

The Efficacy, Safety and Benefits of Bovine Somatotropin and Porcine Somatotropin

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by

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Please Note: For the web site version of this report, tables are provided but diagrams are not.

Executive Summary

As the world's population grows, the National Research Council estimates that the supply of food required to adequately meet human nutritional needs over the next 40 years will be equal to the amount of food previously produced throughout the entire history of humankind. To meet this demand, animal scientists must develop new technologies to increase productive efficiency (that is, the yield of milk or meat per unit of feed), produce leaner animals and provide increased economic return on investment to producers. During the past decade, scientists have developed many new agricultural biotechnologies that meet these goals. Their adoption will have many positive effects on food production, processing and availability.

On November 5, 1993, the Food and Drug Administration (FDA) approved the first biotechnological product for animal production, bovine somatotropin (bST) for commercial use. This action ushered in a remarkable new era for animal agriculture and the dairy industry. BST use results in a substantial increase in milk yield (4 to 6 kg/day or 10 to 15%) accompanied by an approximate 12% increase in productive efficiency. Milk yield increases in a dose-dependent manner and the composition of milk is unaltered.

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 bST into dairy production. BST does not adversely affect the health of treated cows. Supplemental administration of

bST does not affect the quantity of bST found in milk or the milk's composition. Milk and meat derived from bST treated cows are safe for human consumption.

A second biotechnology product, porcine somatotropin (pST), likely will be approved shortly by the FDA. When maximally effective doses of pST are given to growing pigs, there is a marked increase in growth rate (10 to 15%), productive efficiency (body weight gain/feed consumed) is increased by as much as 15 to 35%, and carcass fat is reduced by as much as 80%. Producing leaner pork will benefit consumers who wish to reduce their intake of total and saturated fat.

Technologies that lower the quantity of feed consumed per unit of output (meat or milk) will also benefit the producer — because feed constitutes the major component (about 50 to 70 percent) of animal production costs. The use of bST and pST will also have a beneficial effect on the environment.^{2,3} A reduction in the amount of feed required to produce a unit of meat or milk would reduce the need for fertilizer and other inputs associated with growing, harvesting, processing and storing animal feed. Increases in productive efficiency reduce the production of animal wastes including methane.

Although the biotechnological advances made in the past 15 years have been accepted by the scientific community, public misunderstanding about the safety and benefits of bST and pST endures. Many consumers do not receive factual information or, even worse, hear misinformation about biotechnology. Thus, it is difficult for them to evaluate accurately the safety and benefits of these products. It is important that credible scientists and scientific organizations make an effort to inform consumers about the benefits and safety of bST and pST. To benefit society, biotechnology products must provide tangible benefits and be accepted by the public as safe.

What Is Bovine Somatotropin (BST)?

Somatotropin (ST) is a naturally occurring protein hormone produced in and secreted from the anterior pituitary gland. It is the master hormone regulating the growth of humans and other animals. It also markedly stimulates milk production and improves productive efficiency.

Insufficient production of ST during childhood markedly retards human growth, resulting in short stature at maturity (dwarfism). In advanced countries, dwarfism is not a common occurrence because physicians can diagnose and treat it with recombinantly-derived human ST (hST). Because of the remarkable effects that ST has on

growth, it also is referred to as growth hormone. However, because somatotropin has many important and diverse biological roles that affect the metabolism of all classes of nutrients,^{2,4} it is preferable to call it somatotropin.

All protein hormones, including ST, are made from naturally occurring amino acids that are derived from the digestion of dietary protein. BST contains 191 amino acids and shares a high degree of amino acid sequence similarity in the range of 90% with somatotropins from other farm animals.^{4,5} Although the amino acid sequence is quite similar among farm animals, there are unique differences when comparisons are made with human ST. For example, the amino acid sequence of hST differs by approximately 35% from that of bST.^{6,7} Because of this, bST is not active in humans even if it is injected into the bloodstream. This is an important attribute assuring its safety for the consumer.

What Is a Hormone?

The circulatory systems of humans and animals are packed with chemical messengers called hormones. These hormones travel through the bloodstream in search of specific hormone receptors on distant cells. There they bind to these receptors and initiate a vital cascade of life-sustaining events inside each cell. Hormone receptors are extraordinarily selective in their ability to recognize and bind to hormones. This property confers great specificity in hormone action.

The behavior of both humans and animals is governed by hormonal signals which are received, decoded and acted on by the appropriate cells that make up tissues and organs. A cell that can respond to a specific hormone is called a target cell for that particular hormone. There is great specificity in the endocrine system. Not all cells respond to all hormones; thus, certain hormones may have very potent effects in some cells and no effect in others.

The Endocrine System

The endocrine system is comprised of cells organized into glands that release many different hormones into the bloodstream, where they circulate throughout the body. Ernest Henry Starling introduced the word hormone in 1905. It is derived from the Greek verb hormao meaning to excite or arouse. A hormone is defined as a substance that affects the activity and function of target tissues. Thus, hormones serve as messengers to coordinate or to orchestrate many cellular events in the body. The endocrine system consists of primarily two classes of hormones: protein hormones and steroid hormones. Protein hormones are made of individual amino acids linked

together in precise sequences. These amino acid sequences are specified by the genetic code stored in DNA and make each protein unique. In contrast, steroid hormones are lipid-like molecules derived from cholesterol. There are literally scores of hormones circulating in the blood at any given time in humans and animals. The vast majority of these hormones are present at concentrations less than 10×10^{-9} grams/milliliter of blood (<10 parts per billion (ppb)).

The term “hormone” alarms some people. This is likely the result of numerous articles in the lay press about athletes illegally using massive doses of anabolic steroids (steroid hormones). There are a number of serious side effects caused by taking massive doses of anabolic steroids. Because of this, it is important to distinguish a protein hormone from a steroid hormone because their biological effects are different. As shown in Table 1, the biological differences between protein hormones and steroid hormones need to be appreciated to understand why bST poses no increased health risk to consumers.

The History of BST

Evans and co-workers first demonstrated the presence of a substance in the anterior pituitary that increased the growth rate of rats in the 1920s.^{8,9} By the 1930's, subsequent studies revealed that administration of a crude anterior pituitary extract stimulated lactation in laboratory animals and increased milk yield of lactating goats.¹⁰ Asimov and Krouze¹¹ conducted the first substantial study involving over 500 dairy cows and found that administering crude pituitary extracts increased milk yield. During the 1940s, further research established that the component in the crude pituitary extracts that increased milk yield and stimulated growth was the same substance, somatotropin.^{12,13} In the mid-1950s Brumby and Hancock¹⁴ conducted the first study of the effects of long-term administration of bST preparations on lactation on twin cows. Milk production increased by approximately 50% in the twin which received daily injections of bST for 12 weeks compared with the control twin. Machlin¹⁵ obtained similar results in a 1973 study by using a more highly purified source of naturally-occurring pituitary bST.

When Machlin reported his results there was little enthusiasm for the commercial development of a bST-based product for the dairy industry since it was prohibitively expensive to purify bST from bovine pituitary glands, and the quantity of cattle pituitaries was insufficient to provide an adequate amount of bST. This changed dramatically with the development of biotechnology techniques in the mid-1970s. Using these tools, scientists made some of the most significant scientific advances in the history of humankind. Landmark breakthroughs in biotechnology permitted the

large-scale production of recombinantly-derived bST. This was a major milestone because large quantities of recombinant bST made possible studies that previously could not have been conducted. In 1982, the first study of the effects of recombinant bST on milk production was reported in the scientific literature.¹⁶

The Efficacy of BST

The data base establishing the production response to bST is impressive.^{2, 17-23} Somatotropin supplementation modifies the shape of the lactation curve (see Figure 2;^{17,24}) in two ways by: (1) shifting to a higher level of milk production and (2) improving the persistency of lactation.* On average, milk yield is increased 4 to 6 kg/d or about 10 to 15% . This is associated with a significant increase in productive efficiency of about 12%.

Because bST is a protein, it cannot be fed to cows since it would be digested in the gastrointestinal tract into individual amino acids and peptide fragments which have no hormonal activity. As a result, bST has to be injected into the circulatory system. In early studies, it was necessary to administer bST daily because the hormone — like all protein hormones — is not stored in the body. It is removed rapidly from the circulation and inactivated (a normal process involving the breakdown of proteins). A more practical commercial method for treating cows was needed. Subsequent research led to the development of a product in which the bST was formulated as a sustained-release preparation. Using this formulation, a dairy farmer need not inject cows daily, yet a portion of the hormone is released into the circulation each day. This provides significant labor savings.

The quantity of bST necessary to cause a significant lactation response is small. For example, the first bST product to receive FDA approval is a 14-day sustained-release formulation that contains 500 mg of bST. Each day a portion of the bST (approximately 36 mg) is released into the bloodstream of the cow.

The increase in bST concentration in blood initiates a number of biological events that account for the changes in milk yield and productive efficiency. The biological mechanisms by which bST acts have been reviewed in articles by Bauman² and Bauman and Vernon.⁵

The response to bST in milk production varies according to the stage of lactation. In general, the response is minimal when bST is administered early in the lactation cycle,** prior to peak milk yield. Therefore, commercial use will involve bST supplementation over the last two-thirds to three-fourths of a lactation cycle with the

increase in milk yield persisting over this period. Because of this, dairy farmers should begin bST supplementation in healthy cows nine weeks after calving. Quality of management will be the single most important factor in determining response in milk production to bST supplementation .

The Effects of BST on Milk Composition

Bovine somatotropin does not change the composition of milk in any significant way. The concentration of fat and protein in milk varies due to genetics, stage of lactation, age, diet composition, nutritional status, environment and season.^{25,26} These factors also affect the composition of milk from bST-supplemented cows. Any minor differences in milk composition from bST supplementation are within the normal range. The variations in the content of fat and protein in milk are of the same magnitude as those usually observed in cows not supplemented with bST.²⁷

Many detailed chemical analyses of milk from bST-treated cows have been conducted.^{2,23,27} Generally, bST supplementation does not alter the proportion of total milk protein represented by whey proteins and caseins.²⁸⁻³¹ Milk from cows supplemented with bST does not differ in the quantity of vitamin A, thiamin, riboflavin, pyridoxine, vitamin B-12, pantothenic acid or choline; the content of biotin increases slightly.^{29,32}

BST naturally occurs in cows' milk in very small quantities (only 0.000006 % of all the milk protein is bST).*Supplemental administration of bST does not affect the quantity of bST found in milk*^{2,27,33}

Another protein hormone found in milk, insulin-like growth factor I (IGF-I), is regulated by bST. Because the biological effects of IGF-I are not species-specific, as they are for bST, some opponents suggested that this poses a safety concern. When bST is administered to dairy cows, the concentration of IGF-I in blood increases about three-fold and the levels of IGF-I in milk can increase up to two-fold.^{2,27,32,34} Nonetheless, IGF-I in milk does not pose a safety risk because it is a protein and is digested like all other dietary proteins.³³ Furthermore, IGF-I is present in human breast milk, and at levels as high or higher than the levels in milk from bST-supplemented cows.³⁵

Studies have also determined that bST does not affect milk flavor nor any manufacturing characteristics that are important during the production of processed dairy foods such as cheese or yogurt.^{2,27}

The Effects of BST on the Nutritional Needs of Dairy Cows

The nutritional needs and responses to adjusting the diets of cows supplemented with bST have been reviewed in depth.^{1,2} Studies have examined the production responses to bST under a wide variety of feeding programs. Obtaining a response in milk production to bST does not require special diets or unique feed ingredients. It is important that the diet meet the cows' nutrient requirements which are influenced by the milk yield. Cows supplemented with bST increase their food intake to provide the extra nutrients needed to sustain the increased milk production, but the nutrient composition and density of the diet do not need to be modified.

Cows typically adjust their voluntary feed intake upward within a few weeks after initiation of bST supplementation.¹⁷⁻¹⁹ Thus, to maximize the milk response to bST, dairy farmers must be attentive to management factors that affect food intake. High quality forage is a critical component in obtaining high levels of voluntary intake. Other important factors that farmers must consider to optimize the response to bST are: ad libitum feeding (free access to feed at all times), unlimited access to clean cool water, nutritionally balanced diet, adequate dietary protein, proper levels of digestible fiber and control of temperature and humidity. If cows consume an insufficient quantity or imbalanced composition of nutrients, the response to bST will decrease according to the extent of the inadequacy.²

Animal Safety and Health

In addition to establishing the effectiveness of bST, companies seeking regulatory approval of the product were required by FDA to prove that it was safe. Evidence of bST's safety was required in three areas: 1) the safety of animal food products (milk/beef) for humans, 2) the safety of bST for the treated cow and 3) the safety of bST for the environment.

Safety concerns were seized upon by some opponents of biotechnology in an attempt to misinform the public and politicians about bST. They waged their campaigns in an attempt to gain support for their cause and to hinder FDA approval of the product.^{36,37} Opponents made unsubstantiated claims in the popular press that bST would reduce resistance to infectious diseases and thus increase the incidence of sickness in dairy cows.³⁸⁻⁴¹ Responsible scientists* and scientific and governmental organizations** addressed this issue rigorously and concluded that bST is safe and does not adversely affect animal health.

To verify that bST is safe for dairy cows, the FDA required that safety margins be

established. This was done by treating cows with 60 times the commercial dose of bST over a two-week period and up to six times the commercial dose for two consecutive lactations.⁴²⁻⁴⁴ These studies showed that administration of large doses of bST did not affect animal health. A recent review of the literature reinforces this important point. Bauman² surveyed hundreds of studies in which cows were supplemented with bST and did not find a single study that linked bST with an increased incidence of ill health.

There have been some claims in the popular press that bST increases the incidence of clinical mastitis (inflammation of the udder). Susceptibility to mastitis is related to many factors including, but not limited to, season, stage of lactation, environment and milking management. A recent report evaluating 15 full lactation trials (914 cows) and 70 short-term studies (2,697 cows), after accounting for all major factors, found that a small positive association remained between milk yield and mastitis on a per cow basis.⁴⁵ This relationship allows critics to make the increased mastitis charge, but their interpretation is erroneous. BST supplementation causes no more mastitis than would have occurred with any increase in milk yield. More importantly for farmers and consumers, mastitis incidence declined slightly per volume of milk produced. In addition, there is evidence which indicates that bST supplementation is associated with a more rapid recovery of milk secretion in mammary glands of cows experimentally infected with bacteria that cause mastitis.⁴⁶ A recent publication by the International Dairy Federation confirmed that treatment with bST has no effect on the incidence of mastitis.⁴⁷

BST Is Safe for Humans

BST is naturally present in cows' milk and meat.⁴⁸ With respect to meat, bST supplementation of cows for 28 days does not significantly increase bST concentration.⁴⁸ Even if there were an increase in ST concentration in meat as the result of ST supplementation, this would not be a human food safety concern.³³ The scientific basis for the FDA conclusion that milk and meat from bST-supplemented cows is safe is based on the following scientifically established points:

1. BST is a protein and, like all other plant and animal proteins in the diet, it is digested to single amino acids and very small peptides through a combination of the low pH conditions and the digestive enzymes found in the stomach and upper small intestine. The resulting amino acids have no hormonal activity. This has been confirmed in studies reviewed by the FDA in which bST was administered orally to rats for 90 days at doses up to 50 mg/kg/day.³³ Each study met the FDA's minimum requirement of at least 14 days of supplementation with up to 100 times or more of

the bST dose projected to be used commercially for the target animal (based on a mg/kg body weight basis).

2. In addition, pituitary-derived somatotropin from farm animals⁴⁹ and other non-primates⁵⁰ is inactive in human children and adults even when injected. Subsequent research has shown that this “*species-limited*” effect occurs because the amino acid sequence of bST differs from that of hST by approximately 35%.^{6,7,36,51} As a result, somatotropin receptors in human cells cannot recognize bST.^{52,53} Thus, even if a human were injected accidentally with bST, there would be no hormonal effect.

The Environmental Impact of BST

Environmental pollution from dairy operations will be reduced with bST use because of increased productive efficiency.² This benefit occurs because less feed is required to produce a unit of milk (a 12% decrease). With the quantity of milk produced in the United States in 1988 as a base and assuming a 100 percent adoption rate, a marked reduction in the total amount of cereal grains fed to all dairy cows in the U.S. could be projected along with a reduction in the production of animal wastes . These projections, however, represent the maximum likely benefits. Realistically, it is difficult to predict the environmental impact of bST because it is not possible to determine the proportion of dairy farmers that will adopt the technology. Adoption of all new technologies by society is gradual. Rarely does any technology achieve an adoption rate of 100%.

Common Questions about BST

Is bST “natural”?

The use of the word natural is somewhat misleading because the structure of a protein depends upon its amino acid sequence rather than upon the organism that produces it. Recombinantly-produced bST contains the same amino acids in the identical sequence as bST produced by cows. Some opponents of bST contend that recombinantly-derived bST produced in bacteria or yeast has a different shape and different properties than the bST produced by a cow — this is not true. The shape of the recombinant molecule and all of its biological properties are identical to that of bST produced in the cow’s pituitary gland.

Furthermore, the source of a molecule should not prejudice us against its use. As a society, we already have accepted recombinant products in the medical arena. Today, many recombinant pharmaceuticals are used to treat and cure illness world-wide. For

example, insulin for the treatment of diabetes is a recombinant protein as is the human ST given to children with growth disorders.

Are there increased levels of bST in milk from cows supplemented with bST?

No. BST is normally found in cows' milk, and many studies have shown that bST supplementation does not affect the concentration of bST in milk.

Can bST be absorbed into the bloodstream of humans?

No. All proteins in the diet (including bST) are digested into individual amino acids and peptide fragments in the stomach and small intestine. The digestion process destroys the hormonal activity of all dietary proteins. Numerous studies reviewed in this report support the conclusion that bST is not orally active.

Is milk from bST-supplemented cows safe for children and adults?

Yes. As a part of the approval process, FDA has concluded, based on convincing evidence, that milk from bST-supplemented cows is safe for humans and is similar compositionally and nutritionally to ordinary milk.

Will supplementing cows with bST increase antibiotic residues in milk?

No. Federal and state monitoring programs, as well as testing by farmers and processors, ensure the safety and wholesomeness of milk. Milk is the most monitored product in the American food supply. Every shipment of milk is tested and thoroughly inspected several times during the journey from the farm to the grocery store. The vast majority of milk contains no residues, and in all instances the milk supply meets strict government-established residue safety limits.

Dairy farmers appreciate the importance of good animal health to optimize milk production and productive efficiency. To maximize their economic return, they must be attentive to animal health. The most effective means of reducing antibiotic residues in milk is to minimize the need for animal medicines. To do this, dairy farmers and veterinarians employ preventive herd health programs. These are effective, yet even with sound herd health management practices in place, dairy cows may contract a number of illnesses. When this occurs, medications such as antibiotics are an effective, appropriate and legal means to help sick cows regain their health. All medications used on cows must be approved by FDA. To prevent residues from entering the milk supply, FDA has established withdrawal periods that require farmers to wait a

specified time (72 to 96 hours) before including the milk from treated cows in the commercial milk supply.

As previously discussed, there is no evidence whatsoever that bST increases the incidence of illness in dairy cows. On the contrary, there is evidence to indicate that bST may have beneficial effects on cow health.² Somatotropin plays a key role in maintaining the immune system which protects animals against disease. Immunity and disease resistance are compromised in laboratory animals and humans that have low levels of somatotropin in their blood.²

Does consuming milk from bST-supplemented cows increase the risk of developing allergies?

No. Milk from bST-supplemented cows is the same as milk from non-supplemented cows. Individuals who were not allergic to milk products prior to the use of bST will not be allergic to milk from bST-supplemented cows.

Has bST been approved for use in other countries?

Yes, at this writing bST has been approved for commercial use in Brazil, Bulgaria, Costa Rica, The Czech Republic, Jamaica, Mexico, Namibia, Russia, South Africa, the Ukraine and Zimbabwe.

The Safety and Efficacy of Porcine Somatotropin (PST)

In addition to bST, other animal biotechnology products are under commercial development. With respect to meat animals, one of the major research efforts has been to develop effective and commercially feasible means of reducing animal fat. Porcine somatotropin (pST) meets this objective.⁴ This technology involves treating growing pigs with pST for the last 60 days before marketing the animal (at a body weight of 100 to 110 kg). The results of this research are impressive; maximally effective doses of pST have been shown to: (1) increase growth rate by 10 to 20%; (2) improve productive efficiency by 15 to 35% (i.e., increase body weight gain/unit feed consumed); (3) decrease carcass fat (adipose tissue) by as much as 80%; and (4) increase muscle growth by as much as 50%.^{54,55} The most important of these for the consumer is that the pork is leaner.

For those who consume pork, having a leaner product available will help them decrease their intake of total fat and saturated fatty acids (SFA) and reduce their risk of chronic diseases. Numerous recommendations have been made for Americans to

reduce their intake of fat to 30% of calories (presently fat intake is 37%) and decrease SFA intake to between seven and 10% of calories.^{56,57} These recommendations are based on numerous studies which have established that some dietary SFA elevate total and low-density lipoprotein-cholesterol (LDL-C) levels.^{58,59} This is an important health issue since an elevation of total and LDL-C is a major risk factor for coronary heart disease (CHD). Based on the role that dietary fat plays in the development of CHD and other chronic diseases, it is clear that animal scientists must develop and implement new cost effective and efficient strategies to reduce carcass fat. Not only is it important to reduce the fat content of fresh meat but there is also a need to reduce the quantity of fat in processed meat products.

The safety issues regarding pST are virtually identical to those discussed for bST because pST and bST are very similar (the amino acid sequences of the two molecules are 90% identical). As a result, pST does not have any biological effects in humans because human cells do not react to it. At this writing, the FDA has not yet approved pST for commercial use. Nonetheless, a large body of evidence indicates that pST is effective and poses no increased health risk to pigs or humans.^{4,36,60}

Consumer Issues

Although bST and pST have been received with great excitement in the scientific community and their development through biotechnology represents one of the most important recent scientific breakthroughs in animal agriculture, there is misunderstanding among the public about their safety and benefits. Because scientists do not present the facts publicly often enough about safety of these products, consumers are susceptible to campaigns conducted by opponents of bST or pST in which these products are unjustifiably condemned as posing a health risk to humans or target animals.

The public discussion between proponents and opponents of ST, in particular bST, has been controversial and typically has involved scientists responding to misinformation disseminated by groups who oppose the use of animals for food production or oppose the adoption of new technology in general. Many of the claims made by opponents of agricultural biotechnology are designed to scare the public rather than address the scientific facts. One example of this “scare tactic” is characterized by the erroneous statement that bST would cause antibiotic-resistant infections in the public and create infections in humans similar to AIDS.⁴¹

Consumers form perceptions about a food’s safety based either on what they hear from scientists or alternatively from activists whose ideas are not supported by valid scientific findings. From a scientific viewpoint, bST and pST are efficacious and safe

products. Results from more than 2,000 studies support the position that these technologies do not increase risk for either the consumer or the target animal. As the world population continues to expand, advances in technology which increase productivity and productive efficiency will be imperative. Nonetheless, it is the attitudes and beliefs of consumers about bST, pST and other products of biotechnology that will determine whether they will be adopted successfully.

Table 1.

Biological differences between protein hormones and steroid hormones. 2, 4

<u>Protein Hormones</u>	<u>Steroid Hormones</u>
Bind to specific cells	Can accumulate in the body
Are not stored in adipose tissue (fat)	Are stored in body fat
Are complex protein molecules made of amino acids	Are organic molecules derived from cholesterol
Have species-specific biological effects	Do not have species-specific effects
Are orally inactive and are digested in the stomach and small intestine into amino acids like all other dietary proteins	Can be orally active and absorbed intact
Are rapidly broken down (degraded) in the body	Are not rapidly degraded and can have residual effects

Table 2.

A summary of the effects of bovine somatotropin (bST) on milk yield. a

Review Reference	Milk yield (kg/day) at different doses of bST (mg/day)				
	0	5	10-15	20-27	31-50
Chalupa and Galligan, 1989 ^b	24.9	+3.6	+3.8	+5.0	+5.7
Chilliard, 1988 ^{c,61}	26.0	+2.8	+4.1	+5.3	+6.2
Erdman <i>et al.</i> , 1990 ^{d,62}	25.6	+1.8	+3.5	+4.2	+4.8

^a Milk yield is presented as kg/day for control animals and as the response (kg/d) to treatment with different doses of bST.

^b Data are summarized from 7 studies reviewed in the paper.

^c Data are summarized from 20 studies reviewed in the paper.

^d Data are summarized from 44 studies using 3,286 cows.

Table 3.**Effects of bST on milk composition. ^a**

	from bST-supplemented cow	from control cow
% Fat	3.7	3.8
% Protein	3.2	3.3
% Lactose	4.8	4.9

^a*Adapted from Daughaday and Barbano.²⁷***Table 4.****Quantity of selected proteins found in cows'milk.^a**

<u>Protein fractions</u>	<u>Percent total milk protein</u>
Caseins (Alpha, beta, gamma, kappa)	76-86
Whey Proteins	14-24
Lactalbumin	10-16
beta-lactoglobulin	7-12
alpha-lactalbumin	2-5
Serum albumin	0.7-1.3
Bovine Somatotropin	0.000006
Insulin-like growth factor I (IGF-I)	0.00003

^a*Adapted from Daughaday and Barbano.²⁷ and The Technical Manual for POSILAC (Monsanto Co., 1993).*

Table 5.

Impact of bST on feed requirements and waste production of dairy cows. ^a

<u>Variable</u>	<u>Impact of bST ^b</u>
Number of cows	decrease 10.7 %
Milk yield per cow	increase 12.0 %
Feed	
Corn	decrease 2.5×10^9 kg
Soybean meal	decrease 5.6×10^7 kg
Animal Waste	
Manure	decrease 6×10^9 kg
Urine	decrease 8×10^9 liters

^a US milk production in 1988 was 66×10^9 kg. Data contained in this table were adapted from Bauman (1992).

^b The estimates were based on a 100% adoption rate and that the average milk yield per cow would increase by 12%.

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