Development of a Model to Predict the Growth of Pigs When Increasing Dietary Levels of Paylean® are Fed

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Introduction

Most previous trials have evaluated the response of Paylean® (ractopamine) when constant levels were fed for the last 90 lb of live weight gain. Recently, three trials have been conducted to compare the response to Paylean fed at increasing levels to a similar constant level throughout late-finishing. These trials indicated that the magnitude and duration of the Paylean response could be enhanced by using a step-up program. The objectives of this research were 1) to model the Paylean response in terms of variables related to underlying biological changes; and 2) to use the model to predict performance and essential amino acid requirements for subsequent economic analyses.

Experimental Procedures

Data from three trials were used for this analysis. The first trial was conducted at Purdue University (Herr et al., 2001). Eighty barrows and 80 gilts were assigned into 32 pens (5 pigs/pen) to four dietary treatments. The dietary treatments were: 1) Control diet containing no Paylean; 2) Step-down diet sequence: 18 g/ton (20 ppm) Paylean weeks one and two, 9 g/ton (10 ppm) Paylean weeks three and four, and 4.5 g/ton (5 ppm) Paylean weeks five and six; 3) Step-up diet sequence: 4.5 g/ton Paylean weeks one and two, 9 g/ton Paylean weeks three and four; and 18 g/ton Paylean weeks five and six; 4) Constant diet containing 10.5 g/ton (11.6 ppm) Paylean.

Gilts were fed a 19.6% CP diet with a 1.2% lysine level while barrows were fed an 18.5% CP diet with a 1.1% lysine level. Pigs were weighed and feed intakes were recorded weekly for the six-week period to determine average daily gain (ADG) and daily feed intake (DFI), from which feed efficiency (gain:feed, G:F) was calculated. In this initial trial, the step-up effect was observed. During weeks three and four, pigs of the step-up treatment had numerically better average daily gain (2.36 vs. 2.24) and better feed efficiency (0.39 vs. 0.35 gain:feed; $P < 0.05$) than pigs of the constant treatment.

The second trial was conducted by North Carolina State University. Barrows (N = 100) and gilts (N = 100) were allotted to the same treatments as the first trial. Pigs were weighed and feed intakes were recorded at biweekly intervals. All pigs were fed diets containing 1.2% lysine and 20.65% crude protein.

The third trial was conducted at Purdue University. Barrows (N = 143) and gilts (N = 149) were randomly assigned to one of five treatments at a mean weight of 156.1 pounds. The five treatments were: 1) Control; 2) 4.5 g/ton Paylean for weeks one through six; 3) 4.5 g/ton Paylean for weeks one through four and 9 g/ton weeks five and six; 4) 4.5 g/ton Paylean from weeks one through three and 9 g/ton weeks four through six; and 5) 4.5 g/ton for weeks one and two, 6.75 g/ton for weeks three and four, and 9 g/ton for weeks five and six. Pigs were weighed and feed intakes were recorded weekly for the six-week period.

Statistical Analyses

A ractopamine model (Schinckel et al., 2001a) was used to predict the daily compositional live weight growth and feed efficiency of pigs fed constant levels of Paylean. The model predicted the daily performance of barrows and gilts fed 4.5, 9, and 18 g/ton of Paylean in average and above average environmental conditions. The increases in daily protein accretion, average daily gain, daily feed intake, and feed efficiency produced by Paylean above the controls were calculated. The increase in daily protein accretion (RPA, g/day) was fit to a regression equation including the increase in average daily gain (RADG, lb/day), response in feed efficiency (RGF, G:F), weight gain on test (WTGAIN, lb), and days on test (DOT) as independent variables. The most accurate equation was RPA = -5.78 + (56.79 × RADG) + (385.8 × RGF) + (0.08709 × WTGAIN) + (0.169 × DOT). The equation had an R^2 of 0.994 and residual standard deviation (RSD) of 1.4 g/day.

The Paylean response for the three trials was calculated as the performance of the constant or step-up Paylean treatments minus the sex-week or sex-bi-week means. The mid-period weight gain on test and mid-period days on test were calculated. The weekly or biweekly increases in protein accretion (RPA) were fit to regression equations. The prediction equations included independent variables from three sets of variables: 1) a variable to account for the Paylean level (ppm) for the specific period; 2) variables that account for changes in the level of Paylean fed each period compared to previous levels; and 3) variables to describe the duration of Paylean feeding (weight gain on test, days on test, grams of Paylean intake). These variables had been used previously to predict the observed weekly increases in average daily gain and feed efficiency produced by Paylean (Schinckel et al., 2001b).

Numerous variables were used to account for the changes in the weekly levels of Paylean fed. The initial variables were the current level of Paylean fed minus the level of Paylean fed one, two, three, or four weeks prior (Schinckel et al., 2001b). Based on numerous regression analyses, the current Paylean level minus the mean level fed two and three weeks prior (PLM23, ppm) was identified as the best independent variable. The PLM23 variable was only assigned to pens in which the Paylean level had been increased from the 4.5 g/ton level weeks three to week six. Also, alternative exponential powers 0.25, 0.50, 0.70, and 1.0 of PLM23 were evaluated. The final regression equation included the current Paylean level to the 0.228 power, body weight gain on test, body weight gain on test squared and PLM23 to the 0.50 power. The increase in protein accretion produced as a result of an increased Paylean level was predicted as: RPA = 8.26 $(PLM23)^{.50}$. The average daily protein accretion of the controls during the time in which Paylean levels increased was 122.7 g/d. Thus, the percentage increase in daily protein accretion predicted by the increased Paylean level equals 6.73 $(PLM23)^{.50}$. The PLM23 values and increases in daily PA predicted by the model are presented in Table 1.

The effect of increasing Paylean levels was incorporated into the ractopamine compositional model. The weekly performance, carcass composition, and economic returns were predicted for barrows and gilts fed either constant or step-up dietary levels of Paylean. Five 4-week treatments of Paylean feeding were evaluated: 1) control; 2) 4.5 g/ton (5 ppm) constant level; 3) 9 g/ton (10 ppm) constant level; 4) 4.5 g/ton (5 ppm) for two weeks, followed by 9 g/ton for two weeks; and 5) two weeks of 4.5 g/ton (5 ppm) followed by 6.75 g/ton (7.5 ppm) for two weeks.

The model predicted the growth of late finishing pigs starting at 150 lb live weight. Paylean supplementation began at 172 lb of live weight and continued for four weeks. Three diets were fed: one before Paylean supplementation and two with Paylean. Therefore, in step-up programs, a diet with 4.5 g/ton Paylean was fed for two weeks, followed by a diet with the higher dosage of Paylean for the second two weeks. If the Paylean level was constant, the switching day between the two diets was optimized with the total period for the two diets restricted to four weeks. For

control pigs, the second diet was restricted to begin at 172 lb and the total period for the last two diets restricted to 4 weeks, to be consistent and comparable with Paylean-fed pigs. Lysine levels were optimized to maximize daily returns above feed costs.

Economic Evaluation

The profitability of a Paylean step-up program was evaluated with the current Paylean price and historical average prices for pigs, feed and production costs. The price levels, which are averages of annual prices from 1991 to 2000, are given in Table 2. The data on live hog, corn and soybean meal (48% crude protein) prices were obtained from NASS, USDA. Feeder pig prices, transportation cost, and daily variable costs, which include utilities, veterinary and medical expenses, were obtained from the statistics of the Cooperative Extension Service of Iowa State University. Profitability was evaluated on the basis of contribution margin per pig space per day. Thus the model assumed that the hog production operation is a continuous process, and there are always replacement feeder pigs available.

Two payment schemes were used to estimate carcass value: a lean to fat value ratio of 4:1, which is close to true carcass cut-out value (Whipker and Akridge, 1990), and a lean to fat value ratio of 2:1, which approximates carcass merit pricing systems commonly used in pork processing plants today. For both payment schemes, the actual lean and fat prices were calculated so that the total payment for a control pig weighing 250 lb were the same as the value in Table 2. The actual lean prices employed in the two payment schemes were \$1.06/lb and \$0.925/lb, respectively.

Results

The weekly and overall 4-week predicted growth and feed efficiency data are shown in Table 3. The predicted daily protein accretion rates and average daily gains for gilts of each treatment are shown in Figures 1 and 2. The predicted improvements in average daily gain and feed efficiency were greater for the constant treatments for weeks one and two than weeks three and four. The predicted average daily gains and gain to feed ratios were greater during weeks three and four for the step-up programs than the 4.5 g/ton (5 ppm) constant treatment (Figure 2).

For a 4-week feeding program, the model predicted the step-up programs to have slighter higher fat-free lean growth and lower carcass fat gain than the 9 g/ton constant level (Table 4). Backfat depth, loin eye area and percent fat-free lean were similar for the two step-up Paylean programs and 9 g/ton constant Paylean program.

The predicted optimal lysine levels increased when Paylean was fed (Table 5 and 6). The optimal lysine levels in the pre-Paylean and first Paylean diets of step-up programs were the same as those of 4.5 g/ton constant dose. The optimal lysine levels of the second Paylean diet in both step-up programs were higher than either the 4.5 g/ton or the 9 g/ton (10 ppm) constant dose. The 4:1 ratio of lean to fat value resulted in slightly higher optimal dietary lysine levels than the 2:1 value ratio.

Paylean-fed pigs were predicted to be more profitable than controls, while Paylean step-up programs were predicted to be more profitable than constant level programs. With a 4:1 ratio of lean value to fat value, Paylean resulted in an increase in net returns from \$5.36 to \$7.25 per pig. The 4.5 to 9.0 g/ton step up had the greatest returns over the controls, followed by the 4.5 to 6.75 g/ton step-up, and 9.0 and 4.5 g/ton constant feeding programs (Table 5). With a 2:1 lean fat value ratio, the 4.5 to 9 g/ton (5 to 10 ppm) step-up program provided the highest average daily return, while the constant levels, 4.5 g/ton and 9 g/ton yielded about the same levels of return (Table 6).

Implications

The step-up programs increase the duration of Paylean response and required increased lysine levels. Initial economic evaluations indicate step-up programs provide a greater return than constant Paylean dosage programs. In this evaluation process, the diet durations are fixed rather than optimized, and hence may underestimate the profitability potential of Paylean step-up programs.

References

Herr, C. T., A. P. Schinckel, L. Watkins, B. Weldon, and B. T. Richert. 2001. Optimal Paylean sequence (step-up/step-down) when fed to late-finishing swine. Purdue Swine Research Reports 2001. pp 35-48.

Schinckel A. P., B. T. Richert, and M. E. Einstein. 2001a. Evaluation of an updated model to describe the compositional growth of pigs fed Paylean. Purdue Swine Research Reports 2001. pp 26-34.

Schinckel A. P., Y. Wang, B. T. Richert, M. E. Einstein, and C. Herr. 2001b. Development of models to describe the weekly response to ractopamine when constant or variable dietary levels of Paylean are fed. Purdue Swine Research Reports 2001. pp 1-8.

Whipker, L. D. and J. T. Akridge. Pricing Lean: A Lotus template for determining the price of lean pork. Ver. 2.0. February 25, 1990.

Table 1. Predicted increase in protein accretion (PA, g/d) as a result of increasing dietary Paylean levels[a]

Week	Paylean level, ppm	PLM23, ppm	Increase in PA
Four-week step-up (5 to 10 ppm)			
1	5		
2	5		
3	10	7.5	22.6
4	10	5.0	18.4
Six-week step-up program (3-weeks 5 ppm and 3 weeks 10 ppm)			
1	5		
2	5		
3	5		
4	10	5	18.4
5	10	5	18.4
6	10	2.5	13.1
Six-week step-up program (5, 7.5, and 10 ppm)			
1	5		
2	5		
3	7.5	5	18.4
4	7.5	2.5	13.1
5	10	3.75	16.0
6	10	2.5	13.1

[a]The increase in protein accretion (PA, g/d) produced by the increase in dietary Paylean concentration above that expected based on the current Paylean level and duration of Paylean feeding.

Table 2. Ten-year average price levels used in model simulation

Commodity Unit	Corn, $/bushel	Soybean meal, $/ton	Feeder pig, $/head	Live hog, $/cwt	Paylean, $/gram	Transportation, $/pig	Vet., med., & misc, $/day/pig
Average	2.32	177.45	42	43	2.25	2	0.09

Table 3. Predicted growth and feed efficiency under constant and step-up Paylean levels for SEW pigs

Paylean level, ppm	Control pigs		5 ppm for 4 weeks		10 ppm for 4 weeks		5 ppm to 10 ppm		5 ppm to 7.5 ppm	
Sex	**Barrow**	**Gilt**	**Barrow**	**Gilt**	**Barrow**	**Gilt**	**Barrow**	**Gilt**	**Barrow**	**Gilt**
Week 1										
Start wt., lb	171.7	171.3	172.0	171.7	172.0	171.7	172.0	171.7	172.0	171.7
PA, g/d	140	140	182	182	189	190	182	182	182	182
ADG, lb/d	2.38	2.29	2.703	2.67	2.77	2.71	2.73	2.67	2.73	2.67
ADFI, lb/d	6.47	6.15	6.41	6.10	6.36	6.05	6.41	6.10	6.41	6.10
Gain:Feed	0.367	0.372	0.427	0.438	0.436	0.448	0.427	0.438	0.427	0.438
Week 2										
Start wt., lb	188.4	187.3	191.1	190.2	191.4	190.5	191.1	190.2	191.1	190.2
PA, g/d	137	137	174	174	180	181	174	174	174	174
ADG, lb/d	2.39	2.30	2.70	2.62	2.73	2.66	2.70	2.62	2.70	2.62
ADFI, lb/d	6.79	6.45	6.77	6.43	6.72	6.38	6.77	6.43	6.77	6.43
Gain:Feed	0.352	0.356	0.398	0.408	0.406	0.416	0.398	0.408	0.398	0.408
Week 3										
Start wt., lb	205.1	203.4	210.0	208.6	210.3	208.6	210.0	208.6	210.0	208.6
PA, g/d	133	133	157	159	161	163	186	187	179	181
ADG, lb/d	2.39	2.29	2.60	2.52	2.61	2.53	2.76	2.70	2.73	2.67
ADFI, lb/d	7.03	6.66	7.00	6.65	6.93	6.59	6.85	6.51	6.91	6.56
Gain:Feed	0.340	0.343	0.371	0.378	0.375	0.384	0.404	0.415	0.396	0.406
Week 4										
Start wt., lb	221.9	219.4	228.0	226.1	228.6	226.7	229.3	227.5	229.1	227.2
PA, g/d	128	129	140	142	142	144	161	163	155	157
ADG, lb/d	2.38	2.27	2.45	2.36	2.45	2.36	2.55	2.48	2.53	2.46
ADFI, lb/d	7.29	6.90	7.19	6.82	7.08	6.73	7.03	6.68	7.11	6.74
Gain:Feed	0.327	0.329	0.341	0.347	0.343	0.350	0.362	0.371	0.358	0.364
Overall										
Market wt., lb	236.1	233.0	242.7	240.2	243.1	240.8	244.5	242.3	244.2	241.9
PA, g/d	134	134	163	164	168	169	176	177	172	174
ADG, lb/d	2.385	2.286	2.621	2.544	2.635	2.563	2.686	2.618	2.674	2.604
ADFI, lb/d	6.90	6.54	6.84	6.50	6.77	6.44	6.77	6.43	6.80	6.46
Gain:Feed	0.346	0.349	0.381	0.389	0.387	0.396	0.397	0.407	0.393	0.403

Lysine levels fed for 4:1 ratio of carcass lean to fat value.

Table 4. Predicted carcass measurements after 4 weeks of Paylean fed at constant and step-up levels to SEW pigs

Paylean level, ppm	Control pigs		5 ppm for 4 weeks		10 ppm for 4 weeks		5 ppm step-up to 10 ppm		5 ppm step-up to 7.5 ppm	
Sex	**Barrow**	**Gilt**	**Barrow**	**Gilt**	**Barrow**	**Gilt**	**Barrow**	**Gilt**	**Barrow**	**Gilt**
Fat-free lean gain, lb/day	0.682	0.717	0.922	0.974	0.967	1.022	1.002	1.059	0.979	1.034
Total carcass fat gain, lb/day	0.682	0.558	0.644	0.502	0.638	0.491	0.602	0.457	0.615	0.471
Tenth rib fat depth, in	0.96	0.86	0.91	0.81	0.90	0.79	0.87	0.77	0.88	0.78
Loin eye area at 10^{th} rib, in^2	5.35	5.88	5.91	6.49	6.02	6.61	6.06	6.67	6.02	6.62
Fat-free lean, %	46.30	49.02	48.22	50.98	48.66	51.40	48.92	51.65	48.71	51.46
Dressing percent	74.26	74.91	75.10	75.73	75.38	76.03	75.31	75.94	75.23	75.86

Diets fed for a 4:1 ratio of carcass lean value to carcass fat value.

Table 5. Economic returns and nutrition levels with constant and step-up Paylean levels using a lean:fat value ratio of 4:1

Paylean level, ppm	Control pigs		5 ppm for 4 weeks		10 ppm for 4 weeks		2 wks 5 ppm & 2 wks 10 ppm		2 wks 5 ppm & 2 wks 7.5 ppm	
Sex	**Gilt**	**Barrow**	**Gilt**	**Barrow**	**Gilt**	**Barrow**	**Gilt**	**Barrow**	**Gilt**	**Barrow**
Optimal lysine level, %										
Diet (pre-Paylean)	0.80	0.75	0.80	0.75	0.80	0.75	0.80	0.75	0.80	0.75
Diet 1	0.71	0.68	0.96	0.91	1.01	0.96	0.96	0.91	0.96	0.91
Diet 2	0.63	0.60	0.78	0.73	0.81	0.76	0.94	0.89	0.90	0.85
Market age	143	140	143	140	143	140	143	140	143	140
Market wt., lb	233.0	236.1	240.2	242.7	240.8	243.1	242.3	244.5	241.9	244.2
Hot carcass wt., lb	174.5	175.4	181.9	182.2	183.1	183.3	184.0	184.2	183.5	183.7
Revenue, $/pig	104.72	101.54	111.93	108.37	113.26	109.67	114.04	110.40	113.48	109.86
Cost, $/pig	78.16	77.48	79.64	78.97	80.56	79.93	80.23	79.59	80.00	79.34
Return, $/pig	26.56	24.06	32.28	29.40	32.70	29.74	33.81	30.81	33.48	30.52
Daily return, $/pig space/day	0.286	0.267	0.347	0.327	0.352	0.330	0.364	0.342	0.360	0.339

Based on a 4:1 ratio of the value of carcass lean to carcass fat, which approximates true carcass cut-out value.

Table 6: Return and nutrition levels under lean and fat value ratio 2:1

Paylean level, ppm	Control pigs		5 ppm for 4 weeks		10 ppm for 4 weeks		2 wks 5 & 2 wks 10 ppm		2 wks 5 & 2 wks 7.5 ppm	
Sex	**Gilt**	**Barrow**	**Gilt**	**Barrow**	**Gilt**	**Barrow**	**Gilt**	**Barrow**	**Gilt**	**Barrow**
Optimal lysine level, %										
Diet (pre-Paylean)	0.79	0.74	0.79	0.74	0.79	0.74	0.79	0.74	0.79	0.74
Diet 1	0.71	0.67	0.95	0.90	1.00	0.95	0.95	0.90	0.95	0.90
Diet 2	0.63	0.59	0.76	0.72	0.80	0.75	0.92	0.87	0.88	0.83
Market age	143	140	143	140	143	140	143	140	143	140
Market wt., lb	233.0	236.1	240.2	242.7	240.7	243.1	242.2	244.5	241.8	244.2
Hot carcass wt., lb	174.5	175.3	181.9	182.2	183.0	183.2	183.9	184.1	183.5	183.7
Revenue, $/pig	103.26	101.75	109.14	107.44	110.24	108.54	110.70	108.93	110.30	108.54
Cost, $/pig	78.14	77.44	79.58	78.93	80.52	79.89	80.17	79.52	79.94	79.28
Return, $/pig	25.12	24.31	29.56	28.51	29.72	28.65	30.53	29.41	30.36	29.26
Daily return, $/pig space/day	0.270	0.270	0.318	0.317	0.320	0.318	0.328	0.327	0.326	0.325

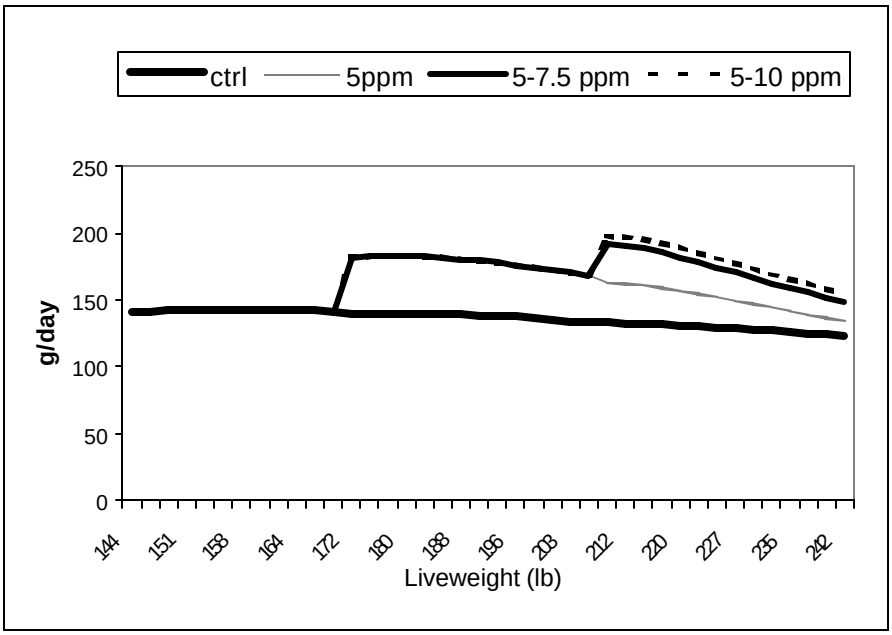

Figure 1: Protein accretion under constant and step-up Paylean concentration for SEW gilts.

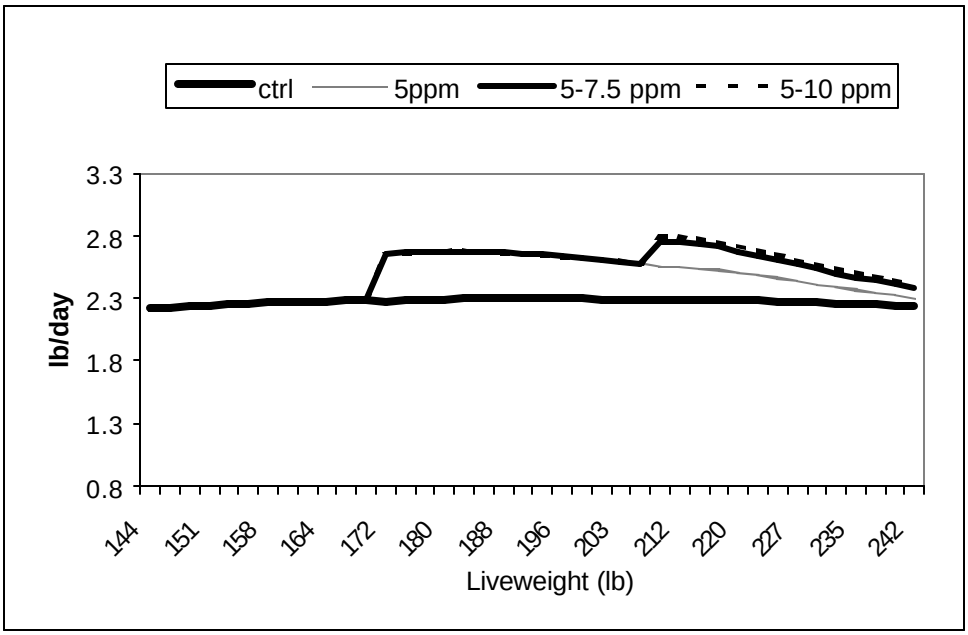

Figure 2: ADG Under constant and step-up Paylean concentration for SEW gilts.