Effects of Ractopamine and Carnitine in Diets Containing 5% Fat for Finishing Pigs

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Introduction

The activation The pork industry is continually looking for means to increase pig growth rate, feed efficiency, and carcass lean percentage. To accomplish this, one option would be to explore increasing the amount of energy available for lean gain accretion. It is known that energy intake limits pig performance from 25 – 120 lb live weight. Therefore, by increasing dietary fat levels, energy intake and pig growth rate could be increased. However, the efficiency in which dietary fat is utilized for lean growth may decrease as dietary fat levels increase and as the pig matures. To compensate for this problem, it has been found that feeding carnitine may improve the utilization efficiency of dietary fat.

Recently ractopamine (RAC) has been approved as a feed additive to increase lean growth rate, improve feed efficiency, and increase carcass lean percentage. Based on research conducted at Purdue University, the duration of response to ractopamine has decreased to four weeks. With a four-week duration response, it is important to maximize daily energy intakes to maximize the total response to ractopamine. As a result, it is thought that elevated fat diets with the inclusion of carnitine may enhance the lean accretion of pigs fed ractopamine by effectively increasing the available energy for lean tissue synthesis.

The objective of this study is to incorporate ractopamine and carnitine into diets with elevated fat levels to determine the effects on growth rate, feed efficiency, and lean gain of finishing pigs.

Materials and Methods

Three hundred gilts (avg. initial BW = 188.3 lb) of two genetic populations, one high lean gain – lower feed intake European terminal cross (ET) and one medium lean gain U.S. terminal cross (UST), were randomly assigned one of five diets fed for four weeks before slaughter. Six pens were assigned to each treatment/genotype combination (60 pens on test). Five dietary treatments (TRT) were used: 1) the control (CONT); 2) 45 g/ton carnitine (CARN); 3) 4.5 g/ton RAC (RAC4.5); 4) 45 g/ton carnitine and 4.5 g/ton RAC (CARN+RAC); and 5) 9 g/ton RAC (RAC9). Table 1 displays the diet formulations for each treatment of the trial. Two weeks prior to starting the dietary treatments, all gilts were fed a 1.15% lysine corn-soy diet with no added fat. Treatment diets were formulated to 1.15% lysine and contained 5% added choice white grease. The gilts and feeders were weighed to determine average daily gain (ADG), average daily feed intake (ADFI), and feed efficiency (F:G) on days 0, 14, and 28. In addition, 3 gilts/pen (36/TRT) were ultrasonically scanned on days 0, 14, and 28 to measure loin eye area, and last rib and tenth rib backfat. With these real-time ultrasound data, tissue accretion curves were generated. After four weeks on test, the gilts were taken to a commercial pork processor where individual hot carcass weights and carcass ultrasounds of loin and backfat depth measurements were collected. Pork quality measurements of the loin (color, marbling, firmness, and pH) were additionally evaluated at the time of slaughter for a subset of gilts. An average of two independent, objective pork quality scores was recorded. Statistical analysis of all the data was performed using the

GLM procedures of SAS, allowing dietary treatment to be examined for its effect on growth and carcass characteristics of the finishing pigs.

Results

Diet effects. The growth performance data of the finishing pigs can be found in Tables 2 and 3. While initial and final body weight of the gilts proved to be statistically insignificant, the gilts that were fed diets with ractopamine had numerically heavier body weights by day 28. Pigs fed the CARN+RAC and the RAC9 diets had greater ADG during days 0-14 (1.84, 1.91, 2.10, 2.32, 2.37 lb/d; $P < 0.001$, diets 1-5 respectively) and overall from days 0-28 (1.88, 1.86, 2.00, 2.12, 2.08 lb/d; $P < 0.01$, diets 1-5 respectively) compared to pigs fed the CONT and CARN diets. No significant difference was found in ADFI among diets at any time point in the study. Gilts fed the RAC4.5, CARN+RAC, and RAC9 diets had greater feed efficiency ($P < 0.001$) from days 0-14 (0.37, 0.38, 0.43, 0.45, 0.47 G:F, diets 1-5 respectively) and days 0-28 (0.36, 0.35, 0.39, 0.40, 0.40 G:F, diets 1-5 respectively) compared to pigs fed the CONT and CARN diets.

The results of the plant-measured carcass characteristics are shown in Tables 4 and 5. Hot carcass weights (183.6, 182.1, 186.3, 188.7, 189.4 lb, diets 1-5 respectively) for gilts fed the CARN+RAC and RAC9 diets were found to be greater ($P < 0.05$) than those fed the CONT and CARN diets. Pigs fed diets with ractopamine also had increased carcass loin depths (2.67, 2.65, 2.78, 2.77, 2.83 in; $P < 0.01$, diets 1-5 respectively). However, only the RAC4.5 and RAC9 diets had increases in percent lean ($P < 0.01$) compared to the other diets. No difference in percent carcass yield was found among treatments. The pigs fed RAC9 resulted in a significant increase ($P < 0.01$) in carcass grade premium (6.95 $/cwt.) compared to those fed the CONT or CARN diets (5.98 and 6.11 $/cwt) while the RAC4.5 and CARN+RAC diets resulted in intermediate grade premiums (6.49 and 6.47 $/cwt.). As a result, the CARN+RAC and RAC9 diets produced a significantly higher ($P < 0.01$) total value per pig than the CONT and CARN diets ($121.93, $121.53, $125.12, $126.80, $128.08, diets 1-5 respectively).

Pork quality measurements were also evaluated and the results are presented in Tables 4 and 5 as well. Marbling and firmness did not differ significantly among treatments, but the CARN+RAC diet resulted in a darker color score (2.09, 2.06, 2.04, 2.34, 1.99; $P < 0.05$, diets 1-5 respectively) than the other treatments.

The results of the real-time ultrasound data can be found in Tables 6 and 7. Table 6 provides data for serial scans of a subset of pigs from each pen at days 0, 14, and 28. By day 28 pigs fed diets with ractopamine but no carnitine resulted in a significant decrease in last rib backfat (0.58, 0.58, 0.52, 0.58, 0.53 in; $P < 0.05$, diets 1-5 respectively). Pigs fed the CARN+RAC diet had an increase ($P < 0.05$) in loin eye area as compared to the CONT and CARN diets (6.96, 7.00, 7.22, 7.50, 7.33 in^2; diets 1-5 respectively).

Genotype effects. The UST gilts had a greater ADG from day 14-28 ($P < 0.006$) and tended to have greater overall ADG from day 0-28 (2.03 vs. 1.95 lbs/day; $P < 0.07$) than the ET gilts. Since the ET gilts had lower ADFI ($P < 0.02$) during day 0-14, they had an improved feed efficiency during days 0-14 ($P < 0.02$) as well. However, because the UST gilts had a greater feed efficiency during days 14-28 ($P < 0.06$), there was no difference found between genotypes for feed efficiency during the entire trial, days 0-28.

At slaughter the UST gilts had greater final body weights (247.7 vs. 244.1 lbs; $P < 0.03$). However, the UST gilts also had increased fat depths (0.61 vs. 0.53 in; $P < 0.001$) with reduced percent lean (56.0 vs. 56.6%; $P < 0.01$) and reduced carcass yield (75.2 vs. 76.1%; $P < 0.01$) compared to the ET gilts. Similar to the plant-measured carcass data, the real-time ultrasound data indicated that the ET gilts had decreased backfat depth (0.58 vs. 0.66 in; $P < 0.001$) with no

difference in LEA throughout the trial as compared to the UST gilts. The ET gilts also had less loin marbling characteristic (1.57 vs. 2.07; $P < 0.001$) than the UST gilts.

Application

This study indicates that during the first 14 days while feeding ractopamine, carnitine may enhance the ractopamine response with increased body weight gain and improved feed efficiency. Additionally, the combination of 45 g/ton carnitine and 4.5 g/ton ractopamine may provide the potential to increase gain and feed efficiency as well as provide similar carcass characteristics equal to the higher dose (9 g/ton) of ractopamine, resulting in a substantial savings in feed input costs when using ractopamine.

Table 1. Experimental diet compositions for finishing pigs

Diet Composition, %	Pre-Trial Diet	CONT	CARN	RAC4.5	CARN + RAC	RAC9
Corn	68.370	62.435	62.385	62.410	62.360	62.385
SBM - 48%	29.070	30.000	30.000	30.000	30.000	30.000
Limestone	1.000	0.960	0.960	0.960	0.960	0.960
Dical. Phos.	0.580	0.640	0.640	0.640	0.640	0.640
Salt	0.300	0.300	0.300	0.300	0.300	0.300
Vitamin Premix	0.250	0.250	0.250	0.250	0.250	0.250
TM Premix	0.125	0.125	0.125	0.125	0.125	0.125
Selenium Premix	0.050	0.050	0.050	0.050	0.050	0.050
Fat	0.000	5.000	5.000	5.000	5.000	5.000
Lysine – HCl	0.120	0.100	0.100	0.100	0.100	0.100
DL-Methionine	0.055	0.060	0.060	0.060	0.060	0.060
Phytase	0.080	0.080	0.080	0.080	0.080	0.080
Carnitine	0.000	0.000	0.050	0.000	0.050	0.000
Paylean-9	0.000	0.000	0.000	0.025	0.025	0.050
Totals	100.000	100.000	100.000	100.000	100.000	100.000
Nutrient Profile						
Met. Energy, kcal/lb	1506.00	1593.00	1593.00	1593.00	1593.00	1593.00
Crude protein, %	19.530	19.500	19.500	19.500	19.500	19.500
Crude fiber, %	2.560	2.460	2.460	2.460	2.460	2.460
Crude fat, %	3.540	8.330	8.330	8.330	8.330	8.330
Amino Acids, %						
Lysine	1.150	1.150	1.150	1.150	1.150	1.150
Threonine	0.736	0.736	0.736	0.736	0.736	0.736
Tryptophan	0.230	0.230	0.230	0.230	0.230	0.230
Methionine	0.365	0.370	0.370	0.370	0.370	0.370
Meth. + Cystine	0.710	0.710	0.710	0.710	0.710	0.710
Isoleucine	0.820	0.820	0.820	0.820	0.820	0.820
Minerals, %						
Calcium	0.600	0.600	0.600	0.600	0.600	0.600
Total Phosphorous	0.500	0.500	0.500	0.500	0.500	0.500
Available Phosphorous	0.180	0.180	0.180	0.180	0.180	0.180
Phytase Avail. P	0.280	0.280	0.280	0.280	0.280	0.280
Potassium (K)	0.230	0.230	0.230	0.230	0.230	0.230

CONT = Control; CARN = 45 g/ton Carnitine; RAC4.5 = 4.5 g/ton Ractopamine; CARN+RAC = 45 g/ton Carnitine + 4.5 g/ton Ractopamine; RAC9 = 9 g/ton Ractopamine.

Table 2. The effect of varying levels of carnitine and/or ractopamine on ADG, ADFI, and feed efficiency in finishing pigs

							Probability, P <		
Treatment:	**CONT**	**CARN**	**RAC4.5**	**CARN+ RAC**	**RAC9**	**SE**	**Diet**	**Genotype**	**Diet ´ Genotype**
Initial wt., lb	188.5[a]	187.9[a]	188.2[a]	188.4[a]	188.6[a]	2.233	0.999	0.594	1.000
Day 14 wt., lb	215.2[a]	215.7[a]	218.7[a]	222.0[a]	223.0[a]	3.210	0.315	0.920	0.986
Day 28 wt., lb	241.8[a]	240.5[a]	244.9[a]	248.3[a]	247.5[a]	3.080	0.300	0.135	0.979
Day 0-14									
ADG, lb/d	1.84[c]	1.91[c]	2.10[cb]	2.32[ba]	2.37[a]	0.095	0.004	0.616	0.762
ADFI, lb/d	4.89[a]	5.03[a]	4.90[a]	5.15[a]	5.09[a]	0.130	0.540	0.019	0.728
F:G	2.69[a]	2.67[a]	2.39[b]	2.24[b]	2.19[b]	0.096	0.004	0.032	0.546
G:F	0.37[b]	0.38[b]	0.43[a]	0.45[a]	0.47[a]	0.015	0.001	0.019	0.667
Day 14-28									
ADG, lb/d	1.91[a]	1.80[a]	1.92[a]	1.89[a]	1.83[a]	0.079	0.784	0.006	0.767
ADFI, lb/d	5.67[a]	5.70[a]	5.40[a]	5.49[a]	5.37[a]	0.158	0.475	0.547	0.700
F:G	2.99[ab]	3.24[a]	2.87[b]	2.96[ab]	2.98[ab]	0.142	0.442	0.029	0.877
G:F	0.34[a]	0.32[a]	0.36[a]	0.35[a]	0.34[a]	0.016	0.496	0.058	0.928
Overall									
ADG, lb/d	1.88[b]	1.86[b]	2.00[ba]	2.12[a]	2.08[a]	0.051	0.002	0.072	0.674
ADFI, lb/d	5.28[a]	5.36[a]	5.15[a]	5.32[a]	5.23[a]	0.133	0.809	0.128	0.690
F:G	2.80[a]	2.88[a]	2.59[b]	2.52[b]	2.52[b]	0.062	0.001	0.743	0.780
G:F	0.36[b]	0.35[b]	0.39[a]	0.40[a]	0.40[a]	0.008	0.001	0.940	0.838

[a,b,c] Means in a row with different superscripts differ, $P < 0.05$.

CONT = Control; CARN = 45 g/ton Carnitine; RAC4.5 = 4.5 g/ton Ractopamine; CARN+RAC = 45 g/ton Carnitine + 4.5 g/ton Ractopamine; RAC9 = 9 g/ton Ractopamine.

Table 3. Performance summary by genotype of finishing pigs fed varying levels of carnitine and ractopamine

	Genotype			
	ET	**UST**	**SE**	**Probability, P <**
Initial wt., lb	187.8	188.8	1.412	
Day 14 wt., lb	219.1	218.8	2.030	0.920
Day 28 wt., lb	242.5	246.7	1.948	0.135
Day 0-14				
ADG, lb/d	2.13	2.09	0.060	0.616
ADFI, lb/d	4.87	5.15	0.082	0.019
F:G	2.34	2.53	0.061	0.032
G:F	0.44	0.40	0.009	0.019
Day 14-28				
ADG, lb/d	1.77	1.97	0.050	0.006
ADFI, lb/d	5.48	5.57	0.100	0.547
F:G	3.15	2.86	0.091	0.029
G:F	0.33	0.35	0.010	0.058
Overall				
ADG, lb/d	1.95	2.03	0.032	0.072
ADFI, lb/d	5.18	5.36	0.084	0.128
F:G	2.67	2.66	0.039	0.743
G:F	0.38	0.38	0.005	0.940

ET = European Terminal Cross gilts.
UST = U.S. Terminal Cross gilts.

Table 4. The effect of varying levels of carnitine and/or ractopamine on carcass characteristics in finishing pigs

							Probability, P <		
Treatment:	**CONT**	**CARN**	**RAC4.5**	**CARN + RAC**	**RAC9**	**SE**	**Diet**	**Genotype**	**Diet ´ Genotype**
Slaughter wt., lb	244.1[b]	241.6[b]	245.8[ab]	248.6[a]	249.5[a]	1.853	0.016	0.030	0.859
HCW, lb	183.6[b]	182.1[b]	186.3[ab]	188.7[a]	189.4[a]	1.530	0.002	0.638	0.765
Ave. fat depth, in	0.57[abc]	0.59[ab]	0.52[c]	0.62[a]	0.56[bc]	0.019	0.007	0.001	0.970
Ave. loin depth, in	2.67[b]	2.65[b]	2.78[a]	2.77[a]	2.83[a]	0.036	0.002	0.877	0.893
% Lean	56.02[b]	55.94[b]	56.81[a]	56.15[b]	56.76[a]	0.198	0.002	0.005	0.996
% Yield	75.21[a]	75.40[a]	75.80[a]	75.91[a]	75.94[a]	0.300	0.311	0.002	0.669
Base meat price, $/cwt.	60.42[a]	60.63[a]	60.63[a]	60.76[a]	60.74[a]	0.500	0.990	0.576	0.999
Carcass grade Premium, $/cwt.	5.98[b]	6.11[b]	6.49[ab]	6.47[ab]	6.95[a]	0.196	0.005	0.724	0.816
Total value, $/pig	121.93[b]	121.53[b]	125.12[ab]	126.80[a]	128.08[a]	1.313	0.001	0.875	0.910
Color[1]	2.09[a]	2.06[a]	2.04[a]	2.34[b]	1.99[a]	0.090	0.054	0.109	0.430
Marbling[1]	1.83[a]	1.92[a]	1.69[a]	1.92[a]	1.73[a]	0.093	0.293	0.001	0.999
Firmness[1]	2.34[a]	2.45[a]	2.33[a]	2.53[a]	2.35[a]	0.092	0.469	0.334	0.784
pH[2]	5.59[b]	5.64[ab]	5.61[ab]	5.70[a]	5.63[ab]	0.041	0.312	0.210	0.981

[a,b,c] Means in a row with different superscripts differ, P < 0.05.

[1] n = 124.

[2] n = 87.

CONT = Control; CARN = 45 g/ton Carnitine; RAC4.5 = 4.5 g/ton Ractopamine; CARN+RAC = 45 g/ton Carnitine + 4.5 g/ton Ractopamine; RAC9 = 9 g/ton Ractopamine.

Table 5. Genotypic carcass characteristics of finishing pigs fed varying levels of carnitine and ractopamine

	Genotype			Probability, P <
	ET	UST	SE	
Slaughter wt., lb	244.1	247.7	1.172	0.030
HCW, lb	185.7	186.4	0.968	0.638
Ave. fat depth, in	0.53	0.61	0.012	0.001
Ave. loin depth, in	2.74	2.74	0.022	0.877
% Lean	56.59	56.08	0.126	0.005
% Yield	76.06	75.24	0.002	0.002
Base meat price, $/cwt.	60.76	60.51	0.317	0.576
Carcass grade Premium, $/cwt.	6.43	6.37	0.124	0.724
Total value, $/pig	124.79	124.60	0.830	0.875
Color[1]	2.17	2.04	0.055	0.121
Marbling[1]	1.57	2.07	0.058	0.001
Firmness[1]	2.36	2.44	0.057	0.347
pH[2]	5.61	5.66	0.026	0.190

[1] n = 124.
[2] n = 87.

ET = European Terminal Cross gilts.
UST = U.S. Terminal Cross gilts.

Table 6. The effect of varying levels of carnitine and/or ractopamine on back fat and loin eye area in finishing pigs

Treatment:	CONT	CARN	RAC4.5	CARN+ RAC	RAC9	SE	Probability, P <		
							Diet	Genotype	Diet ´ Genotype
Serial scan, no. pigs	36	36	36	36	36				
Day 0									
Body wt., lb	187.3[a]	188.8[a]	189.4[a]	189.2[a]	188.6[a]	1.694	0.914	0.501	0.735
10[th] Rib BF, in	0.44[a]	0.48[a]	0.45[a]	0.48[a]	0.46[a]	0.014	0.207	0.001	0.313
Last Rib BF, in	0.50[a]	0.49[a]	0.51[a]	0.51[a]	0.47[a]	0.016	0.359	0.001	0.723
Loin Eye Area, in^2	6.08[a]	6.20[a]	6.04[a]	6.02[a]	6.02[a]	0.126	0.844	0.451	0.695
Day 14									
Body wt., lb	215.7[b]	216.3[ab]	218.8[ab]	222.7[a]	222.7[a]	2.348	0.088	0.964	0.637
10[th] Rib BF, in	0.52[bc]	0.57[ab]	0.50[c]	0.56[ab]	0.52[bc]	0.018	0.012	0.002	0.217
Last Rib BF, in	0.53[a]	0.52[a]	0.51[a]	0.53[a]	0.51[a]	0.013	0.810	0.001	0.111
Loin Eye Area, in^2	6.79[a]	7.07[a]	7.00[a]	7.01[a]	7.20[a]	0.154	0.437	0.519	0.899
Day 28									
Body wt., lb	241.3[b]	240.9[b]	246.1[ab]	248.7[a]	247.4[a]	2.259	0.044	0.082	0.945
10[th] Rib BF, in	0.62[ab]	0.65[a]	0.58[b]	0.66[a]	0.59[b]	0.020	0.018	0.001	0.464
Last Rib BF, in	0.58[a]	0.58[a]	0.52[b]	0.58[a]	0.53[b]	0.016	0.017	0.001	0.505
Loin Eye Area, in^2	6.96[b]	7.00[b]	7.22[ab]	7.50[a]	7.33[ab]	0.140	0.037	0.947	0.911
Overall Change									
10[th] Rib BF, in	0.18[a]	0.17[ab]	0.13[b]	0.19[a]	0.13[b]	0.016	0.027	0.820	0.962
Loin Eye Area, in^2	0.88[ab]	0.80[a]	1.23[bc]	1.48[c]	1.35[c]	0.147	0.003	0.572	0.869

[a,b,c] Means in a row with different superscripts differ, P < 0.05.

CONT = Control; CARN = 45 g/ton Carnitine; RAC4.5 = 4.5 g/ton Ractopamine; CARN+RAC = 45 g/ton Carnitine + 4.5 g/ton Ractopamine; RAC9 = 9 g/ton Ractopamine.

Table 7. Genotypic differences in back fat and loin eye area of finishing pigs fed varying levels of carnitine and ractopamine

	Genotype			Probability, (P <)
	ET	UST	SE	
Serial Scan, no. pigs	90	90		
Day 0				
Body wt., lb	188.2	189.2	1.071	0.501
10^{th} Rib BF, in	0.42	0.50	0.009	0.001
Last Rib BF, in	0.46	0.53	0.010	0.001
Loin Eye Area, in^2	6.12	6.03	0.080	0.451
Day 14				
Body wt., lb	219.2	219.3	1.480	0.964
10^{th} Rib BF, in	0.51	0.57	0.008	0.002
Last Rib BF, in	0.47	0.57	0.011	0.001
Loin Eye Area, in^2	7.06	6.97	0.097	0.519
Day 28				
Body wt., lb	243.1	246.7	1.433	0.082
10^{th} Rib BF, in	0.58	0.66	0.010	0.001
Last Rib BF, in	0.53	0.59	0.013	0.001
Loin Eye Area, in^2	7.20	7.21	0.089	0.947
Overall Change				
10^{th} Rib BF, in	0.16	0.16	0.010	0.820
Loin Eye Area, in^2	1.11	1.18	0.092	0.572

ET = European Terminal Cross gilts.
UST = U.S. Terminal Cross gilts.