Facts about Recombinant Bovine Somatotropin (rbST)

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Executive Summary

Recombinant bovine somatotropin (rbST) was among the first proteins produced through the use of 'biotechnology'. Initially, several companies actively pursued the development of rbST, but Monsanto's injectable-formulation proved advantageous. After a thorough review of well-controlled studies, the U.S. Food and Drug Administration (FDA) approved the commercial use of Monsanto's rbST in November, 1993 and commercial sales in the U.S. began on February 4, 1994 under the trade name "Posilac". At that time biotechnology was a new development and its application caused concern and uneasiness in some producers and consumers. This lack of familiarity contrasts sharply with today where 80-90% of the corn, soybeans and cotton grown in the U.S. are transgenic and recombinant-produced proteins are used extensively in the food and biomedical industries. Examples of proteins produced by recombinant technology include rennin used in production of cheese, lactase used to produce lactose-free milk, and insulin used to control human diabetes. Nevertheless, some still express concerns about the use of biotechnology in agriculture and medicine, and often times this concern is based on misinformation.

Scientists in academia, government and industry have conducted more than 2,000 scientific studies of bST throughout the world. These studies have clearly shown the efficacy, safety and benefits realized by integrating rbST into dairy production. Recombinant bST does not adversely affect the health of treated cows. Supplemental administration of rbST does not affect the quality or nutrient composition of milk or dairy products, and the milk and meat derived from rbST-treated cows are safe for human consumption.

Sustainability is an important consideration in agriculture, with emphasis on meeting human nutritional needs while mitigating the environmental impact of food production. Advances in agricultural productivity have allowed for the production of food that is safe, nutritious, and affordable. In particular, milk and dairy products are excellent sources of high-quality protein and many essential vitamins and minerals for the human diet. One technology that allows for the production of milk and dairy products with a lower resource input and a smaller environmental footprint is rbST. The research group of D. E. Bauman conducted the first studies with rbST in dairy cows and made many key contributions establishing the biology of somatotropin and the potential use of rbST in dairy production. The following uses a Question and Answer format to address common questions about bovine somatotropin and provide a list of selected reviews and key references from the Cornell research that can supply additional information as needed.

Question: What is bST?

Bovine somatotropin, also known as bovine growth hormone or BGH, is a protein hormone produced by the pituitary gland of cows. There are 20 amino acids that comprise the structure of all proteins and each specific protein has a unique sequence of amino acids similar to the use of letters in the alphabet to spell a word. These 20 amino acids are combined in specific sequences to form the individual proteins that comprise all life - plants and animals. Typically in a day we would consume over 50,000 different proteins from plant and animal source foods. When consumed orally, proteins are broken down in the digestive processes to amino acids which are then absorbed from the gastrointestinal tract. In the case of humans, the 20 amino acids are used to make the more than 10,000 different proteins in the body.

The sequence of amino acids dictates the three-dimensional shape and properties of each specific protein; the sequence of the protein bST is 191 amino acids. Recombinant-DNA technology has allowed for the commercial production of rbST which is biologically equivalent to natural pituitary-derived bST and has the same amino acid sequence plus one extra amino acid (the essential amino acid methionine) at one end.

Question: What is the history of bST?

The somatotropin (ST) story began in the 1920s and 1930s when it was discovered that an extract from the pituitary glands affected animal performance, including milk production by dairy cows. During the 1940s, U.K. scientists conducted an impressive series of studies that were driven by the food shortages associated with World War II. British scientists identified ST as the primary protein in the pituitary extract which was responsible for the increase in milk production, but found the availability of bST, obtained from the pituitary glands of slaughtered cattle, was too limited to significantly impact the UK milk supply. Additional studies were conducted over the next several decades, but work was limited by the supply of pituitary-derived bST and the dogma that bST would only be effective in fat, low-producing cows.

In the late 1970s, Cornell scientists D.E. Bauman and W.B. Currie proposed new concepts on the regulation of nutrient use during lactation. In a series of studies using pituitary-derived bST, Bauman's group demonstrated that bST markedly improved milk yield even in high-producing dairy cows. The results with pituitary-derived rbST coincided with advances in biotechnology including the development of recombinant DNA technology. Several companies committed to produce bST by recombinant technology and the first success was from a collaboration between Monsanto and Genentech. The rbST produced by this collaboration was used Bauman's group in the first studies with dairy cows in December, 1981. Thereafter, supply of rbST increased and rbST investigations in dairy cows expanded to include university, government, and industry scientists worldwide.

FDA approved Monsanto's rbST in November, 1993 and U.S. commercial sales began February 4, 1994 under the trade name Posilac. Posilac was marketed in the U.S. by Monsanto Dairy Business whereas Elanco distributed Posilac to countries outside the U.S. In October, 2008, Elanco purchased the Posilac business and became the world-wide distributor for rbST. Over the first 20 years of commercial use in the U.S., over 35 million dairy cows have received rbST supplementation.

Question: How does bST work and when is it used?

In lactating dairy cows, somatotropin is a major regulator of milk production. In biology terms it is referred to as a homeorhetic control and acts to coordinate metabolism thereby allowing more nutrients to be used for milk production. This coordination involves most organs and tissues in the body, and includes the metabolism of all nutrient classes – carbohydrates, lipids, proteins, and minerals. Thus, rbST-supplemented cows produce more milk and utilize nutrients more efficiently. The net effect is an improvement in milk output per feed resource input, commonly referred to as an improvement in "productive efficiency". Productive efficiency is highest for a dairy producer's best cows and indeed, genetically superior cows make more somatopropin and have a greater productive efficiency.

The period of rbST supplementation is done in synchrony with a cow's natural lactation cycle. A cow's peak milk yield occurs about eight weeks after the calf is born, and thereafter daily milk production gradually declines through the remainder of the lactation cycle. The use of rbST is initiated during the 9th or 10th week of lactation and continues until the end of lactation. Posilac is a plant oil formulation of rbST in which about 1-cc is injected subcutaneously (under the skin) at two-week intervals. There is some variation among individual cows and herds, but the typical response is a 4.5 kg (10 pounds) increase in a cow's daily milk yield. From a producer prospective the use of rbST makes all cows more like the best cows in the herd. Milk responses have been observed for all cows regardless of genetic merit and for all breeds of dairy cattle. There are no special nutritional needs other than feeding a balanced diet, and cows receiving rbST increase their voluntary intake to an extent needed to meet nutrient requirements. Comprehensive management programs related to nutrition, reproduction, and cow health are the same for cows of comparable production regardless of whether rbST supplements are used to achieve that production.

Question: What is the basis for the gains in productive efficiency?

Dairy cows are able to take feed resources and byproducts from the human food industry and convert them into a nutritious product - milk. Bioengeric studies established that one benefit from the use of rbST is that supplemented cows require less feed per unit of milk produced. This improvement in productive efficiency is a consequence of what is referred to as “dilution of maintenance”.

The feed used to maintain the cow is analogous to a fixed cost required for the dairy cow to live and carry out normal body functions, and a constant quantity of nutrients is required to meet the cow’s maintenance requirement regardless of her performance. Additional feed is required to make the milk, and the extra feed nutrients are constant for each increment of milk produced. For example, a cow producing 30 kg (~66 pounds) of milk per day uses almost one-third of her net energy intake to meet the fixed cost of maintenance. While the quantity of nutrients required for milk production increases as milk output increases, the fixed costs of maintenance are unchanged. Thus, rbST-supplemented cows have a greater feed intake to support their increased milk output, but all of the extra nutrients are used to make milk. Technologies like rbST which lower the quantity of feed required per unit of milk are of special value to dairy producers because feed constitutes the major component (about 50 to 70 percent) of animal production costs. The overall effect is rbST-supplemented cows use less feed resources to produce a gallon of milk.

Question: What are the environmental effects of rbST?

All food production has an environmental impact, but the environmental impact of dairy production is reduced when milk yield per cow is increased. A reduction in the amount of feed required to produce a unit of milk also means there is a reduced need for fertilizer and other inputs associated with growing, harvesting, processing and storing animal feed. Increases in productive efficiency are associated with a reduction in the production of methane, a greenhouse gas originating from the cow’s digestive processes and from manure and animal waste. The use of rbST allows each cow to produce about 4.5 kg (10 pounds) of extra milk per day, and the net effect of this is an 8 to 9 percent reduction in the carbon footprint per gallon of milk. To put this in perspective, if just 15 percent of the U.S. dairy herd was supplemented with rbST, the reduction in the carbon footprint to produce the same amount of milk would equal taking about 400,000 cars off the road each year, or planting about 300 million trees annually.

The dairy industry has made remarkable increases in efficiency, and the carbon footprint to produce of a gallon of milk has been reduced by almost two-thirds since 1944. The use of rbST continues this trend and allows the milk supply to be produced with fewer total cows and feedstuffs. Therefore, an adequate milk supply can be achieved, requiring less land and water to raise crops, which in turn means a reduction in soil erosion and the use of herbicides and pesticides. The reduction in total cows and feedstuffs to meet market requirements for milk also means less fossil fuel and electricity are required for the dairy and cropping operations, and the output of manure and animal waste is reduced. Thus, rbST use in dairy production mitigates environmental parameters including eutrophication and acidification potentials, greenhouse gas emissions, and fossil fuel use.

Question: What is the effect of rbST on milk composition?

Use of rbST has no effect on the composition of milk. This includes major milk components such as fat, protein and lactose as well as minor components including minerals and vitamins. There are minor variations in milk composition due to cow-related factors (e.g. genetics, stage of lactation, age, diet composition, and nutritional status) as well as environment and season, and these affect milk composition in an identical manner in rbST-supplemented cows and unsupplemented cows. Likewise, use of rbST does not affect milk flavor or any manufacturing characteristics, the latter being an especially important consideration for the production of processed dairy foods such as cheese or yogurt.

Question: What about retail milk labeled as rbST-free?

In addition to conventional (unlabeled) fluid milk, today's retail dairy case may contain milk labeled as 'rbST-free' or 'organic'. These specialty labeled milks represent an effort to develop market demand for niche products labeled according to production practices. However, studies comparing conventional milk with milk labeled as 'rbST-free' or 'organic' show at the retail level these milks have no important differences and are similar in nutritional quality and wholesomeness. Overall, there is no way to differentiate between milk from rbST-supplemented and non-supplemented cows. Milk is a wholesome, nutritious food and if properly handled, all milk, regardless of the production system, is natural, pure and safe.

FDA requires that all food labels include certain items, e.g., information about the nutrient content of a serving size of the product. FDA also allows labels to include information relating to product branding and the development of a niche market, as long as the information is truthful. The requirement for truthfulness represents a special challenge to processors wishing to label retail milk as rbST-free or organic because there are no compositional differences between the milks and no tests that can verify the label claim. To deal with situations such as this, FDA generally follows a practice that allows producers to sign an affidavit or provides for a third-party certification system. However, there was still a concern that the label "rbST-free" would be misleading to consumers by "incorrectly implying" that the milks were different in nutrition or wholesomeness. To address this, FDA requires the label for "rbST-free" milk also include a disclaimer statement that "no significant difference has been shown between milk derived from rbST-treated and non-treated cows."

Question: Is rbST harmful to cows?

The answer is an unequivocal no. The best indication of the health and well-being of a dairy cow is her own performance and productive efficiency. If cows are stressed or ill, then milk yield is reduced and the efficiency of feed utilization declines. The performance of cows receiving rbST supplements is exactly the opposite - they produce more milk and are able to utilize nutrients more efficiently.

The success of the dairy business is in large part dependent on the health and well-being of the dairy herd. It is the absence of stress and health problems that allows dairy cows to achieve high production. However, high producing cows are also at greater risk for various production-related metabolic disorders and health problems. Thus, a comprehensive management program is essential to the dairy operation; producers, veterinarians and dairy professionals are keenly aware that the production of the dairy herd reflects the management program, and the individual cow's performance is a clear indication of cow's own health and well-being.

The FDA approval of Posilac for commercial use was based on well-controlled studies conducted by university, government, and industry scientists around the world. Following approval, evaluation continued and several large scale field studies investigated the effect of use on commercial dairy farms with results published in peer-reviewed scientific journals. The largest of these was a Cornell investigation over an eight-year period on Northeast dairy herds which involved over 80,000 cows and 200,000 lactations. Results from these studies on commercial dairy farms uniformly confirmed that use of rbST increased the production of milk and milk components with no unmanageable adverse effects on variables associated with animal health and welfare including reproduction, mammary health, lameness and adequacy of body reserves. Thus, overall results including evaluation by FDA, numerous scientific reviews and dairy industry experience involving over 20 years and 35 million dairy cows provide clear evidence that commercial use of rbST has no adverse effects on animal health or welfare.

Question: Is the milk from rbST-supplemented cows safe?

The safety of rbST use has been extensively investigated and comprehensively documented. In addition to FDA, regulatory authorities and their review panels in more than 50 countries, including Canada and the European Union, have concluded that milk and dairy products from rbST-supplemented cows are safe for human consumption.

As one of the first products of biotechnology, the safety of rbST was also evaluated and confirmed by numerous scientific and biomedical groups. Examples include the joint World Health Organization/Food and Agricultural Organization committee (WHO/FAO), National Institutes of Health (NIH Consensus Conference), American Medical Association (AMA), Royal College of Canadian Physicians, American Dietetic Association (ADA), American Society for Clinical Nutrition (ASCN), Institute of Food Technologists (IFT), and U.S. Department of Health and Human Services (USDHHS).

Somatotropin has been the subject of scientific studies for over 50 years and thus there is an extensive base of knowledge about its biology. In particular, in the 1950s attempts were made to use bovine somatotropin to induce growth in humans afflicted with dwarfism. These studies proved that although there were no negative side effects, humans do not respond to bovine somatotropin. There were many considerations in the evaluation of the human safety of milk from rbST-supplemented cows; major reasons for the conclusion that the milk was safe for humans included:

1. rbST is a protein and when consumed orally it is digested, just as occurs for all dietary

proteins.
2. bST is not biologically active in humans even if injected directly into the bloodstream.
3. Milk from rbST-supplemented cows does not differ in composition from milk produced by unsupplemented cows.

There are presently 20 countries where rbST has approval for commercial use, but the human safety of dairy and meat products from rbST-supplemented cows has been confirmed by regulatory authorities in over 50 countries. Even countries that don't allow the commercial use of rbST (e.g. Canada and European Union) allow the import of dairy products from rbST-supplemented cows with no restrictions or special labeling requirements.

Question: Isn't rbST a hormone?

Somatotropin is a naturally occurring protein hormone. Hormones are chemical messengers that are transported in the blood to affect body processes like metabolism and reproduction. Hormones can be broadly divided into two types: protein hormones and steroid hormones. Protein hormones include somatotropin and insulin, and if consumed orally they are digested like other proteins and rendered inactive. This fact was first confirmed for somatotropin in laboratory rats fed large quantities of bST. Just as diabetics must receive insulin injections for this protein hormone to be biologically active, cows have to receive injections of rbST for it to be active.

Humans also make somatotropin, referred to as hST (human somatotropin). While it is similar to bST in structure there are differences in the amino acid sequence. As a consequence the three dimensional configuration of bST and hST differ, such that bST is not biologically active in humans even if injected directly into the bloodstream.

Question: What about hormones in the milk?

Milk contains trace levels of somatotropin, less than one part per billion, and these levels don't differ in the milk from cows receiving rbST supplements and unsupplemented cows. As mentioned earlier, the protein hormones in foods are rendered inactive because they are digested similarly to other dietary proteins. As mentioned earlier, clinical studies in the 1950's demonstrated that bST is not biologically active even if directed directly into the bloodstream of humans. Although hST and bST are similar in size, there is a 30% difference in amino acid sequence resulting in the two proteins differing in 3-dimensional structure such that bST is not functional.

Milk also contains trace levels of other hormones and their concentration range does not differ between milk from cows supplemented with rbST and milk from unsupplemented cows. Insulin-like growth factor-1 (IGF-I) was of special interest because a cow's blood levels of IGF-I are elevated in rbST-supplemented cows, although milk concentrations do not differ from the IGF-I range observed for unsupplemented cows. IGF-I is produced by most cells in the body and is critical for human health because of its role in cell maintenance and repair. Milk IGF-I was deemed to be of no human health concern because levels are low (a glass of milk contains less than one-ten thousandth of the daily production by the human body) and when consumed orally it is digested like other dietary proteins (see reference list for IGF-I Fact Sheet). In fact, recent studies with premature newborns and young adults failed to show any absorption of orally-consumed IGF-I.

Question: What about antibiotic residues and pesticide levels in the milk?

All milk is tested for antibiotics, and none with antibiotic residues is allowed to enter the food chain. The antibiotic testing occurs for samples of each milk load from individual farms, and additional tests occur at several points during the milk's journey from farm to market. If antibiotic residues are detected, the milk is discarded and the producer receives a severe penalty.

The U.S. Department of Agriculture (USDA) analyzes foods, including retail milk and dairy products, for pesticide residues using the tests and standards set by the Environmental Protection Agency. Results are posted on the USDA website; results verify the rarity of violations.

Question: Why is rbST not used in some countries?

Recombinant bovine somatotropin has been approved for commercial use in over 20 countries but some countries, such as Canada and countries in the European Union, do not allow its commercial use. Reasons for countries having not yet approved commercial use are varied, ranging from concerns about animal well-being and production quota-based marketing systems to social customs, preference for traditional food production systems and general opposition to new technologies. Nevertheless, these countries, including Canada and the countries in the European Union, have confirmed the human safety of milk from rbST-supplemented cows and allow imported dairy products from countries using rbST to be marketed with no restrictions or special labeling requirements.

Question: How does rbST impact sustainability of the dairy industry?

The overarching goal of a sustainable agriculture system is to produce sufficient nutritious and safe foods that are accessible and affordable for the population. Food security is a challenge; a 2009 USDA report estimates that more than 17 million American children were at risk of hunger last year – this is an essential issue for the US public and agricultural industry to address. However, as we look toward the future, achieving global food security will be an even greater challenge. The world population is estimated to increase from the present 6.7 billion to over 9 billion by the year 2050. Resources including land are limited and a 2009 UN/FAO Report concluded that advances in technology will have to play a central role in meeting future food needs - their estimate is 70% more food will be needed by 2050 and that 80% of this additional food supply must come from improved productivity.

Recombinant bovine somatotropin is one of a long series of technologies which have improved the sustainability and productivity of the dairy industry. A few examples include artificial insemination and genetic selection, feed analyses and the formulation of balanced rations, improvements in milking systems and milking management practices, and advancements in illness treatments and the development of herd health programs. The rbST technology continues this tradition by reducing feed and resource inputs, reducing animal waste output, and mitigating the environmental effects of milk production. Overall, rbST is a management tool that improves the sustainability of the dairy industry with benefits accruing to producers and consumers.

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