Transgenic Alteration of Sow Milk to Improve Piglet Growth and Health

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Inadequacies of Sow Lactation
In intensive pig production systems, piglets achieve only about half their potential growth-rate during a lactation period.

Rationale
The amount and composition of milk that a sow produces has a significant impact on the growth, health and development of her offspring. Piglet growth and health influences all subsequent aspects of pork production. In swine, 44% of the growth of suckling pigs is accounted for by the volume and solids content of the mother’s milk. Low milk production decreases piglet growth rate and results in decreased piglet weaning weight whether the piglets are weaned at 21, 14 or 7 days of age. This decreased weaning weight affects overall pig performance through the nursery, grower and finishing stages and also affects general piglet health. Decreases in weaning weight affect subsequent reproductive performance of females resulting in prolonged weaning to first estrus interval and lowers the ovulation rate and subsequent litter size.

Lactational efficiency may ultimately affect sow longevity in the herd, because a number of sows are culled from herds due to poor lactational performance. Current swine management schemes attempt to maximize the number of piglets born per litter and piglet survival. In order to utilize the larger litter sizes and keep the piglets alive and healthy, maximum milk production must be obtained. Indeed, the gains that have been made in decreasing newborn mortality combined with the increased litter sizes from selected high genetic merit sows make milk production and milk composition one of the most important limiting factors in piglet survivability and growth.

Project Objectives
1. To study the effects of increasing α-lactalbumin levels on milk production, milk composition, piglet health and survivability in sows transgenic for the bovine α-lactalbumin gene.

2. To generate transgenic swine that produce higher levels of the growth factor IGF-I in their milk and examine its effects on the growth, health and development of the piglets.

Introduction
Transgenic animals are animals that contain a gene or engineered gene that they would not have obtained through normal breeding or mating practices. The genes are transferred into the animals by injecting the gene of interest (DNA) into a developing embryo. In a small percentage of the embryos, the injected gene inserts into the DNA of the animal and becomes part of the animal’s genome. This allows the gene to behave like any other of the animals genes and the gene is passed on to the offspring in a normal fashion.

α-Lactalbumin is a major whey protein of cow and pig milk. Within the mammary gland, α-lactalbumin combines with β1,4 galactosyltransferase to form the enzyme lactose synthase. Lactose synthase produces the main milk carbohydrate, lactose. Lactose also is the major osmole
in milk causing water to be transported into milk.

Our hypothesis is that if more lactose is produced, the lactose will draw water by osmosis into milk and increase milk volume. Thus, we propose that increasing the level of α-lactalbumin in pigs will result in greater lactose production and greater milk volume. We have previously found that this occurs in mice.

Insulin-like growth factor I (IGF-I) is a bioactive protein found in the milk of mammals and at significantly higher levels in colostrum than in later stage milk. When IGF-I is given to piglets in milk replacer, it results in greater intestinal growth and maturation. IGF-I also increases the levels of intestinal enzymes. Based on these results, we wish to test the potential beneficial effect that higher levels of IGF-I in the milk may have on piglet growth, intestinal health and the weaning transition.

Results
Two lines of transgenic pigs containing the bovine α-lactalbumin gene have been produced. One of the lines is currently being studied, while the second line is being propagated to allow further investigation. The first line of pigs produce bovine α-lactalbumin in their milk at a concentration of 0.07%. This is approximately one-half the normal level of porcine α-lactalbumin found in milk, so we have increased the total α-lactalbumin production in these sows by 50% from approximately 0.14% to 0.21%. The effects that this increase has on milk production in the sows and on the growth of their piglets is being examined.

A transgenic boar containing a gene construct that will allow production of higher IGF-I levels in milk has been produced. He is currently being mated to produce transgenic sows that will allow us to study the effects of this gene on piglet growth and health. In addition to the initial boar, three additional transgenic boars have recently been produced with this same IGF-I gene construct.

Potential Impacts on the Swine Industry
1. Increasing sow milk production 10% would result in an additional $2.46 per litter weaned (Average litter size 7.8 piglets).

2. The increased weaning weight will improve the weaning transition and shorten the number of days to market or puberty.

3. Increasing the amount of IGF-I in sow=s milk will improve the intestinal health of the piglets.

4. Improved intestinal health may improve the weaning transition and also decrease the susceptibility to intestinal diseases.