non-uniform distribution of RAC. Pigs fed diets with RAC had improved ($P < 0.05$) ADG, F/G, final BW, HCW, dressing percentage, backfat thickness, loin depth, and percentage carcass lean compared with control pigs. Increasing mix time from 0 to 360 sec decreased CV for Chromium (Cr) from 67 to 12%, but had no effect on the response to RAC for any growth or carcass measurement.

In Exp. 2, a total of 160 pigs (PIC TR4 × 1050; average BW of 205 lb) were used in a 27-d growth assay arranged in a completely randomized design with 2 pigs per pen and 16 pens per treatment. Treatments were a corn-soybean meal-based control mixed for 360 sec and control diets with 9 g/ton RAC mixed for 0, 30, 120, and 360 sec. Thus, this experiment was designed to determine the combined effects of potentially non-uniform distribution of both nutrients and RAC. The use of RAC increased ($P < 0.01$) ADG, F/G, final BW, HCW, dressing percentage, percentage lean, and loin depth. Increasing mix times from 0 to 360 sec decreased CV for salt from 51 to 12% with no significant effect on ADG, F/G, HCW, dressing percentage, backfat thickness, loin depth, or percentage lean.

In conclusion, increasing mix time of diets from 0 to 360 sec did not significantly affect the response of finishing pigs to RAC, but in Exp. 2 a mix time of 120 sec for the complete diet and RAC (CV of 15%) resulted in the numerically lowest (quadratic, $P < 0.15$) F/G.

Key words: diet CV, mix time, finishing pig, Ractopamine HCl

Introduction

The goal of mixing a diet is to ensure that each animal receives the intended daily intake of nutrients. The proposed industry standard to represent a homogenous mixture is a diet mixed long enough to ensure a CV of 10% for the concentration of salt in

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10 random samples taken from the batch of feed. Previous research at Kansas State University has reported no effects on growth performance, carcass characteristics, or bone strength in finishing pigs fed diets with CV for salt of 40 to 50% (Traylor et al., 1994[2]); however, concern is growing about the importance of mixing with the increased use of low inclusion level ingredients.

Ractopamine HCl is a feed additive used in late finishing swine diets to improve growth performance and carcass leanness. A quite low inclusion of only 4.5 to 9 g/ton of RAC for the last 45 to 90 lb of gain is recommended by the manufacturer. For maximum performance in pigs consuming diets with RAC, much attention is given to dietary factors such as increasing the concentration of protein and amino acids, but a factor that has not been addressed is the importance of mixing time for diets with RAC; therefore, our objective was to determine the effects of dietary mix uniformity on the response to RAC in finishing pigs.

Materials and Methods

General. This experimental protocol was approved by the Kansas State University Institutional Animal Care and Use Committee.

Diets were mixed in a 3,000-lb-capacity horizontal ribbon mixer (DS30, Davis and Sons Manufacturing Company, Bonner Springs, KS) at the K-State Animal Science Feed Mill. Batch size was 2,000 lb and batches were mixed separately. Mix times were the amount of time the mixer was turned on before opening the discharge gate. The mixer discharge time is approximately 60 to 100 sec. After mix times were completed, the feed was discharged via a 8.2-ft-long screw conveyor, dropped into a bucket elevator, elevated 96.8 ft, and dropped 36.1 ft into a bin. The feed then was carried 36.1 ft horizontally via a round-bottom conveyor and dropped 42.7 ft into a surge bin to be bagged. Each bag of feed was labeled and a sample was collected from every fourth bag (a total of 10 samples) as the feed was added to individual feeders.

Pigs and feeders were weighed at first and final day of the growth assay to allow for calculation of ADG, ADFI, and F/G. The pigs were tattooed and shipped to a commercial abattoir (Farmland Foods Inc., Crete, NE) and HCW, carcass yield, backfat thickness, loin depth, and percentage fat-free lean index (FFLI) were recorded.

All data were analyzed as a randomized complete block design for Exp. 1 and a completely randomized design for Exp. 2 using the MIXED procedure of SAS (SAS Institute Inc., Cary, NC). Pen was the experimental unit with the shape of the response to increasing mix time characterized using polynomial regression for unequally spaced treatments. For Exp. 2, initial BW was used as a covariate. Hot carcass weight was used as a covariate for analyses of backfat thickness, loin depth, and FFLI. Means were considered significant at $P < 0.05$ and trends at $P < 0.15$.

Experiment 1. Two hundred finishing pigs (TR4 × PIC 1050, initially 198.4 lb) were used in a 33-d growth assay to determine the effects of mix time of diets with RAC on growth performance. The pigs were weighed, blocked by BW, and allotted to pens based on sex and ancestry. Pigs were assigned to 10-ft by 5-ft pens with concrete slatted floor-

[2] Traylor et al., Swine Day 1994, Report of Progress 717, pp. 175.

ing and a nipple waterer and single-hole self-feeder to allow ad libitum consumption of feed and water. Each pen had 5 pigs per pen and each treatment had 8 pens.

All diets (Table 1) were formulated to 16% CP, 1.01% total lysine, 0.65% Ca, 0.56% total P, and to meet or exceed all other nutrient requirements suggested by the National Research Council (NRC, 1998[3]) for 176- to 265-lb pigs. To prepare the diets, the major ingredients (corn and soybean meal) were augured into the stopped mixer, the micro ingredients (monocalcium phosphate, limestone, synthetic amino acids, salt, vitamins, and minerals) were added, and the complete diet was mixed for 360 sec.

The control diet was corn-soybean meal-based and mixed for 360 sec. Other treatments were the control diet mixed for 360 sec, 9 g/ton of RAC and 0.5% chromic oxide added, and the diet mixed for an additional 0, 30, 120, and 360 sec. A CV was calculated by expressing the standard deviation for Cr concentration in the 10 samples as a percentage of the grand mean.

Experiment 2. One hundred and sixty finishing pigs (TR4 × PIC 1050, initially 205 lb) were used in a 27-d growth assay. The pigs were weighed and allotted to pens based on weight, sex, and ancestry. Pigs were assigned to 10-ft by 5-ft pens with concrete slatted flooring and nipple waterer and single-hole self-feeder to allow ad libitum consumption of feed and water. There were a total of 80 pens with 2 pigs per pen and 16 pens per treatment.

All diets (Table 1) were formulated the same as in Exp. 1. To prepare the diets, the major ingredients (corn and soybean meal) were augured into the stopped mixer, the micro ingredients (monocalcium phosphate, limestone, synthetic amino acids, salt, vitamins, and minerals) were added, and the complete diet was mixed for 360 sec.

The control diet was a corn-soybean meal-based and mixed for 360 sec. Other treatments were the same formulation as the control with 9 g/ton RAC. These diets were mixed for 0, 30, 120, and 360 sec. In contrast with Exp. 1, mix uniformity was determined using Quantab Cl titrators (low range 0.005 to 0.1% as NaCl; Environmental Test Systems) to measure the concentration of salt.

Results and Discussion

Experiment 1. Pigs fed diets with RAC had greater ($P < 0.01$) ADG, improved ($P < 0.01$) F/G, and decreased ($P < 0.002$) ADFI compared with pigs fed the control diet (Table 2). HCW and carcass yield improved ($P < 0.05$) when pigs were fed diets with RAC compared with those fed the control diet. In addition to the improvements in HCW and carcass yield for the pigs in our experiment, pigs fed diets with RAC had decreased ($P < 0.005$) backfat thickness compared to those fed the control diet. Finally, loin depth ($P < 0.003$) and percentage FFLI ($P < 0.002$) were greater for pigs fed diets with RAC.

As additional mix time increased from 0 to 360 sec, CV for Cr decreased from 67 to 12%. The majority of this improvement in uniformity occurred during the first 30 sec

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

of mixing, with CV dropping from 67 to 37, and an additional 360 sec of mix time needed to decrease the CV further to 12%.

As for the effect of these changes in CV on animal performance, increasing mix time of diets after addition of RAC had no effect on ADG, ADFI, or F/G. Furthermore, increasing mix time from 0 to 360 sec yielded no differences in HCW or loin depth. A quadratic response ($P < 0.03$) was observed for backfat thickness and a tendency ($P < 0.07$) was found for this same quadratic response in carcass yield and percentage carcass lean, but these effects did not indicate a positive effect of increased mix time.

Experiment 2. As in Exp. 1, pigs fed diets with RAC had improved ($P < 0.001$) ADG and F/G (Table 3). Pigs fed diets with RAC had greater ($P < 0.05$) HCW, carcass yield, loin depth, and percentage FFLI. A trend was measured toward a decrease ($P < 0.07$) in backfat thickness among pigs fed RAC vs. the control.

Resulting CV for salt were decreased from 51 to 12% as mix time was increased from 0 to 360 sec. The lowest CV for a diet with RAC was 12% with 360 sec of mixing, which compares favorably with the CV for the control (without RAC), also mixed for 360 sec. As in Exp. 1, the majority of improvement in diet uniformity was achieved with the first 30 sec of mixing with CV dropping from 51 to 19, and an additional 330 sec of mix time was needed to decrease the CV further to 12%. Increasing mix time of diets with RAC from 0 to 360 sec had no effect on ADG and ADFI; however, a numeric trend occurred for an improvement (quadratic, $P > 0.11$) in F/G, with a 5% decrease in F/G as mix time was increased from 0 to 120 sec (CV from 51 to 13%). Carcass characteristics did not differ ($P > 0.10$) when mixed time was increased from 0 to 360 sec.

In conclusion, addition of 9 g/ton RAC to diets for finishing pigs resulted in improved ADG, F/G, HCW, carcass yield, loin depth, and percentage FFLI in both of our experiments. Increasing the mix times from 0 to 360 sec reduced CV for Cr (Exp. 1) from 67 to 12% and CV for salt (Exp. 2) from 51 to 12%. These decreases in CV had no significant effect on growth performance or carcass measurements, but in Exp. 2, a mix time of 120 sec for the complete diet and RAC (CV of 15%) resulted in the numerically best F/G.

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

Item	
Ingredient, %	
Corn	76.50
Soybean meal (46.5% CP)	20.4
L-Lysine HCl	0.25
DL-Methionine	0.03
L-Threonine	0.09
L-Tryptophan	0.01
Monocalcium P (21% P)	0.96
Limestone	1.11
Salt[3]	0.35
Vitamin premix	0.15
Mineral premix	0.15
Calculated analysis, %	
Standardized ileal digestible (SID) lysine	0.90
SID methionine	0.27
Ca	0.65
Available P	0.27

[1] Experimental treatments contained 9 g/ton of Ractopamine HCl (Paylean; Elanco Animal Health, Greenfield, IN).
[2] In Exp. 1, 10 lb/ton of chromic oxide was added as a marker for determination of mix uniformity.
[3] In Exp. 2, salt was used as a marker for determination of mix uniformity.

Table 2. Effects of a thoroughly mixed diet with a potentially non-uniform distribution of Ractopamine HCl (RAC) on finishing pig performance (Exp. 1)[1]

		Additional mixing time of RAC, sec					*P*-value		
Item	Control	0	30	120	360	SE	Control vs others[2]	Linear[3]	Quadratic[3]
CV for chromium, %[4]	15	67	37	24	12	3	0.43	0.001	0.001
ADG, lb	2.54	2.66	2.73	2.70	2.74	0.06	0.02	0.49	0.91
ADFI, lb	8.56	7.56	7.69	7.81	7.79	0.22	0.001	0.37	0.40
F/G	3.37	2.85	2.81	2.90	2.85	0.06	0.001	0.85	0.45
Carcass measurements									
HCW, lb	209.0	214.7	219.1	214.0	217.3	5.8	0.001	0.66	0.31
Carcass yield, %	73.3	74.8	74.6	74.1	74.8	0.4	0.001	0.72	0.07
Backfat thickness, in.[5]	1.00	0.86	0.92	0.95	0.88	0.04	0.005	0.88	0.03
Loin depth, in.[5]	2.33	2.51	2.52	2.61	2.59	0.06	0.003	0.17	0.18
FFLI, %[5,6]	47.7	50.0	49.3	49.0	49.8	0.5	0.002	0.69	0.08

[1] A total of 200 finishing pigs (PIC TR4 × 1050, average initial BW of 198.4 lb, 5 pigs per pen and 8 pens per treatment) were used in a 33-d growth assay.
[2] Control without RAC compared to the average of the 4 treatments containing RAC.
[3] Polynomial regression for increasing the additional mix time of RAC from 0 to 360 sec.
[4] Coefficient of variation for chromium concentration was determined from ten samples, taken from every fourth bag, for each batch of feed.
[5] HCW used as a covariate.
[6] Fat-free lean index.

Table 3. Effects of potentially non-uniform distribution of both nutrients and Ractopamine HCl (RAC) on finishing pig performance (Exp. 2)[1]

		Mixing times of diets containing RAC, sec					*P*-value		
Item	Control	0	30	120	360	SE	Control vs. others[2]	Linear[3]	Quadratic[3]
CV for salt, %[4]	11	51	19	15	12	7	0.90	0.04	0.05
ADG, lb[5]	2.37	2.75	2.72	2.83	2.76	0.05	0.001	0.69	0.20
ADFI, lb[5]	7.86	7.80	7.62	7.64	7.51	0.14	0.18	0.22	0.77
F/G[5]	3.33	2.84	2.81	2.70	2.72	0.06	0.001	0.13	0.15
Carcass measurements									
HCW, lb[5]	195.8	206.2	206.7	209.5	208.5	1.5	0.001	0.30	0.19
Carcass yield, %[5]	72.7	73.7	74.3	74.2	74.5	0.4	0.001	0.28	0.73
Backfat thickness, in.[6]	0.85	0.76	0.80	0.76	0.79	0.03	0.07	0.83	0.64
Loin depth, in.[6]	2.43	2.75	2.64	2.64	2.79	0.06	0.001	0.18	0.10
FFLI, %[6,7]	50.4	52.0	51.2	51.9	51.7	0.5	0.05	0.92	0.87

[1] A total of 160 finishing pigs (PIC TR4 × 1050, average initial BW of 205 lb, 2 pigs per pen and 16 pens per treatment) were used in a 27-d growth assay.
[2] Control without RAC compared with the average of the 4 treatments containing RAC.
[3] Polynomial regression for increasing the mix time of the diet containing RAC from 0 to 360 sec.
[4] Average coefficient of variation for salt concentration was determined from 2 batches per treatment, 10 samples per batch, and samples taken from every fourth bag.
[5] Initial BW used as a covariate.
[6] HCW used as a covariate.
[7] Fat-free lean index.