



National Swine Nutrition Guide

Feed Additives for Swine- Paylean®

Authors

Brian Richert, Purdue University
Allan Schinckel, Purdue University

Reviewers

Joel DeRouchey, Kansas State University
Eric van Heugten, North Carolina State University

Introduction

Pork producers have the goal to efficiently produce lean, quality pork to meet consumer demands for lean – high quality meat products. The implementation of lean value carcass pricing systems has led to the selection of pigs with increased lean growth rates, increased carcass lean percentages and improved lean feed conversion. Health, nutrition, and facility management strategies have been implemented across the swine industry to increase commercially achievable lean growth rates. Paylean® (Elanco Animal Health) is a feed additive that when added to a swine diet increases the rate and efficiency of muscle tissue growth and reduce fat deposition. The active ingredient in Paylean® is ractopamine hydrochloride. Paylean® was approved in 1999 to be fed at levels of 4.5 to 18 grams per ton (5 to 20 ppm) from 150 to 240 lbs live weight (last 90 lbs of live weight gain prior to slaughter). However, in 2006 the FDA approval was modified to reduce the maximum dietary level fed (4.5-9.0 g/ton) and removal of the upper weight restriction such that Paylean® can be fed for the last 45-90 lbs of weight gain prior to slaughter. Because of the increased muscle growth and protein accretion, pigs fed Paylean® have increased dietary essential amino acid requirements and have a minimum dietary crude protein requirement of at least 16% CP based on label restrictions.

Objectives

- Describe the growth and carcass response to Paylean® in pigs
- Describe the increased lysine and amino acid needs when feeding Paylean®
- Discuss the potential increased needs for other nutrients when feeding Paylean®

General background of Paylean®

One technology that will help producers provide the lean pork consumers are demanding is the use of repartitioning agents like beta-agonists. Beta-adrenergic agonist compounds alter an animal's metabolism by shifting nutrients to lean muscle accretion and away from fat accretion. One of these beta-agonists which has gained approval (Dec., 1999) to be used for pigs in the United States, is a compound known as Ractopamine HCl, marketed under the trade name Paylean® by Elanco Animal Health. Paylean® and other beta-adrenergic agonists are in a class of compounds known as phenethanolamines, which have been discovered to improve the growth and body composition of livestock [1]. Phenethanolamines are referred to as repartitioning agents because of their effects on the animal, enabling them to shift nutrients towards lean tissue accretion and away from fat accretion [1]. When pigs are fed Paylean®, pigs have increased rate of gain, improved feed efficiency, increased carcass leanness and dressing percentage [2,3].

General growth response to Paylean®

In a review of 23 experiments feeding Paylean® (between 1990-2005), Paylean® increased ADG by an average of about 12% across Paylean® concentrations [3] (Table 1). While the changes in feed intake and

feed efficiency were more dose dependant. Feeding 4.5 or 9 g/ton Paylean® there was a slight 2% reduction in feed intake but pigs fed 18 g/ton had reduced feed intake of 4%. The response to feed efficiency is directly related to the level fed, with a 10% improvement at 4.5 g/ton, a 13.3% improvement at 9 g/ton and a 16.7% improvement at 18 g/ton [3].

Table 1. Average Paylean® effects on growth and carcass traits of pigs.				
Paylean® Level, g/ton	0	4.5	9	18
ADG, lb/d	1.87 ^a	2.09 ^b	2.07 ^b	2.09 ^b
ADFI, lb/d	6.26 ^a	6.24 ^{ab}	6.11 ^{ab}	6.00 ^b
Gain:Feed	0.30 ^a	0.33 ^b	0.34 ^{bc}	0.35 ^c
Hot Carcass Wt, lb	171.5 ^a	175.5 ^b	176.8 ^b	176.2 ^b
Carcass dressing percent	75.3	75.5	75.9	76.2
Tenth Rib Backfat, in	0.92 ^a	0.91 ^{ab}	0.87 ^{bc}	0.83 ^c
Loin Eye Area, in ²	5.52 ^a	5.88 ^b	6.06 ^{bc}	6.22 ^c
Estimated Fat Free Lean, %	51.4 ^a	52.3 ^{ab}	52.7 ^b	53.8 ^c

^{abc} Values with different letters within a row are different from each other at P<0.05. Note: Carcass yield effects were different at P<0.06. Adapted from Apple et al., 2007 [3].

The carcass effects also are dose dependent. Carcass weight is increased similarly by all levels of Paylean®, which matches the response to ADG noted above. Tenth rib backfat is not affected at 4.5 g/ton, but is reduced at 9 and 18 g/ton Paylean®. However, loin eye muscle area (LEA) is increased in a step-wise dose dependent manner with each step-wise increase in Paylean® dose. The combination of these two traits (backfat and LEA) leads to a numerical increase in estimated carcass fat free lean with 4.5 g/ton and a significant step-wise improvement in carcass lean with 9 and 18 g/ton. Carcass yield is slightly improved with each increasing dose of Paylean® going from 75.3% for the control pigs to 76.2% for pigs fed 18 g/ton [3].

Research has shown that the growth response to Paylean® is not constant over time. The response is the greatest the first and second week of feeding and then gradually declines for the duration of a typical 4 week feeding period. The ADG of pigs fed Paylean® during the 4th week is reported to be only slightly greater than the non-Paylean® fed pigs during that same week [4,5]. Using of a step-up Paylean® feeding program where the concentration of Paylean® is increased during the second two weeks of feeding helps minimize this reduction in Paylean® response over time [6,7].

Changes in lysine needs when feeding Paylean®

Due to the metabolic changes that occur when Paylean® is fed, increased protein accretion in muscle tissue and decreased lipogenesis in adipose tissue, changes in nutritional requirements must also be considered to accommodate these changes in tissue growth and metabolism. When discussing dietary protein and amino acid requirements while feeding Paylean®, two factors affect the dietary requirement of the pig. The first is the dramatic increase in protein accretion that occurs when feeding Paylean® [1,2] and the second is the slight reduction in feed intake observed, resulting in a decrease in total nutrient intake [3,4].

To account for the increased protein deposition, dietary amino acid requirements need to be increased. In early research with lighter pigs (132-198 lb pigs) the effects of increasing dietary protein (lysine) levels (8.5-22.2% CP) while feeding 0 and 18 g/ton Paylean® was evaluated [8]. Dunshea et al. (1993) [8] observed increased ADG with increasing amino acid supply, reaching a plateau at a 19.5% CP diet or 1.25% total lysine (1.13% SID Lysine). Carcass protein accretion rate was maximized at a similar level as ADG (19.5% CP), however, fat tissue gain decreased linearly as dietary CP increased and was minimized at the 22.2 % CP (1.39% total lysine) diet. The increase in protein deposition associated with Paylean® feeding was determined to require a dietary CP level of at least 3 percentage units greater than the control pigs [8]. Recent studies with modern genotypes and slaughter weight pigs suggest that pigs fed 4.5 g/ton of Paylean® require approximately 1.0% total lysine (0.88TID lysine) and when pigs are fed 9 g/ton they require a 1.2%

total lysine (1.06% TID lysine) when Paylean® is fed for 28 days prior to slaughter [9]. Feeding Paylean® at 4.5 g/ton resulted in a 35% increase in protein accretion, whereas 9 g/ton concentration resulted in a 46% increase in protein accretion, which drives these increased lysine levels needed by pigs fed Paylean® [9]. In subsequent work, TID lysine requirements were estimated to be approximately 0.92% TID lysine for pigs fed 4.5 g/ton Paylean® for 28 days from 215 to 275 lb [10]. This data suggests that dietary lysine needs to be increased 0.20 to 0.30% above the standard finishing diets to maximize the benefit of feeding Paylean®.

Modeling the Paylean® response and lysine needs of pigs fed Paylean®

A model has been developed to predict the dietary lysine requirements for Paylean®-fed pigs [4]. The lean growth response to Paylean® is not constant over the entire 90 lb gain feeding period. Research indicates that the response to Paylean® is immediate and substantial during the first week of Paylean® feeding and then decreases (Figure 1). During the first week of feeding Paylean®, lean accretion can increase by over

50% and then slowly declines to be 15-20% greater by the end of the 4 week Paylean® feeding period.

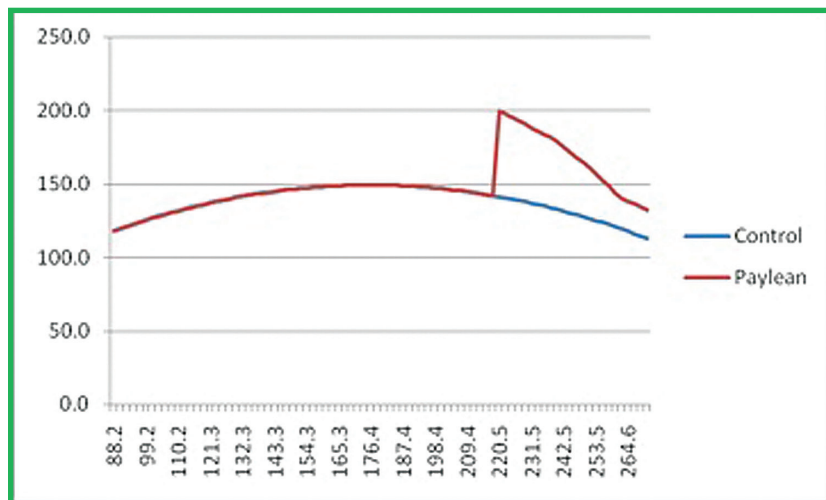


Figure 1. Protein accretion (g/day) for pigs with and without Paylean® (9 g/ton) 215 – 270 lbs live weight. Modeling data from Schinckel et al., 2003 [4] was applied to performance of gilts in Schinckel et al., 2009 [15] from 215-270 lb of body weight.

The magnitude of the Paylean® response will be greater in high health environments due to the greater lean accretion rates pigs achieve when housed under a high health environment resulting in a greater predicted grams of dietary lysine requirement for pigs fed Paylean® in high health environments. However, the predicted percent dietary lysine may be similar for pigs in high and low health environments due to the higher feed intakes often observed for high health pigs, resulting in similar dietary percent lysine requirements when fed Paylean® [11]. This may not always be the case for different production systems and

genetics and the use of on farm feed intakes and growth performance data will allow for a more optimal Paylean® diet formulation in each production situation.

The predicted percent lysine requirement for pigs fed 4.5 or 9 g/ton of Paylean® rapidly increases during the first week of feeding Paylean®, and then declines with the declining Paylean® response (Table 2) [4]. Phase feeding will be required to closely meet the lysine requirements while feeding Paylean®. If the 4 week average of the predicted lysine requirement is fed, pigs will not achieve the maximum performance during the first week of Paylean® feeding during the period of peak potential Paylean® response. Also, lysine will be overfed during the period of decreased Paylean® response during weeks 3 and 4 if lysine levels to meet the first weeks' response to Paylean® are fed. If only one diet can be fed, then targeting the predicted lysine levels for week 2 would more optimally meet the pigs' needs and minimize the expense of over feeding of amino acids.

Level of Paylean®	0	4.5	% Increase	9.0	% Increase
Week 1	.72	.95	31.9	1.01	40.3
2	.66	.86	30.3	.91	37.9
3	.62	.75	21.0	.79	27.4
4	.57	.66	15.8	.68	19.3
Avg.	.64	.81	26.6	.85	32.8

Modeling data from Schinckel et al., 2003 [4] was applied to performance of gilts in Schinckel et al., 2009 [15] from 215-270 lb of body weight.

Energy needs when feeding Paylean®

Dietary energy also needs to be considered when determining the nutritional requirements when feeding Paylean®. Increased energy intakes, in late-finishing swine, up to 9.5 Mcal/d of ME resulted in an increase in lean tissue accretion, a decrease in fat tissue accretion, and improved feed efficiencies [12]. However, when Paylean® was added to the diet (18 g/ton), no response to increased dietary energy was observed in lean tissue accretion [12]. Similar results were observed by Apple et. al. (2004) [13], when pigs were fed Paylean® at 9 g/ton and pigs required about 1500 kcal/lb of dietary ME (similar to a corn-soy diet) to maximize growth when fed Paylean®. However, in genetics with a tendency for lower feed intakes, a 5% added fat diet provided an enhanced response to feeding Paylean® at 9 g/ton [14].

This limited amount of information would indicate that dietary energy levels generally do not need to be increased when feeding Paylean® above dietary energy levels found in a corn-soybean meal diet. The lack of increased dietary energy needs is logical based on the decrease in carcass fat caused by the increase in lipolysis and/or decrease in lipogenesis when feeding Paylean®. The ability of Paylean® to repartition energy towards protein accretion is the primary factor allowing dietary energy levels to remain unchanged. Dietary energy required for fat deposition is approximately 5 times greater than for lean tissue (4.67 Mcal/lb of fat tissue vs. 1.01 Mcal/lb of lean tissue). This shift to increased protein and lean tissue accretion that occurs in pigs fed Paylean® should spare dietary energy.

Other nutrients

Other amino acids appear to be needed in similar ratios to lysine for grow-finish swine fed Paylean®. Total sulfur amino acids are near 58% (TID) relative to lysine when feeding Paylean® and this is close to the ratio used in grower pigs not fed Paylean® [10]. There is limited research on the requirements of other amino acids relative to lysine when Paylean® is fed. It could be assumed that a similar ratio relative to lysine for the other amino acids as used in non-Paylean® supplemented diets would meet the pigs needs when feeding Paylean®.

Other nutrients that need future research and may need dietary increases are the vitamin and trace mineral levels. Some research indicates that there is an increased need for B vitamins in high lean gain pigs which would suggest an increase in B vitamins requirement in pigs fed Paylean® due to the large increase in lean tissue deposition with Paylean® feeding. Therefore, it is recommended to increase the vitamin and trace mineral supplementations similar to the amounts recommended for grower pig diets which would have similar dietary CP concentrations (1-1.2 % Lys). There is no increase in bone mass when Paylean® is fed. However, lean tissue contains approximately 25% of the body phosphorus in the pig and the increased lean tissue accretion when feeding Paylean® indicates the dietary digestible or available phosphorus needs to be increased by approximately 0.02-0.05% in the diet. This will accommodate the needs for lean tissue accretion and prevents potential mobilization of bone phosphorus reserves to meet the increased phosphorus needs when feeding Paylean®.

Summary

Paylean® can substantially improve the rate and efficiency of lean growth. The Paylean® response is immediate and then declines over time. Paylean® increases fat-free lean accretion by approximately 25-35%, depending on concentration and duration of use prior to market. Because of the increased protein deposition, dietary amino acids, phosphorus, vitamin and trace mineral concentrations need to be increased to support the improvement in lean gain. An increase in SID lysine of 5 to 6 g per day when pigs are fed Paylean® is required. The dietary lysine concentration needs to be increased by approximately 0.20 to 0.30 percentage units relative to diets without Paylean® to meet these amino acid needs. In general, the recommended lysine levels would be 0.90-1.00% (0.80-0.90% SID lysine) for barrows and 0.95-1.05% (0.85-0.95% SID lysine) for gilts. All other amino acids need to be increased to maintain an ideal amino acid ratio relative to lysine to maximize lean tissue synthesis. Dietary energy levels do not need to be increased in diets containing Paylean® and can be similar to diets without Paylean®. The increased lean tissue accretion when feeding Paylean® indicates the dietary digestible or available phosphorus needs to be increased by approximately 0.02-0.05% in the diet compared to non-Paylean® diets for the same weight pigs.

References

1. Mersmann, H.J. 1998. Overview of the effects of α -adrenergic receptor agonists on animal growth including mechanisms of action. *J. Anim. Sci.* 76:160-172.
2. Moody, D.E., D.L. Hancock, and D.B. Anderson. 2000. Phenethanolamine Repartitioning Agents. In: D'Mello, J.P.F. (Eds) *Farm Animal Metabolism and Nutrition: Critical Reviews*. CAB International, Wallingford, Oxon, UK. pp. 65-96.
3. Apple, J.K., P.J. Rincker, F.K. McKeith, S.N. Carr, T.A. Armstrong, and P.D. Matzat. 2007. Review: Meta-analysis of the ractopamine response in finishing swine. *Prof. Anim. Sci.* 23:179-196.
4. Schinckel, A.P., N. Li, B.T. Richert, P.V. Preckel, and M.E. Einstein. 2003. Development of a model to describe the compositional growth and dietary lysine requirements of pigs fed ractopamine. *J. Animal Sci.* 81:1106-1119.
5. Kelly, J.A. M.D. Tokach, S.S. Dritz. 2003. Weekly growth and carcass response to feeding ractopamine (Paylean®). *Amer. Assco. Swine Vet. Proceedings* pp 51-58.
6. Schinckel, A.P., N. Li, B.T. Richert, P.V. Preckel, K. Foster, and M.E. Einstein. 2006. Development of a model to describe the compositional growth and dietary lysine requirements of pigs fed increasing dietary concentrations of ractopamine. *Prof. Anim. Sci.* 22: 438-449.
7. See, M.T., T.A. Armstrong, and W.C. Weldon. 2004. Effect of a ractopamine feeding program on growth performance and carcass composition in finishing pigs. *J. Anim. Sci.* 82:2474-2480.
8. Dunshea, F.R., R.H. King, and R.G. Campbell. 1993. Interrelationships between dietary protein and ractopamine on protein and lipid deposition in finishing gilts. *J. Anim. Sci.* 71:2931-2941.
9. Webster, M.J., R.D. Goodband, M.D. Tokach, J.L. Nelssen, S.S. Dritz, J.A. Unruh, K.R. Brown, D.E. Real, J.M. DeRouchey, J.C. Woodworth, C.N. Groesbeck, and T.A. Marsteller. 2007. Interactive effects between ractopamine hydrochloride and dietary lysine on finishing pig growth performance, carcass characteristics, pork quality, and tissue accretion. *Prof. Anim. Sci.* 23:597-611.
10. Frantz, N.Z., M.D. Tokach, R.D. Goodband, S.S. Dritz, J.M. DeRouchey, J.L. Nelssen, and C.L. Jones. 2009. The optimal standardized ileal digestible lysine and total sulfur amino acid requirement for finishing pigs fed ractopamine hydrochloride. *Prof. Anim. Sci.* 25:161-168.
11. Kendall, D.C., B.T. Richert, T.E. Weber, K.A. Bowers, S.A. DeCamp, A.P. Schinckel, and P. Matzat. 2000. Evaluation of pig genotype, strategic use of antibiotics and grow-finish management effects on lean growth rate and carcass characteristics. *Purdue University Swine Day Report*. p. 60.
12. Williams, N.H., T.R. Cline, A.P. Schinckel, and D.J. Jones. 1994. The impact of ractopamine, energy intake, and dietary fat on finisher pig growth performance and carcass merit. *J. Anim. Sci.* 72:3152-3162.
13. Apple, J.K., C.V. Maxwell, D.C. Brown, K.G. Friesen, R.E. Musser, Z.B. Johnson, and T.A. Armstrong. 2004. Effects of dietary lysine and energy density on performance and carcass characteristics of finishing pigs fed ractopamine. *J. Anim. Sci.* 82:3277-3287.
14. Weber, T.E., B.T. Richert, M.A. Belury, Y. Gu, K. Enright, and A.P. Schinckel. 2006. Evaluation of the effects of dietary fat, conjugated linoleic acid, and ractopamine on growth performance, pork quality, and fatty acid profiles in genetically lean gilts. *J. Anim. Sci.* 84:720-732.
15. Schinckel, A.P., M.E. Einstein, S. Jungst, C. Booher, T.S. Stewart, and S. Newman. 2009. Development of a stochastic model of pig growth to evaluate the impact of birth and twenty-one day body weight and potential sorting strategies on the body composition growth and lysine requirements of pigs. *Prof. Anim. Sci.* 25: 663-688.

Frequently asked questions

What are the restrictions when feeding Paylean®?

Paylean® (Elanco Animal Health) is a feed additive that increases muscle protein growth and improves feed efficiency. Paylean® was originally approved in 1999. In 2006 the FDA approval was modified to reduce the maximum level fed to 4.5-9.0 g/ton and to remove the upper weight restriction so Paylean® can be fed the last 45-90 lbs of weight gain prior to slaughter for market swine. Because of the increased muscle growth and protein accretion, pigs fed Paylean® have increased dietary essential amino acid requirements and consequently have a minimum dietary crude protein requirement of at least 16% CP based on label restrictions.

What are the nutritional modifications required when feeding Paylean®?

Paylean® will improve the rate and efficiency of lean growth by approximately 25-35%. Therefore, lysine and dietary amino acid requirements increase substantially while feeding Paylean®. The dietary lysine level needs to be increased by approximately 0.20 to 0.30% above concentrations in equivalent diets without Paylean®. In general, the recommended lysine levels would be 0.90-1.00% (0.80-0.90% SID lysine) for barrows and 0.95-1.05% (0.85-0.95% SID lysine) for gilts. All other amino acids need to be increased to maintain an ideal amino acid ratio relative to lysine. A similar dietary energy level should be fed in diets containing Paylean® as compared to diets without Paylean®. Other nutrients (phosphorus, B- vitamins, etc.) should be increased to meet the needs associated with the enhanced muscle growth when feeding Paylean® and to prevent the pig from depleting body reserves to meet the Paylean® needs for these nutrients.