Review On The Role Of Bovine Somatotropin Hormone On Milk Production

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Abstract: Biotechnology has the potential to improve the productivity of animals via increase in growth, carcass quality and reduced waste through more efficient utilization of resources. Bovine somatotropin is the first biotechnological product for animal production. Recombinant bovine somatotropin (rBST) is a supplement that increases milk production in healthy lactating cows by increasing activity and/or longevity of mammary secretary cells via Insulin-like Growth Factor (IGF)-I and coordinating metabolism of nutrients, allowing farmers to produce safe, nutritious milk without affecting milk composition. Milk from Recombinant bovine somatotropin-supplemented cows, like milk of un-supplemented cow is a good and wholesome source of vital nutrient. Supplemented cows have a greater feed intake to support their increased milk output. Commercial use of recombinant bovine somatotropin has no adverse effects on animal and human health. The technical constraint use of bovine somatotropin in developing countries will be the cost of bovine somatotropin, disease, lack of awareness about their use, inadequate quality Feed resources and disease condition. Cows which are subjected to poor quality management will be no response to recombinant bovine somatotropin (rBST) supplementation. In order to economic return the recommended use of this technology is only on farms where cows are fed and managed properly.
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1. Introduction

Livestock contribute directly to livelihoods worldwide, providing not only food, but also non-food products, draught power and financial security [1]. For generations, food production increased with the help of new technologies, such as crop rotation, fertilizers, information management, and selective breeding of plants and livestock. Now, biotechnology claim that it will supply more food at less cost to meet growing demand at home and abroad in markets that will become more competitive [2].

Biotechnology has the potential to improve the productivity of animals via increase in growth, carcass quality and reproduction, improved nutrition and feed utilization, improved quality and safety of food, improved health and welfare of animals and reduced waste through more efficient utilization of resources. Therefore, the biotechnology of livestock production is growing faster than any other sectors [3]. It have contributed immensely to increasing livestock productivity, particularly in developed countries, and can help to alleviate poverty and hunger, reduce the threats of diseases and ensure environmental sustainability in developing countries [4]. Recombinant DNA technology, also known as genetic engineering is a means of altering the genes in a living organism to produce a Genetically Modified Organism (GMO) with a new genotype. It is a technique used for direct genetic modification of organisms or population of organisms using recombination of DNA, This technique are used to identify, replicate, modify and transfer the genetic material of cells, tissues or complete organisms [5].

The first major agriculture related product of biotechnology research is Bovine somatotropin. It is a protein hormone produced in cattle by the pituitary gland located at the base of the animal's brain. This is actually natural substance that affects the way the body operates and has the tendency to increase mitotic cell division or growth. A hormone similar to bovine somatotropin is produced in all species of animals and is important for growth, development, and other body functions [6].

It was observed in the 1930, in an experimental trial that bovine somatotropin injected into lactating cows significantly increased milk production. Until the introduction of recombinant DNA technology only small and impure amounts of Bovine somatotropin could be obtained from slaughter houses [7].

Bovine somatotropin was for the first time approved by the Food and Drug Administration (FDA) in 1993, as the first biotechnological product for animal production, for commercial use. This action ushered in a remarkable new era for animal agriculture and the dairy industry [8].

Recombinant bovine somatotropin (rBST) is one example of the kinds of efficient food production practices that will help feed the world in the future. It also known by its Monsanto trade name Posilac, is a biosynthetic version of the naturally occurring

pituitary hormone in cows [9]. It is a supplement that increases milk production in healthy lactating cows, allowing farmers to produce safe, nutritious milk that is not only more affordable because of efficient farming practices but also produced in a more environmentally responsible way [10]. Milk from Recombinant bovine somatotropin-supplemented cows, like milk of unsupplemented cow is a good and wholesome source of vital nutrient [11].

Recombinant bovine somatotropin is commonly used as a supplement in the dairy industry. The use of this Technologies that lower the quantity of feed consumed per unit of output (milk) will benefit the producer and also a beneficial effect on the environment. A reduction in the amount of feed required to produce a unit of 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.

Therefore, the objectives of this paper are:

❖ To familiarize the effect of somatotropine hormone in dairy industry.

❖ To introduce the importance of somatotropine hormone in varies aspect of bovine product and productivity.

❖ To initiate its utilization in developing countries via awareness creation.

❖ To induce or create an idea as a starting point for researchers.

2. Production Process Of Bovine Somatotropin

Bovine somatotropin (BST) is a natural neurohormone produced by the pituitary gland of the cattle that coordinates the body growth through the regulation of protein, fat and carbohydrate metabolism. It is also an important regulator of lactation in cows. Circulating concentrations of BST are positively correlated with the level of milk production [12]. In the 1980's, through recombinant DNA biotechnology, scientists developed Recombinant bovine somatotropin (rBST), a synthetic version of the naturally occurring bovine somatotropin hormone. The BST gene is first isolated, and then inserted into the genomes of bacteria, which rapidly reproduce the hormone. The hormones are then harvested [13]. This Genetically Modified Organism (GMO) is then injected into the cattle where it replicates causing an increase in milk production. This concept of genetic combination is the foundation for the name "Recombinant" Growth Hormone or Bovine Somatotropin [14]. Recombinant bovine somatotropin (rBST) is a synthetically derived hormone that may be identical to naturally occurring bovine growth hormone, or slightly modified by the addition of extra amino acids [15].

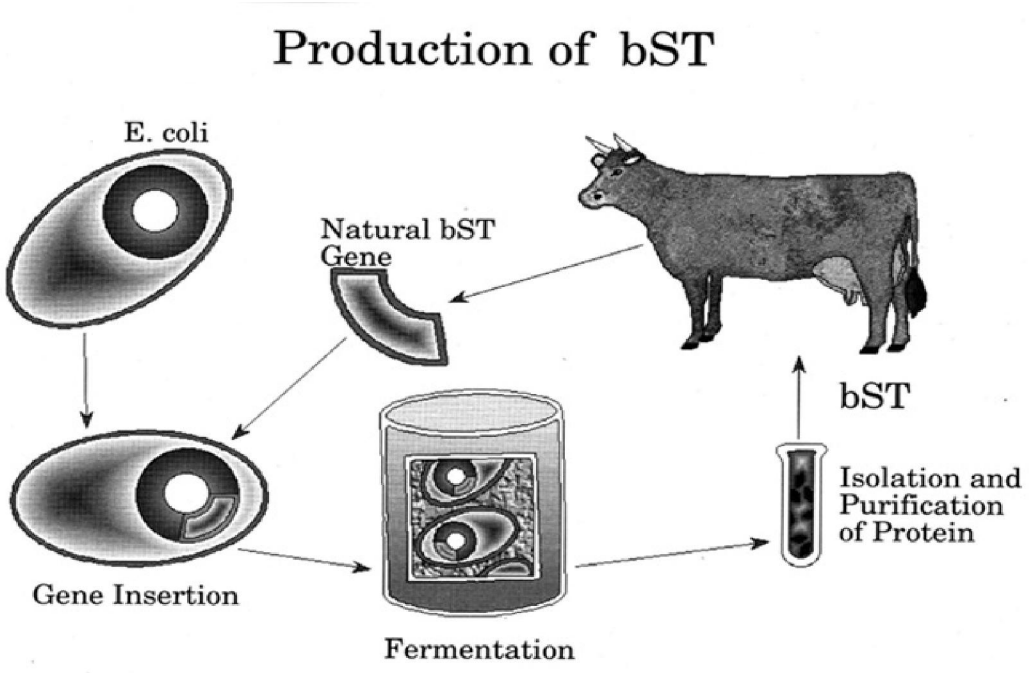

Figure 1. Bovine Somatotropin (BST) Production Process. **Source:** [16]

2.1 Treatment of Cows with Recombinant Bovine Somatotropin Hormone

Post production the hormone is stored in sterile vials from which it can be directly injected into the cows to increase milk production. With injections every 14 days milk production can be increased between 10 and 25 %. The hormone injections work by allowing the continuation of milk production at the part in the lactation cycle where the level of milk production typically begins to decrease [17]. Routes of administration is subcutaneous injection and Recommended Dosage is One syringe (500 mg) every 14 days; beginning of the treatment during the 9th week after calving and continuing until the end of lactation [18].

2.1.1. During Prepartum Period

Supplementing cows with low doses of somatotropin during the periparturient period has been associated with beneficial effects on the physiological adaptations and liver function [10]. Somatotropin has direct effects on the partitioning of nutrients to target tissues as well as indirect effects expressed in the mammary gland and other tissues that are mediated by Insulin-like growth factor-1 [19]. In this regard, somatotropin injection during the peripartum period is able to increase serum IGF-I concentration and milk production [20] [21]. In addition, injection of somatotropin exclusively in the prepartum period can also lead to increased dry matter intake in the early postpartum period. These indicate that prepartum injection of somatotropin is a potential tool to improve metabolic adaptation of transition dairy cows, and thus can have a positive impact on early postpartum ovulation [22]. Somatotropin plays a pivotal role in stimulating liver for production of IGF-I, Circulating IGF-I is highly related to the extent of negative energy balance, and concentrations start to decline in the third trimester of lactation, reaching a nadir at calving [23].

2.1.2. During Postpartum Period

Early postpartum injections of bovine somatotropin (BST) shows no significant differences were detected for milk yield of control versus bovine somatotropin treated cows. Unfortunately, the cows assigned to bovine somatotropin had lower milk yield potential based on the rate and extent of decline in milk yield after cessation of bovine somatotropin injection [22]. Thus, bovine somatotropin injections enhanced milk yield to levels similar to those of controls. Bovine somatotropin treatment significantly enhanced milk yield beyond 60 day and the peak milk production increased for injected cows [24].

2.1. Mechanism Action of Bovine Somatotropin Hormone

Bovine somatotropin injection will increase the concentration of somatotropin in the blood and reached a peak after 8 hours of injection [25]. Initially, elevated levels of somatotropin will stimulate the work of the heart rate to pump blood flow, in response to lactation, cows are needed to bring subtract and precursor to the cells where the activity alveoli milk synthesis. Activities of alveoli cells are highly dependent on continuity supply of nutrients [8]. In this case, somatotropin act as homeorhetic agent that fit the process of body metabolism, especially in nutrient-raising for milk synthesis [26].

Bovine somatotropin Hormone increases activity and/or longevity of mammary secretary cells, probably via Insulin-like Growth Factor (IGF)-I produced by the liver and/or the mammary gland [27].

2.3. Response to Bovine Somatotropin Supplementation

In lactating dairy cows, bovine somatotropin is a major regulator of milk production by coordinating metabolism to allow more nutrients for milk production and utilize nutrients more efficiently [28]. On average, milk yield is increased by 10% - 25% (4 - 6 kg/day) and is associated with a significant increase in feed efficiency of about 12% [12]. However, the response can be much greater with better care and management of the cow [24].

Milk responses have been observed for all cows regardless of genetic merit and for all breeds of dairy cattle. Comprehensive management programs related to nutrition, reproduction, and cow health are the same for cows of comparable production regardless of whether recombinant bovine somatotropin supplements are used to achieve that production [29].

2.3.1. Factor Affecting Milk Yield Responces

A number of factors have been identified as influencing milk production response in bovine somatotropin research trials such as: the quality of herd management, including the availability and quality of feed, the dosage of bovine somatotropin, the age of the cow, with first-lactation cows having a lower response than older cows, and the body condition of the cow prior to the start of treatment, and the cow's initial health before and during treatment [30]. Parity (the number of lactations for a given cow) can also affect the magnitude of milk response to bovine somatotropin. Some studies have observed higher levels of milk response in multiparous cows as compared to primiparous (first-lactation) cows. Differences probably relate to the extent to which first-lactation cows need to divert nutrients for growth in order to achieve mature size [2].

3. Effects Of Recombinant Bovine Somatotropin

3.1. Effect on Mammary Gland

It was probable that bovine somatotropin (BST) affect mammary gland indirectly via stimulation of the synthesis of somatomedins or other protein-factors by the liver. These factors might then act directly on mammary gland [8]. The somatotropin treatment increased the blood flow to the mammary glands of the ruminant animals. Increased blood flow would likely be the result of altered metabolic activity of the mammary glands, as indicated by a measured rise in oxygen consumption by the glands and IGF-I of cows injected with bovine somatotropin [31]. Bovine somatotropin was associated with an increase in mammary cell proliferation and an increase in total volume of secretory tissue in cows [32].

3.2. Effect on Milk Composition

Administering recombinant bovine somatotropin to cows does not significantly change milk's composition or nutritional quality. Any minor differences in milk composition reported between recombinant bovine somatotropin-supplemented and unsupplemented cows are within the normal biological ranges [33].

Factors such as breed, genetics, age, stage of lactation, environment and season influence the major composition of milk such as fat, protein and lactose as well as minor components including minerals and vitamins in an identical manner in recombinant bovine somatotropin supplemented and untreated cows [34].

The dairy product manufacturing properties of milk from recombinant bovine somatotropin supplemented cow did not differ from those of unsupplemented cow, These evaluations included milk freezing point, pH, alcohol stability, thermal properties, proteases, lipases, susceptibility to oxidation and sensory characteristics, including flavour of dairy products [35].

Furthermore, milk and dairy products from cows supplemented with recombinant bovine somatotropin did not differ in concentration of vitamin A, thiamine, riboflavin, vitamin B12, pantothenic acid or choline from milk of unsupplemented cows [36].

3.3. Effect on Voluntary Feed Intake

The voluntary feed intake of cows receiving recombinant bovine somatotropin increased gradually. In the earlier weeks of treatments, body tissues were mobilized to subsidize the increased demands of the mammary glands and the substantial increase in milk energy output [31]. Additional feed is required to make the milk, with a constant quantity of nutrients required for each increment of milk produced. The quantity of nutrients required for milk production increases as milk output increase, Thus, rBST-supplemented cows have a greater feed intake to support their increased milk output, but the entire extra nutrient intake is used to make milk [28].

4. Milk Safety

The safety of recombinant bovine somatotropin use has been extensively investigated and comprehensively documented. In addition to Food and Drug Administration (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 recombinant bovine somatotropin supplemented cows are safe for human consumption [37]. Somatotropin has been the subject of scientific studies for over 50 years and thus there is an extensive base of knowledge about its biology. These studies proved that although there were no negative side effects, humans do not respond to bovine somatotropin [28]. There were many considerations in the evaluation of the human safety of milk from recombinant bovine somatotropin supplemented cows; major reasons for the conclusion that the milk was safe for humans included: recombinant bovine somatotropin is a protein and when consumed orally it is digested, just as occurs for all dietary proteins [2]. recombinant bovine somatotropin is not biologically active in humans even if injected directly into the bloodstream [38].

Milk from recombinant bovine somatotropin supplemented cows does not differ in composition from milk produced by unsupplemented cows, all milk, whether cows are treated or not, contains trace amounts of somatotropin and this miniscule amount is not affected by the use of recombinant bovine somatotropin [11]. Likewise, the ranges for the trace levels of other hormones in milk, including Insulin-like growth factor-1, are unchanged, Pasteurization destroys any somatotropin present in milk. If the milk is not pasteurized, then digestion in the stomach destroys the somatotropin present in milk [35].

5. Health Aspects Of Recombinant Bovine Somatotropin

5.1. On Animal Health

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 recombinant bovine somatotropin (rBST) supplements is exactly the opposite - they produce more milk and are able to utilize nutrients more efficiently [39]. The Food and Drug Administration (FDA) approval of Posilac for commercial use was based on well-controlled studies conducted by university, government, and industry scientists around the world. Thus, overall results including evaluation by Food and

Drug Administration, numerous scientific reviews and dairy industry experience involving over 20 years and 35 million dairy cows provide clear evidence that commercial use of recombinant bovine somatotropin has no adverse effects on animal health or welfare [31]. Studies conducted on commercial herds have observed an increased milk yield in recombinant bovine somatotropin supplemented cows as compared to unsupplemented cows, but there were no differences in overall cow health, cow longevity and the quality of the milk being produced [40].

5.2. On Human Health

Milk also contains trace levels of other hormones and their concentration range does not differ between milk from cows supplemented with recombinant bovine somatotropin and milk from unsupplemented cows [41]. Insulin-like growth factor-1 was of special interest because a cow's blood levels of Insulin-like growth factor-1 are elevated in recombinant bovine somatotropin supplemented cows, although milk concentrations do not differ from the Insulin-like growth factor-1 range observed for unsupplemented cows [2]. Insulin-like growth factor-1 is produced by most cells in the body and is critical for human health because of its role in cell maintenance and repair. Therefore, there is no evidence that this amount of Insulin-like growth factor-1 would pose a health hazard [42].

Milk Insulin-like growth factor-1 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 [43].

6. Challenges Use Of Recombinant Bovine Somatotropin In Developing Country

The main technical constraint to bovine somatotropin use in developing countries will be the cost of bovine somatotropin, lack of awareness about their use, the amount and cost of other incremental inputs required for effective use of bovine somatotropin, the milk prices, the absence of an efficient delivery system; current use of the technology requires regular injections. Feed resources are inadequate in both quality and quantity, particularly during the dry seasons, disease events [44]. Ethiopian dairy production systems generally characterized as a year round calving system with low nutritional input and a limited use of mixed rations [45]. Using recombinant bovine somatotropin costs money and its use provides no benefit on farms where the performance of the herd is limited by inadequate nutrition or poor quality of management. Quite to the contrary, to get an economic return the recommended use of this technology is only on farms where cows are fed and managed properly when cows do not have enough feed or are subject to poor management, there will be no response torecombinant bovine somatotropin (rBST) supplementation [46].

7. Conclusion And Recommendations

Biotechnology have contributed immensely to increasing livestock productivity, particularly in developed countries, and can help to alleviate poverty and hunger, reduce the threats of diseases and ensure environmental sustainability in developing countries. Recombinant bovine somatotropin is a supplement that increases milk production in healthy lactating cows, without adverse effect on milk quality or animal health. milk from Recombinant bovine somatotropin cows is safe for human consumption. Using recombinant bovine somatotropin costs money and its use provides no benefit on farms where the performance of the herd is limited by inadequate nutrition or poor quality of management. Quite to the contrary, to get an economic return the recommended use of this technology is only on farms where cows are fed and managed properly when cows do not have enough feed or are subject to poor management, there will be no response to recombinant bovine somatotropin supplementation.

Based on the above conclusion, the following recommendations should be forwarded.

- ❖ It is important if the application of rBST is introduced and practiced in developing countries considering its effect on dairy product and productivity via adoption and importing of the technology.
- ❖ Attention should be given to conduct a research in our country concerning the use and utilization of this product from Government and NGOs'.
- ❖ The bodies that are participating /involved on importing of veterinary medicine, supplies and equipments should import and create a suitable condition for awareness creation to the practitioners/professionals.

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