Animal Sciences Swine

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Environmental Benefits of Paylean® in Finisher Swine—an Example Based on Adoption in the United States

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Introduction

Paylean® (ractopamine hydrochloride) was approved in December 1999 by the U.S. Food and Drug Administration for use as a feed ingredient in commercial pork production, specifically in finisher swine (Paylean® Technical Manual, 2001). Paylean® is a ß-adrenergic agonist that acts by directing nutrients away from fat deposition to increase the amount of lean pork in a carcass. Paylean® enhances feed efficiency and increases growth rate, resulting in fewer days to market and less feed for equivalent lean growth (Anderson, et al., 1991).

Paylean® has been shown to have no effect on indicators of pork quality, and safety studies have demonstrated that pork from Paylean®-fed pigs is safe for human consumption. Environmental safety studies have shown that Paylean® has no detrimental effects on the environment and will degrade in soil or water very rapidly (Paylean® Technical Manual, 2001). The effects on carcass composition and growth performance are well documented, but the impact of Paylean® also extends into environmental benefits. The potential environmental benefits of Paylean® lie in three main areas.

Environmental Benefits

Positive effects from Paylean® feeding is calculated from the **reduction in animal numbers and leads to a lower demand for grain and other production inputs**, as well as a corresponding reduction in natural resources for grain and pork production.

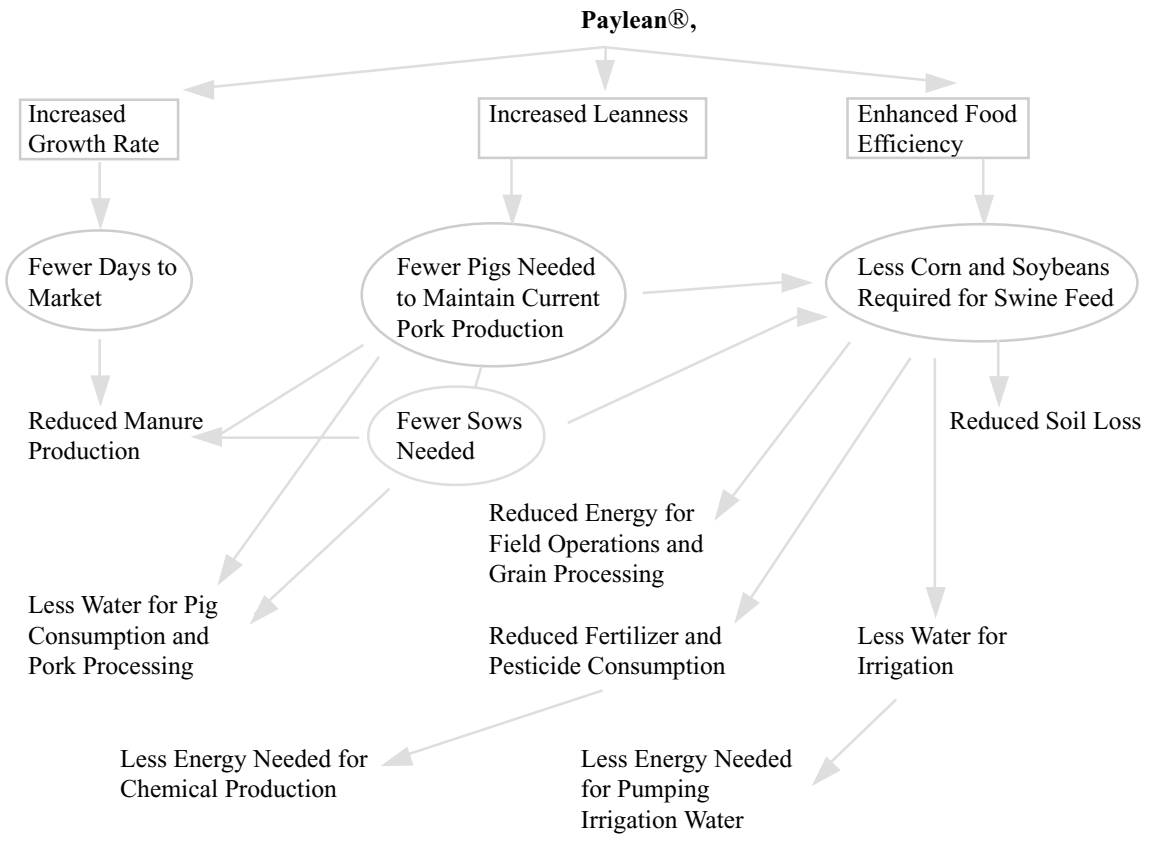
Another potential positive effect is derived from Paylean®'s **improvement in feed efficiency** of those remaining fewer pigs required to produce the pork supply. The pigs that are produced with Paylean® use less feed per animal and in total; therefore, there is an additional reduction in grain and grain inputs required for equivalent pork production. Even though Paylean®-fed pigs must be supplied with a higher protein diet than non-Paylean®-fed animals, the overall effects of Paylean® result in a lowered grain and protein demand for the swine industry.

The final potential area of environmental benefit from Paylean® is from **reduced nitrogen and phosphorus excretion** from Paylean®-fed pigs (DeCamp, et al., 2001). The proposed environmental impacts and interrelationships of using Paylean® in the swine industry are widespread and interrelated, as shown by Figure 1.

A reduction in cropland required to support the swine industry leads to a reduction in water use for irrigation, energy for field operations and processing, soil loss, and chemical use. This land may remain in crop production, but it then can be used for alternative purposes, such as providing food for people or for other livestock industries. If uncultivated or returned to grassland, valuable soil can be spared from erosion. Agricultural soil conservation practices have reduced the severity of soil erosion on cropland, but a total of 2.1 billion tons of United States soil was lost in 1992 due to wind and water erosion (National Resources Inventory, 1995). In addition to the direct benefit of soil conservation, the reduction in cropland can also yield a reduction in inputs for crop production and energy used by these inputs.

Agricultural chemical usage has received much attention from environmentally aware citizens. There can be a substantial reduction in the amount of fertilizers and pesticides needed to produce crops for the pork industry with the adoption of Paylean®. There is the obvious benefit of less fertilizer and pesticide use, but there is also

Figure 1 - The interrelationship of Paylean®, and natural resources



a large hidden benefit of natural resource savings resulting from the production of these chemicals. Much energy and many other natural resources are utilized in fertilizer and pesticide production, with nitrogen fertilizer production being the largest energy user.

The key environmental benefits mentioned above include a reduction in manure, cropland, grain use, water consumption, chemical use, soil loss, and overall energy consumption for pork production and support enterprises. While swine producers profit from an increased lean growth rate and improved feed efficiency, all citizens potentially can benefit from the positive environmental effects of Paylean® use. By utilizing Paylean®, the swine industry can play its part to assist in the conservation of our natural resources, providing a direct benefit to society. This paper reports on a mathematical analyses conducted to evaluate the potential environmental benefits of utilizing Paylean® for U.S. pork production.

Methods

This analysis of the potential environmental benefits resulting from the implementation of Paylean® in the U.S. swine industry is based on numerous statistics of national agricultural production averages and assumptions. In addition, the interrelationships between Paylean® and natural resources depicted in Figure 1 have been used. The main assumption is that all finisher pigs in the United States are fed Paylean® at a dose of 18 grams per ton, the maximum approved level by FDA.

Calculations to determine the reduction in pig numbers assume maintaining the current level of pork production in the United States. Since Paylean®-fed pigs have more pounds of lean pork per animal, fewer pigs are needed to produce an equivalent volume of lean pork. There would be a corresponding reduction in the U.S. sow herd. Boar numbers are reduced, but with the advent of artificial insemination, there are so few boars in the herd that we can ignore those effects.

Reduced Manure Output: Manure reduction calculations include lower manure output due to reduced pig and sow numbers in a farrow-to-finish operation based on a current average of 252 gallons of manure per pig sold from the operation (Table 1). The decreased manure output due to the four fewer days to market is also taken into account, assuming an average daily manure output of 1.2 gallons per day for finishing pigs housed with nipple waters and no wet-dry feeding systems (Sutton, et al., 1999).

Reduced Crop Acreage: Reduced corn and soybean demand for pork production is a result of both reduced animal numbers and an increase in feed efficiency with Paylean® (Table 2). Assumed pig and sow diets were formulated as a standard corn-soybean meal diet meeting the National Research Council (1998) recommendations for gestation, lactation, and pig growth phases. In calculating the savings due to increased feed efficiency, diets for Paylean®-fed pigs were formulated with 16% crude protein and diets for non-Paylean® pigs were formulated with 14% crude protein with similar lysine additions (DeCamp, et al., 2001). All crop statistics were obtained from 1999 USDA Agricultural Statistics. Corn acreage was 72,604,000 acres with an average yield of 134.4 bushels per acre. Soybean acreage was 70,811,000 acres with an average yield of 38.9 bushel per acre. Soil loss is calculated assuming a soil loss rate of 5.6 tons/acre/year from wind and water erosion, as published by the National Resource Inventory (1992).

Reduced Water Usage: Water reduction calculations include water for pig and sow consumption, crop irrigation, and pork processing. Pig consumption of water is from the National Research Council (1998) and water for pork processing is based on 113 gallons per head, as published by Mayberry (2000). Irrigation rates are taken from the 1997 Census of Agriculture and are calculated separately for corn and soybeans, including rates and percentage of crop irrigated (Table 1).

Reduced Chemical Usage: The reduction in chemical use is based on the reduction of cropland required for pork production. Chemical usage is based on statistics from the USDA 1999 Field Crops Summary (Table 3). Corn and soybean usage is calculated separately. Nitrogen, phosphorus, and potassium are also calculated separately, taking into consideration the rates and percentage of U.S. fields that receive those nutrients. Pesticide use includes both herbicide and insecticide application, considering rates, and percentage of crop receiving pesticides.

Reduced Energy Usage: The total energy savings is a conservative calculation, including only energy required for fertilizer production, corn drying, grain grinding, on-farm diesel fuel use, pesticide production, and pumping irrigation water (Table 4). Some other inputs that are not accounted for may include: utilities in swine facilities, feed and fertilizer transportation, pork processing, seed production, and non-grain pork production inputs. Energy expenditure data for phosphorus production was obtained from The Fertilizer Institute (Harry Vroomen, personal communication) and all others are from the *CRC Handbook of Energy Utilization in Agriculture* (Pimentel, 1980).

Results

The analysis of the environmental impacts resulting from the utilization of Paylean® yields a reduction in natural resource demand for pork production in the following areas: cropland, soil loss, fertilizer use, pesticide use, water consumption, swine waste production, and total energy requirements. If all pigs in the United States were fed Paylean®, the same amount of pork could be supplied to the market with 11.3% fewer pigs due to the increase in leanness and dressing percentage resulting from the utilization of Paylean® (see Table 5). Only 86.8 million pigs would be required to equal the current pork production of 97.8 million pigs. This reduction in pig numbers would yield an additional saving of natural resources, such as crops, water, fossil fuels, and other resources required for pork production. Alternatively, 11.3% more pigs could be produced with the current resource allocation.

Due to the fewer numbers of animals required and the increase in feed efficiency resulting from Paylean®, the demand for corn and soybeans for the swine industry could decrease dramatically (Table 6). Based upon typical commercial diets meeting NRC requirements, pork production could be maintained with 217.2 million fewer bushels of corn annually and 20.6 million fewer bushels of soybeans. This amounts to 1.6 million acres of corn, or a 2.23% reduction in total U.S. corn acreage and 530,000 acres of soybeans, a 0.75% reduction in total U.S. soybean acreage (compare Table 2 to Table 6). The reduction in crop inputs for this land yields a substantial savings of natural resources. If the 2.1 million acres of cropland not required for pork production were to be uncultivated or returned to grassland, 12 million tons of soil could be conserved from wind and water erosion each year. There could also be a savings of 18.9 million gallons of diesel fuel for cropping field operations due to the reduction in feed demand for pork production.

The reduction in cropland leads to a corresponding reduction in fertilizer needs. By implementing Paylean® in all U.S. finishing pigs diets, 389.8 million pounds of fertilizer per year can be spared from use for the swine industry. This has a large impact on the overall energy conservation, since considerable energy is required for the production of crop fertilizers. The reduction in cropland also results in a reduction in herbicide and insecticide use. Due to increased efficiency of pork production with Paylean®, 4.2 million pounds of pesticides (including both herbicides and insecticides) annually can be conserved or used alternatively.

The increase in efficiency with Paylean® yields a reduction in water usage for pork production. The reduction in water use results from pork processing, pig water

consumption, and crop irrigation. Irrigation water is the major factor, accounting for 95.5% of all water savings. The total water savings amounts to 109.8 billion gallons per year, which would be equivalent to the personal water usage of nearly 3 million Americans. Put another way, 1,123 gallons of water could be conserved per pig, or 5.7 gallons of water per pound of wholesale pork consumed. Due to the increased feed efficiency of pigs fed Paylean® and the decreased days to market, 3.4 billion fewer gallons of manure would be produced by utilizing Paylean® in the U.S. swine industry. In correspondence to the decrease in manure volume resulting from using Paylean®, pigs fed Paylean® excrete less nitrogen. Recent research showed a 14.6% reduction in total N excretion comparing a 13.8% CP diet to a 16.1% CP diet with Paylean® with similar lysine additions (DeCamp, et al., 2001). This has dramatic implications for the swine industry since nitrogen is a major source of pollution and manure odor.

The increase in production efficiency and reduction in production inputs could lead to a substantial energy savings. Energy savings could amount to nearly 2.8 billion Mcal for only some of the major energy inputs. There are numerous other energy expenditures that are not included in this calculation, making this a conservative estimate. The annual energy savings calculated in this analysis would be equivalent to 91 million gallons of gasoline per year, or the gasoline used by 160,852 U.S. automobiles. This energy saving is also comparable to the energy used by 112,572 U.S. households.

Implications

The FDA approval of Paylean® can have major implications for the swine industry. Pork producers now have another tool available to increase the efficiency of pork production and provide a lean, nutritious product to the American consumer. The increase in leanness obtained by utilizing Paylean® benefits producers, resulting in a higher lean premium paid by the packer. Producers also benefit from the increase in efficiency since their production inputs and costs may be lowered. Unlike many other efficiency enhancing technologies, Paylean® requires no capital investment and is therefore equally valuable to all pork operations, both large and small.

Potential Impacts

The impacts of Paylean® may reach much farther than the increase in production efficiency obtained by the pork industry. All citizens, regardless of their involvement in the pork industry, may benefit from positive environmental benefits that result from the increased efficiency. Some of these benefits can include: lower manure output, water and energy conservation, reduced land for crop production, less soil loss from erosion, and lower fertilizer and pesticide use.

Table 1. Inputs for analysis of reduction in water and swine waste.

Water use for pork processing (gal/hd)	113
Pig water consumption (gal)	231
Annual sow water consumption (gal)	1,483
Corn irrigation rate (gal/ac)	391,020
% of corn irrigated (%)	15.2
Soybean irrigation rate (gal/ac)	260,680
% of soybeans irrigated (%)	6.28
Swine waste per pig sold (gal)*	252
Daily waste in finishing swine (gal)	1.2

*Includes waste from entire farrow to finish operation on a per pig sold basis.

Table 2. Inputs for analysis of reduction in cropland.

Corn acres harvested per year (ac)	72,604,000
Corn yield (bu/ac)	134.4
Soybean acres harvested per year (ac)	70,811,000
Soybean yield (bu/ac)	38.9
Annual sow corn consumption (bu)	27.7
Annual sow soybean consumption (bu)	5.1
Pig corn consumption (bu)	11.2
Pig soybean consumption (bu)	2.8
Paylean®,-fed pig corn consumption for finishing (bu)	3.8
Paylean®,-fed pig soybean consumption for finishing (bu)	1.0
Non-Paylean®,-fed pig corn consumption for finishing (bu)	4.6
Non-Paylean®,-fed pig soybean consumption for finishing (bu)	0.9
Annual soil loss (ton/ac)	5.6
Fuel use (gal/ac)	8.8

The results obtained are the best current estimates of the environmental impact of Paylean®, although the actual environmental response may differ due to the multiple assumptions that provide the basis for this analysis. It is impossible to accurately forecast the number of U.S. finisher pigs that will actually be fed Paylean®, and the responses that will be observed in the commercial industry. The response assumptions used in the calculations are based on data obtained in controlled research trials, which will likely differ from field situations. The diet formulations are very general and do not include all of the feedstuffs utilized in the pork industry. Corn and soybean meal are the major components of most swine diets, but many other grains, by-products, minerals, etc. are also added to many diets. There are also many other inputs and energy expenditures that are not accounted for in this

Table 3. Inputs for analysis of reduction in fertilizer and pesticide.	
Corn nitrogen application rate (lb/ac)	133
% corn acreage receiving nitrogen (%)	98
Corn phosphorus application rate (lb/ac)	54
% corn acreage receiving phosphorus (%)	82
Corn potassium application rate (lb/ac)	81
% corn acreage receiving potassium (%)	67
Soybean nitrogen application rate (lb/ac)	21
% soybean acreage receiving nitrogen (%)	18
Soybean phosphorus application rate (lb/ac)	46
% soybean acreage receiving phosphorus (%)	26
Soybean potassium application rate (lb/ac)	78
% soybean acreage receiving potassium (%)	28
Corn pesticide use (lb/ac)	2.25
Soybean pesticide use (lb/ac)	1.0

Table 4. Inputs for analysis of reduction in energy consumption.	
Energy for nitrogen production (Mcal/lb)	5.45
Energy for phosphorus production (Mcal/lb)	1.09
Energy for potassium production (Mcal/lb)	0.73
Energy equivalent of diesel fuel (Mcal/gal)	35.28
Energy equivalent of gasoline (Mcal/gal)	31.25
Energy for corn drying (Btu/bu)	8,400
Energy for grain grinding (Mcal/lb)	0.02
Energy for pesticide production (Mcal/lb)	37.68
Energy for pumping irrigation water (Mcal/ac)	0.40

analysis. Overall, the environmental benefits calculated from this analysis demonstrated maximum potential positive impacts from Paylean® at the maximum level approved by FDA. Regardless of any discrepancy between the assumptions used in this analysis and actual field conditions, Paylean® use can elicit some positive environmental benefits.

Conclusion

The implications of the increased pork production efficiency resulting from Paylean® use can extend into a multitude of different facets of American life. It is obvious that producers immediately benefit from the utilization of Paylean®, but all people may reap the rewards of positive environmental impacts. There can be a substantial reduction in the use of natural resources for pork production by using Paylean®. These resources that are not needed to maintain the current pork production may be utilized for additional pork production if demand increases, or they can be utilized in a variety of alternative ways.

Table 5. Reduction in swine numbers to equal current pork production.	
No. pigs slaughtered annually (hd)	97,794,000
Annual pork production (lbs)	19,280,000,000
% dissected lean with Paylean® (%)*	57.5
% dissected lean without Paylean® (%)*	51.8
Dressing % with Paylean® (%)*	73.4
Dressing % without Paylean® (%)*	72.3
Pigs/sow/year (hd)	15.6
Live market pig weight (lbs)	256
No. of sows in U.S. breeding herd (hd)	6,815,000
No. of Paylean®-fed pigs needed to equal current pork production (hd)	86,779,344
Reduction in pig numbers to equal current pork production (hd)	11,014,656
% reduction in swine numbers (%)	11.3
Reduction in sow numbers to equal current pork production (hd)	706,068

*From Jones, et al., 2000.

Table 6. Summary of annual resource savings resulting from the utilization of Paylean® in all U.S. finisher swine.	
Reduction in corn acreage (ac)	1,616,192
Reduction in soybean acreage (ac)	529,798
Reduction in total cropland (ac)	2,145,989
Reduction in soil loss (ton)	12,017,541
Reduction in nitrogen usage (lbs)	212,657,079
Reduction in phosphorus usage (lbs)	77,901,354
Reduction in potassium usage (lbs)	99,281,511
Reduction in total fertilizer consumption (lbs)	389,839,944
Reduction in pesticide usage (lbs)	4,166,759
Reduction in water usage (gal)	109,819,410,388
Reduction in swine waste excretion (gal)	3,374,991,473
Reduction in total energy consumption (Mcal)	2,865,173,618

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