CAN PERFORMANCE BE ENHANCED IN STRESSED PIGS WITH MORE NUTRIENT-DENSE DIETS?

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Determining periodic feed intake consumption in growing-finishing pigs is an often-cited management recommendation. From this information, feed intake curves for specific genetic lines of pigs can be generated for various on-farm facilities. Abrupt changes in voluntary feed intake can alert producers to potential changes in herd health and/or negative weather effects.

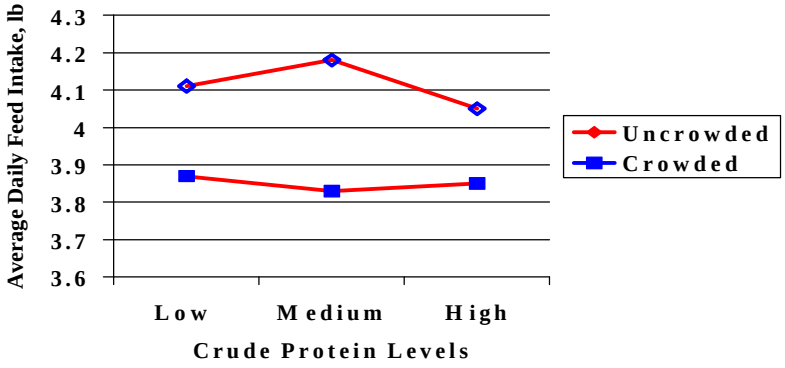
If feed intake levels are lower than expected, due to disease outbreaks, crowding and /or heat stress, there are those who recommend increasing the amino acid concentration in the diet by using synthetic amino acids or intact protein sources. The justification for doing this is to maintain minimum levels of amino acid intakes per day. This in turn is thought to improve performance without hurting profitability. But will it? In our opinion, this concept has been insufficiently documented with appropriate research trials.

To evaluate this concept, we designed trials in which pigs were provided with adequate square footage (uncrowded) or with less square footage (crowded). Feed intake is reduced by crowding pigs. Therefore, we were able to evaluate how pigs with acceptable and lower feed intakes due to crowding stress would respond to increasing the protein (amino acid) level in the diet.

In trial 1, uncrowded grower pigs (40 to 120 lb) received 4 to 5 square feet per pig compared to crowded grower pigs which had 2.5 to 3 square feet. Space was increased as the pigs grew. Pens of crowded or uncrowded pigs were fed, as shown in Figures 1-4, either 15.7% (low), 18.2% (medium) or 20.7% (high) crude protein (CP).

The diets were formulated by using corn and multiple protein sources along with vitamins, minerals, amino acids and medication. Pigs (PIC genetics) were housed in a mechanically ventilated grower-finisher building with fully slatted floors. When slaughtered at 280 pounds, these pigs (mixed-sex) had a fat-free lean index of approximately 49.5% with a last rib backfat of about 0.95 inches.

Figure 1
Feed Intakes of Uncrowded and Crowded Grower Pigs Fed Three Levels of Crude Protein
(Trial 1, 40-120 lb Bodyweight)



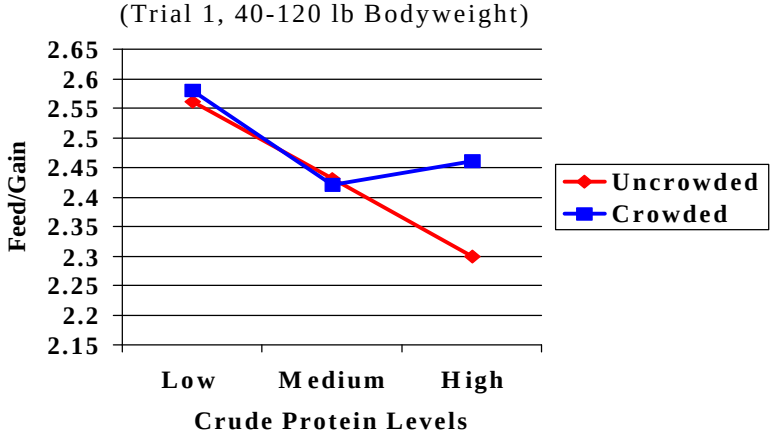
Space effect (P < .05)

Average daily feed intakes, for both uncrowded and crowded grower pigs fed the different protein diets, are shown in figure 1. Pigs that were crowded consumed roughly 6% less feed than those not crowded.

Pigs that were crowded grew considerably slower than the uncrowded pigs (Figure 2). Growth rate was improved similarly for the uncrowded and crowded pigs when fed the medium compared to the low levels of protein. However, note that the uncrowded pigs had even greater growth rates from the high level of protein, whereas the crowded pigs did not respond. Therefore, increasing the amino acid concentration of the diet (to retain minimum amino acid intakes per day) of pigs with lower feed intakes did not improve the growth rate to the standard observed with the uncrowded pigs.

As with the growth performance, both the uncrowded and crowded pigs had improved feed efficiencies from being fed the medium as opposed to the low protein level (Figure 3). It is also clear than only the uncrowded pigs continued to

Figure 3
Feed Efficiencies of Uncrowded and Crowded Grower Pigs Fed Three Levels of Crude Protein
(Trial 1, 40-120 lb Bodyweight)



Low vs. Medium & High CP effect (P < .05)
Low vs. Medium & High CP x space interaction (P < .05)

Low vs. Medium & High CP effect (P < .05)

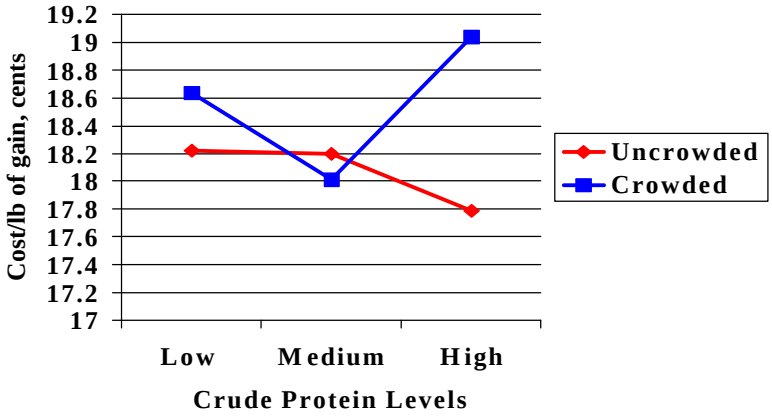
respond with improved feed efficiency to the highest level of protein.

The crowded pigs, which had lower feed intakes (Figure 1) than uncrowded pigs, clearly did not have better gain and feed efficiency from being fed the diet with the highest level of protein.

Economic data are shown in figure 4. Feed cost per pound of gain was similar for the uncrowded and crowded pigs fed the low or medium levels of protein. At the highest protein level fed, the uncrowded pigs had a lower cost per pound of gain than the crowded.

Figure 4
Cost of Gain of Uncrowded and Crowded Grower Pigs Fed Three Levels of Crude Protein

(Trial 1, 40-120 lb Bodyweight)

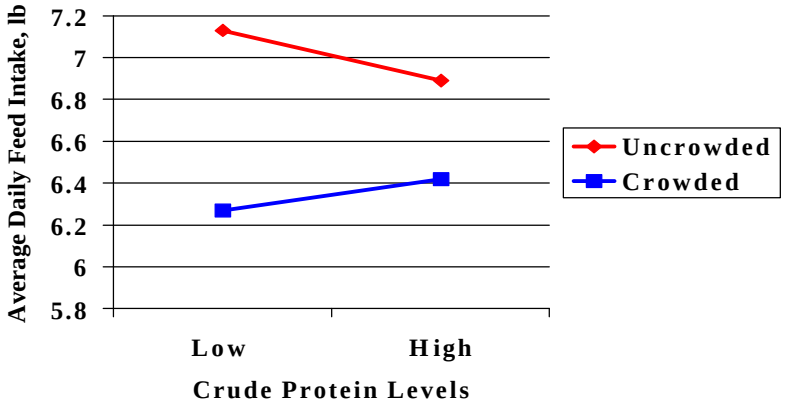


Low vs. Medium & High CP effect ($P < .10$)
Space effect ($P < .05$)

In trial 2, uncrowded finisher pigs received 6.5 (120-200 lb) and 8.0 (200-280 lb) square feet per pig, whereas crowded finisher pigs had 4.0 and 5.4 square feet per pig for the 120-200 and 200-280 lb weight ranges, respectively. The crowded and uncrowded pens of pigs were fed either 14.1% CP (0.67% lysine) or 17.1% CP (0.89% lysine) during the 120-200 lb range followed by either 12.1% CP (0.53% lysine) or 15.1% CP (0.75% lysine) from 200-280 lb. The 14.1 and 12.1% CP sequences were designed to be deficient in amino acids according to Kent Feeds standards. This was done so that the expected responses to additional amino acids (i.e., 17.1 and 15.1% CP) could be compared in uncrowded and crowded pigs.

In figure 5 are the feed intake data for both the uncrowded and crowded pigs fed the low (deficient) or high CP diets. Feed intake was reduced by about 9% when pigs were crowded as opposed to not crowded.

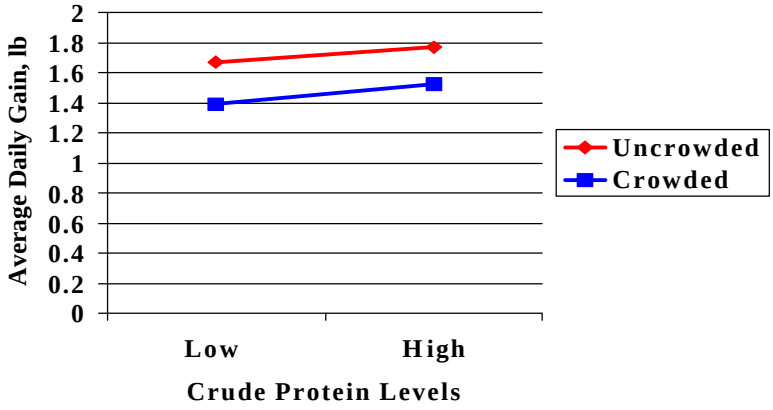
Figure 5
Feed Intakes of Uncrowded and Crowded Finisher Pigs Fed Two Levels of Crude Protein
(Trial 2, 120-280 lb Bodyweight)



Space effect (P < .05)

Growth rate was reduced when pigs were crowded compared to not crowded (Figure 6). There was also a response to feeding the higher levels of amino acids (i.e., 17.1 and 15.1% CP vs. 14.1 and 12.1% CP) in both crowded and uncrowded pigs. Note that both groups of pigs responded in a similar manner to the higher levels of CP.

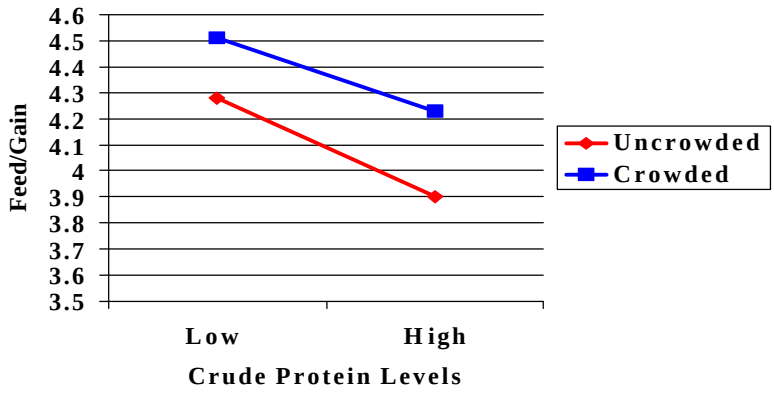
Figure 6
Growth Rates of Uncrowded and Crowded Finisher Pigs Fed Two Levels of Crude Protein
(Trial 2, 120-280 lb Bodyweight)



Crude Protein effect (P < .05)
Space effect (P < .05)

Feed efficiencies were also worse when pigs were crowded compared to uncrowded (Figure 7). As with the growth data, feed efficiences were markedly improved from feeding the higher levels of CP to both the uncrowded and crowded pigs.

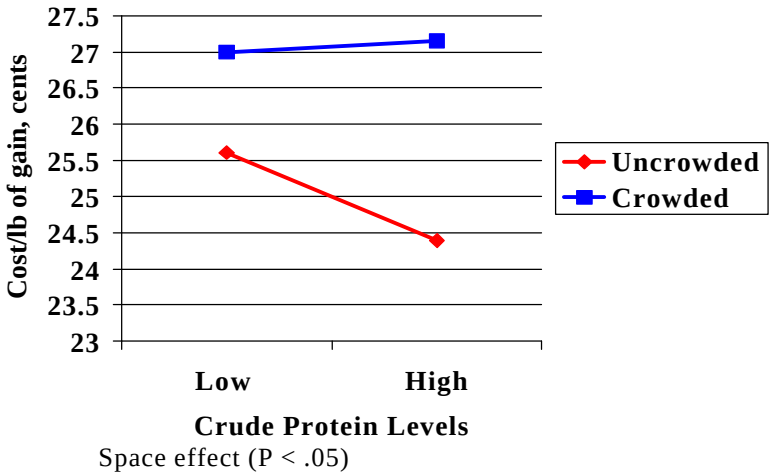
Figure 7
Feed Efficiencies of Uncrowded and Crowded Finisher Pigs Fed Two Levels of Crude Protein
(Trial 2, 120-280 lb Bodyweight)



Crude Protein effect (P < .05)
Space effect (P < .05)

The cost per lb of gain data are shown in Figure 8. Pigs that were crowded had higher cost per lb of gains than those uncrowded. Cost of gain was lowered in uncrowded pigs fed higher levels of CP, but note that cost of gain was essentially unchanged in crowded pigs fed either the low or high CP levels.

Figure 8
Cost of Gain of Uncrowded and Crowded Finisher Pigs Fed Two Levels of Crude Protein
(Trial 2, 120-280 lb Bodyweight)



Space effect (P < .05)

Based on this research, we believe that crowded pigs have a lower amino acid requirement when expressed as grams per day than the same genetic line that is uncrowded and has a higher feed intake and growth rate. Therefore, the amino acid requirements, when expressed as a percentage of the diet, would be similar for uncrowded and crowded pigs.

Feeding stressed pigs a diet with optimum levels of amino acids, rather than an overfortified diet, results in both an improved cost of production and less nitrogen excretion in manure which is beneficial to the environment.

SUPPLEMENTAL VITAMINS & TRACE MINERALS IMPROVE FINISHING PERFORMANCE & NET RETURN

Reports in the popular press in 1996 indicated that omitting vitamins and trace minerals during late finishing (last 30 days) reduced diet costs, without affecting pig performance and carcass quality. To address this issue of supplemental trace nutrients, two studies were conducted at the Kent Research Farm to determine the effect of deleting these nutrients on performance and economic returns.

Two hundred fifty-two (252) terminal crossbred finishing pigs were allotted to three treatments for a 12-week period in trial 1. The treatments were: 1) 14% crude protein diet (0.77% lysine), 2) As 1 minus trace minerals and vitamins the last 6 weeks of the trial, and 3) As 1 minus trace minerals and vitamins the entire 12 weeks of the trial. The diets contained 30 grams of Bacitracin Methylene Disalicylate (BMD) per ton. Each treatment contained six replications of 14 pigs per pen (8.6 square feet per pig). The average initial weight was 120 lb.

In trial 2, 306 pigs were allotted to the same three treatments as outlined in trial 1. In trial 2, however, no growth promotant was included in the diets, and there were 17 pigs per pen (7.1 square feet per pig). The purpose for removing the BMD was to minimize the chance of vitamin contamination from the fermentation process of synthesizing this growth promotant. The square footage was reduced to create more stress on the pigs, and simulate on-the-farm conditions. There were six replications per treatment and the average initial weight was 127 lb.

Pigs in both trials were allotted to treatments on the basis of weight, sex, and ancestry. They were housed in a partially slatted finishing unit. For the economic calculations, corn was priced at $2.50 per bushel.

The results for trial 1 are shown in Table 1. Removing supplemental vitamins and trace minerals for 12 weeks resulted in numerically lower daily gains (1.61 vs. 1.66) which translated into a pig that weighed 4.2 lb less at market. Feed intake was also numerically lower (5.83 vs. 5.92) for pigs fed the diets without supplemental trace nutrients for 12 weeks as opposed to those with the nutrients. Feed efficiency was numerically worse for both treatments without supplemental nutrients compared to the control diet. Cost per lb of gain and fat-free lean index were essentially the same for all three treatments. Net return (value of gain minus cost of gain), however, was reduced by $0.54 per pig when supplemental nutrients were withdrawn for six and 12 weeks.

Table 1
Supplemental Vitamin and Trace Mineral Levels for Finishing Pigs
(Trial 1)

	Length of Withdrawal (weeks) for Vitamins & Trace Minerals		
0-12 weeks	0	6	12
Final weight, lb	259.4	257.8	255.2
Avg daily gain, lb	1.66	1.64	1.61
Avg daily feed, lb	5.92	5.92	5.83
Feed/gain[a]	3.56	3.62	3.61
Cost/lb gain, ¢	25.85	26.04	25.74
Net return, $/pig*	19.79	19.25	19.25
Fat-free lean index, %	49.26	49.20	49.42

KFI; 84 pigs/trt; 6 reps; avg initial weight = 120 lb
[a] Supplementation vs. no supplementation ($P < .13$)
*$40/cwt live price

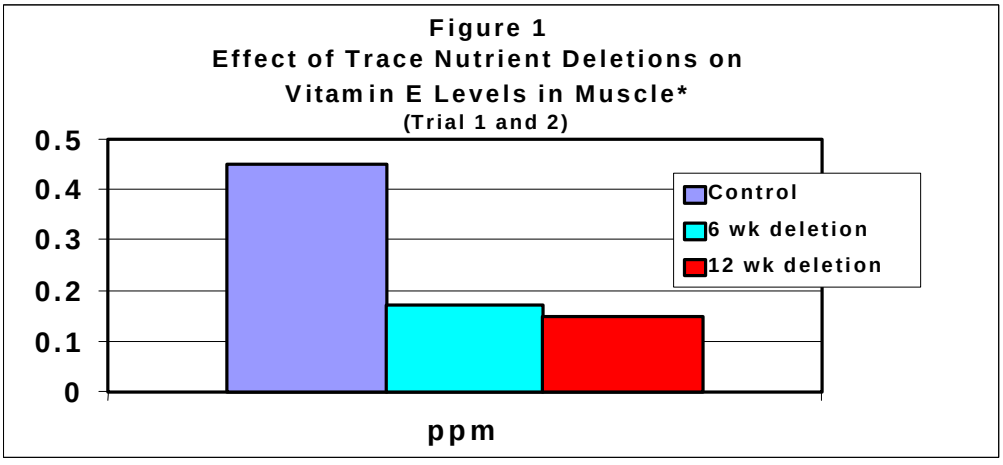
The final market weights in trial 2, for pigs on the six and 12 week withdrawal of supplemental vitamins and trace minerals, were 2.6 and 8.4 lb less than those fed the standard program (Table 2). These lighter market weights were due to reduced gains of 2.1 and 6.9%, respectively for the six- and 12-week withdrawals of supplemental trace nutrients. Feed intake was also reduced by 4.9% when supplemental vitamins and trace minerals were removed for 12 weeks. Feed/gain was numerically higher when supplemental trace nutrients were removed with cost per lb of gain being slightly less for those pigs fed the deficient diets. Net return was essentially the same for the control diet and those pigs fed diets without supplemental trace nutrients for six weeks. With a 12-week withdrawal, however, net return was reduced by $1.10. Percent lean was similar for all three treatments.

Table 2
Supplemental Vitamin and Trace Mineral Levels for Finishing Pigs
(Trial 2)

	Length of Withdrawal (weeks) for Vitamins & Trace Minerals		
0-12 weeks	0	6	12
Final weight, lb	248.0	245.4	239.6
Avg daily gain, lb[a]	1.44	1.41	1.34
Avg daily feed, lb[b]	5.11	5.05	4.86
Feed/gain	3.56	3.58	3.64
Cost/lb gain, ¢	25.24	24.99	25.07
Net return, $/pig*	17.89	17.92	16.79
Percent lean	53.34	53.50	53.29

KFI; 102 pigs/trt; 6 reps; avg initial weight = 127 lb
[a] Supplementation vs. no supplementation for 12 weeks (P = .06)
[b] Supplementation vs. no supplementation for 12 weeks (P < .10)
* $40/cwt live price

Besides the performance and lean data shown in Tables 1 and 2, we also evaluated muscle samples for vitamin E content. In addition to being an antioxidant, vitamin E may also enhance the immune response. Thus, it is a key nutrient that should be adequately supplied in the diet. In Figure 1 are combined muscle vitamin E concentration data from samples of loin (trial 1) and ham (trial 2). Deleting trace nutrients for 6 and 12 weeks prior to market weight resulted in a 64 and 69% decrease in vitamin E content compared to those pigs fed the properly balanced diets.



*Control vs 6- and 12-week deletion of trace nutrients (P < .001)

Table 3 shows the summary of results of both trials combined. In general, final market weights were roughly two to six lb lighter when supplemental vitamins and trace minerals were removed from the diets of finishing pigs. Feed intakes were also reduced by up to 3.1% with feed efficiencies roughly 1 to 2% worse from withdrawing supplemental trace nutrients. Cost per lb of gain was slightly reduced (-$.03 to -$.14) when these nutrients were not included in the diets. In contrast, net return decreased by -$.25 to -$.82 from removing these vitamins and trace minerals.

Table 3
Performance & Economic Differences from
Supplemental Vitamin & Trace Mineral Levels for Finishing Pigs
(Trials 1 & 2)

	Length of Withdrawal (weeks) for Vitamins & Trace Minerals vs. No Withdrawal	
0-12 weeks	6	12
Final weight, lb	-2.1	-6.3
Avg daily gain	-1.6%	-4.8%
Avg daily feed	-0.5%	-3.1%
Feed/gain	+1.1%	+1.8%
Cost/lb gain, ¢	-0.03	-0.14
Net return, $/pig*	-0.25	-0.82

KFI; 186 pigs/trt; 12 reps
* $40/cwt live price

SUMMARY

Based on these trials, a six-week withdrawal of vitamins and trace minerals results in a loss of $.25 per pig. For a 1000-sow operation that markets 24,000 pigs per year, this would result in a loss of $6000. Keep in mind that we evaluated the effect of trace nutrient withdrawals by conducting two very thorough trials that simulated typical on-the-farm conditions. Because vitamins and trace minerals are important for the pig's health and given the stress and high intensity of commercial swine production, removing vitamins and trace minerals from the diet should not be recommended! Moreover, nutritional pork quality – as demanded by today's health-conscious consumer – is compromised by lowering the amount of trace nutrients in meat. We recommend that pork producers "follow the program" and market high-quality pork.

EFFECT OF PROTEIN AND PAYLEAN® LEVELS ON FINISHER PIG PERFORMANCE, CARCASS TRAITS, AND ECONOMICS

Paylean® is a feed ingredient that directs nutrients to increase the amount of quality meat in high value cuts and improves production efficiency. Through extensive research in the last 10 to 15 years, Paylean® has been cleared by the FDA as safe and effective in finishing pigs. Paylean® improves weight gain, feed efficiency, and carcass leanness in finishing pigs and must be fed with at least 16% crude protein (CP) to hogs in the 150 to 240 lb weight range.

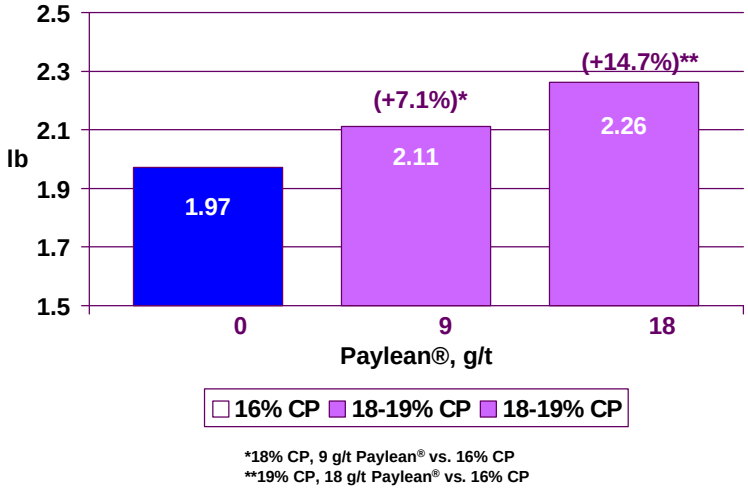
At Kent Feeds, we conducted research with 336 finishing pigs to determine what effect Paylean® and various CP levels would have on performance, carcass traits, and economics. There were 6 treatments (Table 1) in which we compared 0, 9 and 18 grams/ton of Paylean® with either 16 or 18-19% CP diets. We had seven replications per treatment (mixed-sex). The average initial weight was 168 lb with a final weight of 240 lb. In all the data from Figures 1-4 and 7-13, Paylean® resulted in a significant ($P < .05$) improvement in performance and carcass traits. In addition, Paylean® had no significant effect on pork quality as seen in Tables 2 and 3.

Table 1
Paylean® in Finishing Pigs
(6 Treatments)

Crude Protein, %	16	16	16	19	18	19
Lysine, %	.81	.81	.81	1.03	.96	1.03
Paylean®, grams/ton	0	9	18	0	9	18

In figure 1 are the growth data. Addition of 9 and 18 grams/ton of Paylean® resulted in marked improvements in gain when compared to those treatments without Paylean®. Note that growth rate was improved considerably when 18 grams/ton of Paylean® was fed with 19% CP diets compared to 16% CP diets. Figure 2 illustrates the effect of Paylean® and CP levels vs 16% CP diets without Paylean®. Gains were improved (compared to the 16% CP diet without Paylean®) by roughly 7 to 15% from feeding 9 grams/ton of Paylean® with 18% CP and 18 grams/ton of Paylean® with 19% CP, respectively.

Figure 2
Effect of Protein and Paylean® Levels on Average Daily Gain
(168 - 240 lb Bodyweight)



*18% CP, 9 g/t Paylean® vs. 16% CP
**19% CP, 18 g/t Paylean® vs. 16% CP

In figure 3 are the feed efficiency results. As expected, the treatments with Paylean® and increased CP levels resulted in improved feed efficiencies compared to the diets without Paylean®. As observed with the gain data, feeding 19% CP diets with 18 grams/ton of Paylean® resulted in a much improved feed efficiency value (2.67) compared to the 2.96 value with 16% CP and 18 grams/ton of Paylean®. Comparing the higher CP diets with 9 and 18 grams/ton of Paylean® resulted in 10 to 17% improvements in feed efficiencies vs. the 16% CP diet without Paylean® (Figure 4).

Figure 3
Effect of Protein and Paylean® Levels on Feed Efficiency
(168 - 240 lb Bodyweight)

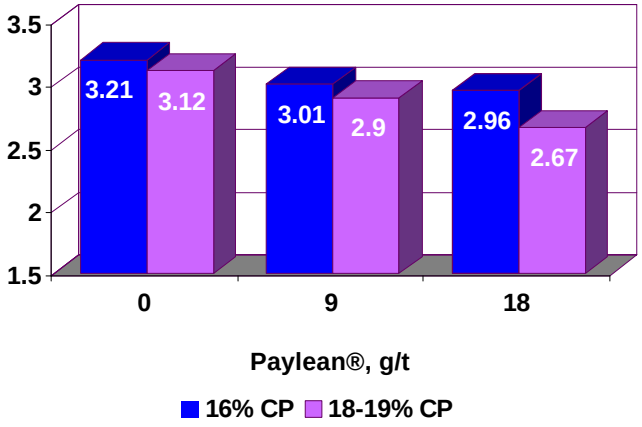
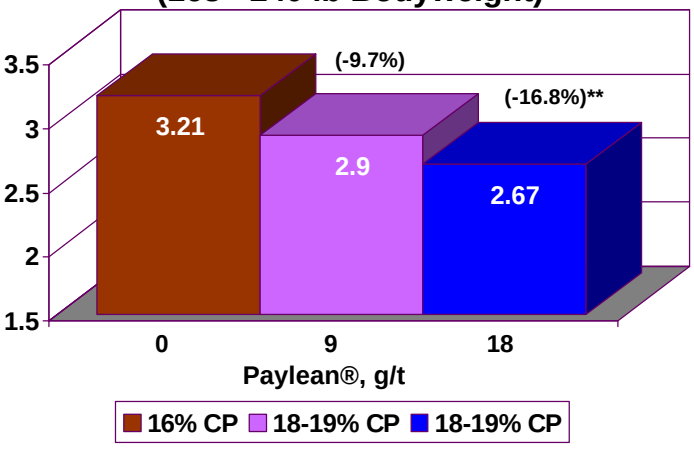


Figure 4
Effect of Protein and Paylean® Levels on Feed Efficiency
(168 - 240 lb Bodyweight)



*18% CP, 9 g/t Paylean® vs. 16% CP
**19% CP, 18 g/t Paylean® vs. 16% CP

Cost per pound of gain values are shown in figure 5. Cost of gain was significantly higher when Paylean® was included in the diets. It is important to note, however, that cost of gain was actually lower when higher CP diets were fed with Paylean® than when lower CP diets were used with Paylean®. This is especially evident for the pigs fed diets with 18 grams/ton of Paylean® in which cost of gain was actually lowered by 1.5¢ (21.3 vs. 22.8) from feeding 19% vs. 16% CP levels. Cost of gains were 2.5 to 4.5¢ higher with Paylean® (9 or 18 grams/ton) supplemented diets with higher CP (18-19%) levels than with 16% CP diets without Paylean® (Figure 6). Based on our calculations with these data, Paylean® would not pay for itself on the basis of increased growth rate and improved feed efficiency without a producer receiving additional money from added carcass merits.

Figure 5
Effect of Protein and Paylean® Levels on Cost per lb of gain
(168 - 240 lb Bodyweight)

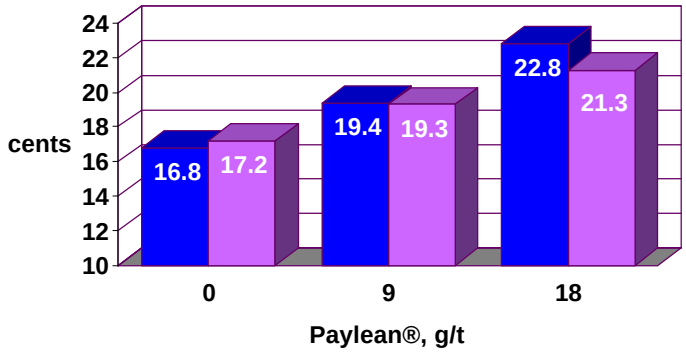
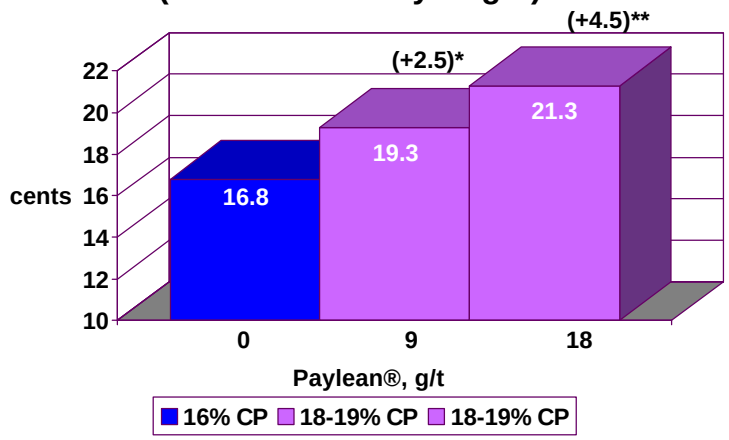


Figure 6
Effect of Protein and Paylean® Levels on Cost per lb of gain
(168 - 240 lb Bodyweight)



*18% CP, 9 g/t Paylean® vs. 16% CP
**19% CP, 18 g/t Paylean® vs. 16% CP

In figures 7 and 8 are the data on last rib backfat. Supplemental Paylean® resulted in pigs having less backfat compared to no supplementation. Backfats were reduced by 0.02 and 0.06 inches when 9 and 18 grams/ton of Paylean® were fed in combination with the 18-19% CP diets as opposed to feeding pigs the 16% CP diet without Paylean®.

Figure 7
Effect of Protein and Paylean® Levels on Fat Depth (last rib)
(168 - 240 lb Bodyweight)

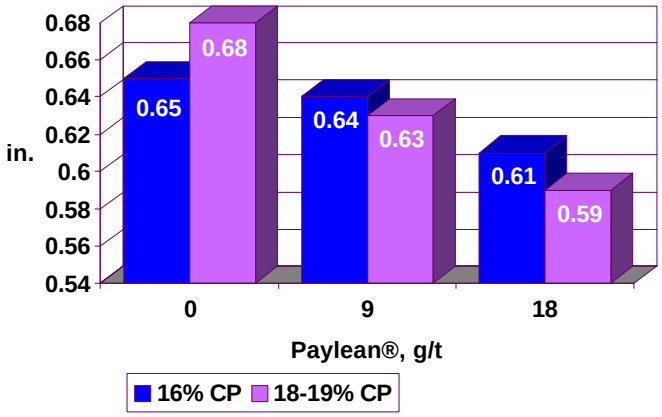
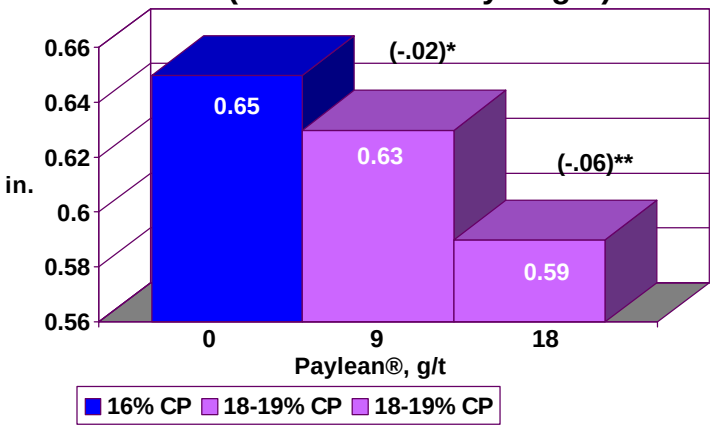


Figure 8
Effect of Protein and Paylean® Levels on Fat Depth (last rib)
(168 - 240 lb Bodyweight)



*18% CP, 9 g/t Paylean® vs. 16% CP
**19% CP, 18 g/t Paylean® vs. 16% CP

Dressing percent data are shown in figures 9 and 10. The addition of Paylean® to these diets resulted in solid improvements in dressing percent. In fact, dressing percent was improved by 0.7 to 1.0 percentage units when Paylean® was fed with the higher CP diets compared to the 16% CP diet without Paylean®.

Figure 9
Effect of Protein and Paylean® Levels on Dressing Percent
(168 - 240 lb Bodyweight)

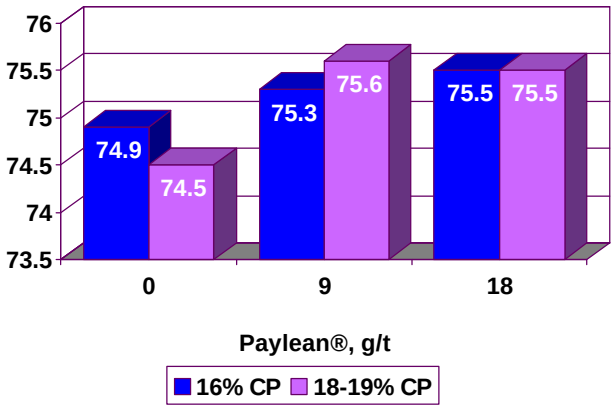
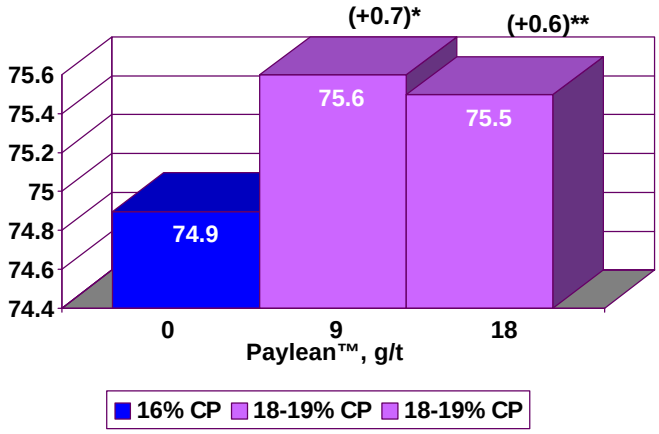


Figure 10
Effect of Protein and Paylean® Levels on Dressing Percent
(168 - 240 lb Bodyweight)



*18% CP, 9 g/t Paylean® vs. 16% CP
**19% CP, 18 g/t Paylean® vs. 16% CP

The percent lean data are shown in figures 11 and 12. Feeding pigs the diets with Paylean® resulted in marked improvements in percent lean. Percent lean was improved by 0.7 to 1.0 percentage units with added Paylean® and increased CP levels vs. 16% CP without Paylean®. This in turn led to higher carcass premiums (Figures 13 and 14) from added Paylean® supplementation in higher CP diets as opposed to 16% CP diets without Paylean®.

Figure 11
Effect of Protein and Paylean® Levels on Percent Lean
(168 - 240 lb Bodyweight)

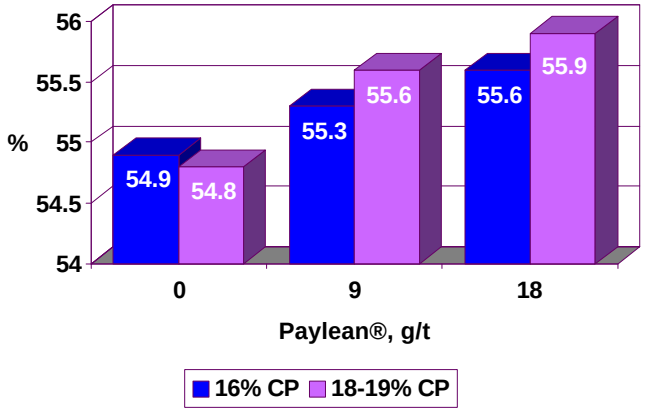
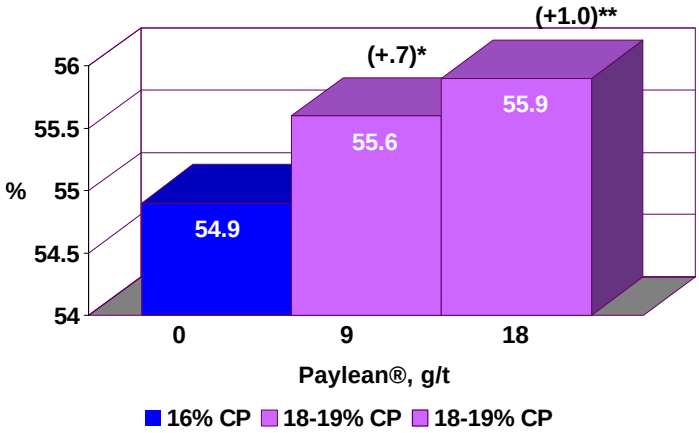


Figure 12
Effect of Protein and Paylean® Levels on Percent Lean
(168 - 240 lb Bodyweight)



*18% CP, 9 g/t Paylean® vs. 16% CP
**19% CP, 18 g/t Paylean® vs. 16% CP

Figure 13
Effect of Protein and Paylean® Levels on Grade Premiums
(168 - 240 lb Bodyweight)

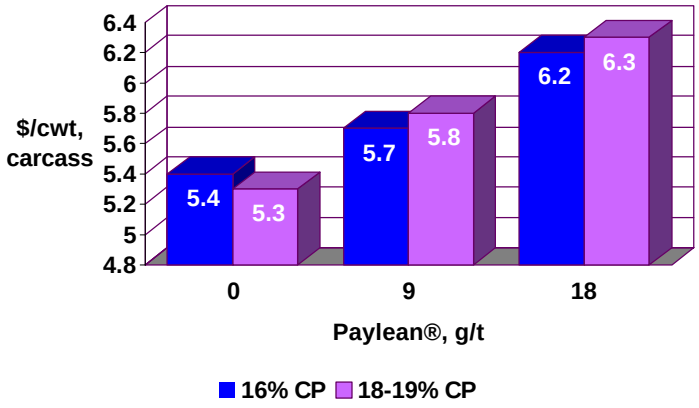
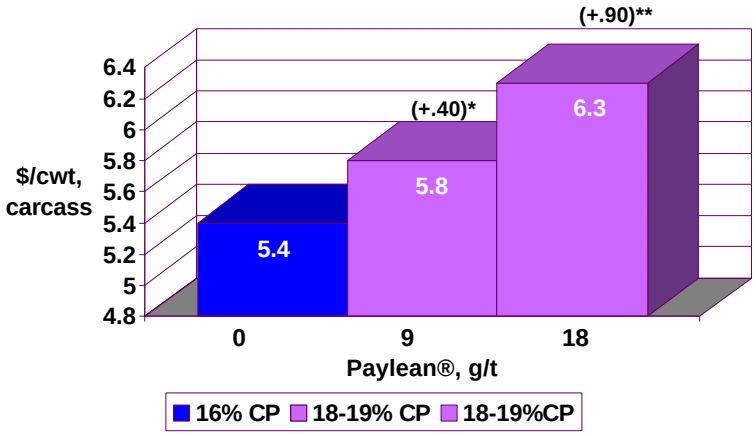


Figure 14
Effect of Protein and Paylean® Levels on Grade Premiums
(168 - 240 lb Bodyweight)



*18% CP, 9 g/t Paylean® vs. 16% CP
**19% CP, 18 g/t Paylean® vs. 16% CP

In table 2 are the loin and ham pH data from this trial for all the treatments. These values were taken 24 hours after slaughter. There were no significant effects due to CP and Paylean® levels on any of these pH values. The 5.6 to 5.8 pH readings are indicative of good quality pork.

Table 2
Effect of Protein and Paylean® Levels on Loin and Ham pH

CP, %	16	16	16	19	18	19
Paylean®, g/t	0	9	18	0	9	18
Loin pH	5.62	5.59	5.59	5.56	5.59	5.69
Ham pH	5.77	5.82	5.80	5.74	5.85	5.79

Table 3 illustrates the color score and marbling data for the various treatments. As with the pH data, there were no significant treatment effects. Color scores of 3 and marbling scores of 2 are considered numbers that represent good quality pork.

Table 3
Effect of Protein and Paylean® Levels on Loin Color Score and Marbling

CP, %	16	16	16	19	18	19
Paylean®, g/t	0	9	18	0	9	18
Color Score	3.05	3.05	2.76	3.01	2.84	3.06
Marbling	2.08	2.07	2.07	2.08	1.99	1.99

The data in table 4 summarize the economic returns from feeding Paylean® with higher CP levels. These calculations are based on an equal time feeding period of 37 days for this trial. A meat price of 53.7¢ per pound was used in the calculations which simulates a live hog market of around $40/cwt. In this trial, we observed added returns per pig of $1.14 to $1.72 from feeding the 9 and 18 grams/ton of Paylean® along with the higher CP levels compared to the 16% CP diet without Paylean®.

Table 4
Effect of Protein and Paylean® Levels on Performance, Carcass Traits, and Economics

Crude Protein, %	16	18	19
Lysine, %	0.81	0.96	1.03
Paylean®, gram/ton	---	9	18
Days on Feed	37	37	37
Initial Weight, lb	168	168	168
ADG, lb	1.97	2.11 (+7.1%)*	2.26 (+14.7%)*
F/G	3.21	2.90 (-9.7%)*	2.67 (-16.8%)*
Diet Cost, $/ton	104.41	132.88	159.85
Cost/lb Gain, ¢	16.75	19.29 (+2.54)*	21.34 (+4.59)*
Final Weight, lb	241	245.9 (+4.9)*	251.8 (+10.8)*
Dressing Percent	74.92	75.62 (+0.70)*	75.51 (+0.59)*
Carcass Weight, lb	180.56	185.95 (+5.39)*	190.13 (+9.57)*
Carcass Value@53.7 ¢/lb meat price, $	96.96	99.86 (+2.90)*	102.10 (+5.14)*
Grade Premium/cwt of carcass**, $	5.42	5.82 (+0.4)*	6.32 (+0.9)*
Total Carcass Value, $	106.75	110.68 (+3.93)*	114.12 (+7.37)*
Cost of Gain/Head[a], $	12.23	15.02 (+2.79)*	17.88 (+5.65)*
Net Return/Head[b], $	94.52	95.66 (+1.14)*	96.24 (+1.72)*
Cost of Paylean®/Pig, $	--	2.80	5.54

*Compared to 16% crude protein; ** IBP, Inc.
[a]lb gain X F/G=Total Feed X (Diet Cost ÷ 2000)
[b]Total Carcass Value - Cost of Gain/Head

In summary, the addition of Paylean® results in substantial improvements in performance and carcass muscling. Feeding diets higher in CP (amino acids) results in a lower cost of production. It is imperative that producers be paid enough money for carcass lean to justify the investment in using 9 and 18 grams/ton of Paylean®. Because of the cost of Paylean®, some producers are using 4.5 grams/ton as a way of reducing their initial investment in this product.