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An Introduction to Swine Growth Enhancers: Porcine Somatotropin and Beta-Agonists

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Introduction

Pork producers are constantly striving to produce high-quality, lean pork. For the most part they have been successful. Adoption of new technology in the areas of nutrition, genetics, reproductive physiology, housing and management have all played a role in their success.

Today, however, the pressure is on. Consumers are demanding wholesome, nutritious pork that is even leaner and free of residues. The meat packing industry is beginning to address consumer demands and is placing a premium on lean, high-quality pork. These trends will continue. Fortunately, pork producers have built a dynamic industry that historically has adjusted well to changes in technology and consumer preferences.

Now, a dramatic new technology is looming on the pork producer's horizon. Several new growth enhancers promise to significantly alter pork production and the pork industry. Increases in growth rates of 10 to 20 percent, improvements in feed efficiency of 15 to 35 percent, decreases in carcass fat content of 50 to 80 percent, and increases in protein deposition of up to 50 percent have been observed in pigs treated experimentally with growth enhancers. These products include several naturally occurring compounds classified as beta-agonists and swine growth hormone (porcine somatotropin or PST).

Growth hormone was initially isolated and studied in the 1920s and its effects on livestock have been well documented. But the technology was ahead of its time. The pork industry has historically placed a much higher premium on fat, particularly during the war years.

Additionally, until recently growth hormone was too expensive to have any practical application. Not until the advent of recombinant DNA technology could pharmaceutical companies economically mass produce synthetic growth hormones for widespread application. This publication provides basic information about swine growth enhancers in order to allow producers to make an initial evaluation of these products for possible future use in their herds.

What are PST and the beta-agonists and how do they work?

Porcine somatotropin (PST)

PST or porcine growth hormone is a naturally occurring hormone produced by the pituitary gland of the pig.

Each animal species, including humans, produces a unique version of growth hormone that is not active in any other species. Synthetic PST, produced using recombinant DNA techniques in the bacteria *E. coli*, generates results similar to those of naturally produced PST.

In the pig, natural PST production is limited by somatostatin, which prevents the release of PST. In beef cattle, immunization of an animal against its own somatostatin has produced results similar to injections of growth hormone. The same results may hold true in swine.

Somatotropins in all animals are proteins composed of 190 to 199 amino acids. They cannot be administered orally because they are broken down in the gastro-intestinal tract. They must be injected.

The exact mechanism by which PST produces its effects is complex and not completely understood. PST reduces the amount of fat or adipose tissue directly by stimulating lipolysis (fat metabolism) and retarding lipogenesis (fat synthesis).

PST stimulates lean tissue growth indirectly by stimulating the liver to produce somatomedin C, an insulin-like growth factor. Somatomedin C synthesis results in an increased growth rate of all lean tissue including the internal organs and skin. In some research trials, the increase in proportion of all lean tissues, including the organs, skin and skeleton, decreased the dressing percentage relative to animals treated with beta-agonists.

PST is also thought to have a direct effect on individual muscle cells. It increases the proportion of lean tissue by increasing the rate and efficiency of amino acid conversion to protein and by decreasing the metabolic rate of protein degradation.

The interaction of PST with other hormones in the pig is being investigated but is not well known. Additionally, there is some early indication that the effects of PST and some beta-agonists in the pig may be additive, producing even larger effects than PST or the beta-agonists alone.

Beta-agonists

Beta-agonists include several naturally occurring chemical compounds and their structural analogs (synthetic copies). The natural compounds are termed catecholamines and include dopamine, epinephrine and norepinephrine. Their analogs include clenbuterol, cimaterol, ractopamine and others. Each of these compounds decreases the proportion of adipose (fat) tissue and increases the proportion of muscle (lean). In contrast to PST, beta-agonists do not influence lean tissues other than muscle.

Beta-agonists reduce the amount of adipose tissue directly by stimulating lipolysis (fat metabolism) and reducing lipogenesis (fat synthesis). Beta-agonists also reduce the amount of adipose tissue indirectly by interacting with other hormones that regulate lipid metabolism. They decrease the activity of insulin, which results in a reduced supply of glucose for lipid (fat) synthesis. Beta-agonists do not regulate adipose tissue mass through regulation of cell division.

Beta-agonists increase muscle mass primarily by stimulating increased cell (fiber) size rather than increased cell numbers. They decrease the rate of protein degradation and increase the rate of amino acid conversion to protein. How they accomplish this is not well known. They may work in tandem with other hormones such as insulin, thyroxine, prolactin, thyroid hormone and cortisol. However, they appear to stimulate growth of muscle tissue directly — by their effects on individual muscle cells — rather than indirectly by elevating insulin or growth hormone levels.

Beta-agonists function as hormones but are not composed of protein. Consequently, they are not broken down in the pig's digestive tract and can be fed in the ration.

How do pigs respond to growth enhancers?

Porcine somatotropin

Daily administration of PST to growing hogs produces dramatic improvements in virtually all economically important performance traits. Growth rate, feed efficiency, fat percentage, loin eye area and the percentage of muscle all improve significantly. Treated pigs consume less feed on a daily basis and may have increased disease resistance and immune function. Sows treated during lactation produce more milk and wean heavier litters.

Pigs will respond to less-frequent administration of PST, such as two injections per week. However, PST is active in the pig for only a few hours so PST must be administered daily for maximum response.

Response to PST is affected by several variables including dose, period of administration, genotype, sex, weight and nutrition. Most research has shown that pigs of similar type increase their level of performance as the daily dose of PST increases. In most studies, the maximum growth rate has occurred at daily doses of 4 to 8 milligrams per head. At daily doses of 8 to 15 milligrams per head, feed consumption and fat thickness are minimized while feed efficiency, loin eye area and percentage of muscle are maximized. The commercially optimal level of PST administration will depend on the weight, sex and genotype of the pig; the ration fed; the mode of administration; and the cost of PST.

Beta-agonists

Like PST, beta-agonists increase the performance of the pig. In most studies, the optimum feeding level of ractopamine, the most widely studied beta-agonist, is 20 parts per million for complete rations fed *ad libitum*. Performance responses to ractopamine are similar to those produced by PST but are less dramatic. The exception is carcass yield or dressing percentage, which is higher in pigs fed ractopamine (Table 1).

Breeding herds

A limited amount of information is available regarding use of growth enhancers on breeding animals. Administration of growth enhancers to growing gilts makes them heavier at puberty but seems to have no effect on age at puberty or on reproductive performance. Severe health and reproductive disorders have been observed in gilts administered PST immediately before or during estrus and in sows during pregnancy.

Administration of PST to lactating sows results in increases in milk production of 10 to 25 percent and significantly increased percentages of solids, fat and lactose in the milk. Consequently, pigs nursing treated sows tend to be significantly heavier at weaning.

Treated lactating sows consume less feed, have a decreased percentage of body fat and weigh less at weaning, which may reduce their reproductive performance in subsequent parities. However, the increase in weight of nursing pigs may allow for weaning before the sow loses excessive weight.

Table 1. Average performance change in response to PST and ractopamine.

Trait	PST[1]	Ractopamine[2]
	(%)	(%)
Growth rate	15.2	8.4
Feed consumption	-15.0	-7.0
Feed/gain	-21.1	-12.7
Backfat thickness	-24.8	-15.3
Loin eye area	18.5	16.3
% muscle	9.9	9.3
Dressing %	-2.4	1.4

Source: Zimmerman, D. 1990. Growth enhancers. *In* Pork: Proceedings on new swine growth enhancers. Iowa State University, Ames. (Performance yields were compiled from numerous research studies.)

Note: Growth enhancers were administered to pigs from 100 to 200 lb through market weight. Pigs were fed complete rations of at least 15 percent crude protein.

[1]Dose varied from 1.5 to 10 mg/head/day.

[2]Dose equalled 20 parts per million.

Animal health

The role of PST in immune function and animal health is not totally clear. PST does not seem to reduce immune function and may in fact enhance immune function for some animals. PST may also improve the performance and carcass characteristics of pigs with chronic disease.

Beta-agonists can suppress or enhance the immune system depending on the type of immune response.

The overall, long-term health status of animals treated with PST or the beta-agonists is not well known. Long-term administration of growth hormone to dairy cows does not affect their health. Effects of long-term administration to lactating swine have not been reported.

How do genetics affect response?

Virtually all pigs respond to administration of beta-agonists and PST when fed diets adequate in protein and lysine. However, the response to growth enhancers varies across breeds, genotypes, sex and diets and is the focus of much ongoing research. Growth enhancers are not cure-alls for genetically poor-performing hogs.

Lean vs. fat hogs

The increase in lean tissue in genetically lean pigs treated with growth enhancers equals or exceeds the response in genetically fat animals in most studies. In other words, high-producing animals maintain or increase their advantage over poor-producing animals when treated with growth enhancers. As hogs become genetically leaner the magnitude of the response may change. However, genetically lean hogs will always be leaner than genetically fat hogs after administration of growth enhancers. The same situation exists for the other performance traits listed in Table 1. Consequently, use of genetically superior breeding stock will remain important and may become even more important as consumers demand leaner pork products.

Breed and line

Several studies have shown differing rates of response to growth enhancers among various breeds, breed crosses and lines. In some studies, the response of individual breeds or lines interacts with the level of protein in the ration. These results indicate that genetic makeup influences the nutrient partitioning (relative distribution of nutrients for protein and fat synthesis) caused by growth enhancers and that partitioning is affected by protein level. Contrary to most findings, certain breeds or lines that are genetically very lean, such as the Pictrain breed, may in fact consume more feed under the administration of growth enhancers in order to satisfy their high genetic and growth-enhanced potential for lean gain.

Sex

The response to growth enhancers of genetically similar hogs of different sexes differs for beta-agonists and PST. Barrows and gilts tend to respond equally to beta-agonists with no change in rank or relative performance. PST, on the other hand, tends to eliminate sex-controlled performance differences, particularly between gilts and barrows.

Barrows, which typically are fatter and lighter muscled than gilts, perform relatively better than gilts with PST administration, lessening or eliminating the sex difference. For most traits, the increase in performance of barrows and gilts is greater than that of boars although all three sexes significantly increase their level of performance. In general, PST tends to eliminate differences in performance among boars, gilts and barrows for most performance and carcass traits, while beta-agonists have little effect on performance rank.

How do growth enhancers affect pork composition and quality?

Composition

The primary effects of growth enhancers on the composition of pork are reductions of external (trimmable) fat and intramuscular fat (marbling). The effect on trimmable fat (backfat thickness) is well documented and described in Table 1.

Several studies using various growth enhancers have also reported reductions of 25 to 50 percent in the intramuscular fat of the loin muscle. In some studies of pigs treated with PST, the intramuscular fat of the loin was reduced to less than 1 to 1.5 percent of the total mass. The loss of intramuscular fat results in a high moisture content of the lean tissues. Growth enhancers appear to have no significant effect on the fatty acid composition of trimmable or intramuscular fat in treated pork.

Quality

Concerns have arisen about the effect of a reduction in intramuscular fat caused by growth enhancers on the tenderness, juiciness and flavor of pork. Several studies have been conducted using scientific equipment and trained sensory panels. Their conclusions have been variable, and the relationship between growth enhancers and the sensory attributes of pork has not been clearly established.

In general, some reduction in tenderness, juiciness and flavor has been observed in pork treated with growth enhancers. However, growth enhancers have much less effect on tenderness and juiciness than does internal end point cooking temperature. An end point temperature of 160°F is recommended for pork products. Intramuscular moisture content contributes to the tenderness and juiciness of the cooked product as much or more than intramuscular fat content.

Growth enhancers seem to have no effect on the sensory attributes of processed or cured products. They do reduce the average belly thickness and fat percentage of the belly. However, the reduction in belly thickness and fat percentage has no effect on the sensory attributes of the bacon.

What are the nutrient requirements of treated pigs?

Growth enhancers affect the conversion of feed to lean body tissue in the pig in two ways:

1. Pigs treated with growth enhancers produce a significantly larger amount of lean body tissue than untreated pigs. Consequently, pigs treated with growth enhancers have a higher protein (amino acid) requirement.
2. Pigs treated with growth enhancers convert feed into lean body tissue more efficiently than untreated pigs, and they utilize dietary protein and amino acids more efficiently. However, because treated pigs consume less total feed than untreated pigs, they may need a higher level of protein in the ration for maximum performance.

Statement number two is supported by studies showing that treated pigs are leaner and more efficient than untreated pigs when both groups receive similar diets. Treated pigs may have higher requirements for calcium and phosphorus. Growth enhancers seem to produce no change in energy requirements.

Various dietary nutrient requirements of growing pigs are altered to some degree by growth enhancers. The magnitude of the change in requirements depends on numerous variables including type of growth enhancer, dosage level and sex and live weight of the animal. The most appropriate diet formulation will depend on the particular growth enhancer and on the sex, weight status and performance potential of the pig.

What are the economic implications of growth enhancers?

Swine producers

The long-term economic impacts of the adoption of growth enhancers on the pork industry are not known. Most economists predict that the primary impact of growth enhancers will be a reduction in production costs combined with increased production of lean tissue per hog.

Initially, lower production costs will increase profit margins for early adopters. This, in turn, will likely stimulate a rapid increase in production. An increase in production will lower both on-farm and retail prices and lessen industry returns as a whole as farm prices fall. Consequently, most of the potential short-term profits generated by growth enhancers will be reaped by early adopters. If growth enhancers are widely adopted by the pork industry, it is likely that individual producers will have to use them to remain competitive.

Due to lower retail prices for pork and pork products, the retail pork industry may regain some ground lost to the poultry industry. However, aggregate pork producer profits will change very little in the long run. The primary beneficiaries of growth enhancers will be consumers because of the overall reduction in retail pork prices.

Many factors could alter the previous conclusions. Factors such as the long-term production impacts and side effects of growth enhancers are difficult to predict. Consumer perception of pork from treated hogs also could have a dramatic impact on the adoption and use of growth enhancers. Other factors include a potential shift in packer demand and specification, the implications and effects of international regulations, import/export restrictions on treated pork products and the effects of adoption of growth enhancers by the competing beef and poultry industries.

Swine processors

Little information is available relative to the effect of growth enhancers on carcass processing, fabrication techniques or carcass specifications. Although few serious problems are anticipated, virtually all segments of the pork processing industry will be affected.

Potential problems for the slaughter industry include an increased proportion of by-products, difficulty in removing skin, changes in carcass chilling rate and changes in cooler shrinkage. Potential problems associated with fabrication of pork into wholesale cuts include difficulty in handling softer lean tissue and difficulty in removing skin without exposing the muscle surface. Changes in water content and protein extraction properties may affect cured meat processing. Changes in belly thickness and the lean to fat ratio will also affect the composition of bacon.

Summary

The effects of growth enhancers on all aspects of the pork industry will be dramatic. Early adopters who have the necessary management and marketing skills will profit. However, the value of the benefits produced by growth enhancers will be passed on to consumers through a reduction in retail prices of pork products. In the long term, consumers will benefit most through the production of leaner, less-expensive pork. However, consumer acceptance of pork produced with growth enhancers could be a limiting factor in their adoption. Producers must be aware of the potential of these products and of the effects they will have on their production and management practices.

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