

Potential Use of Recombinant Bovine Somatotropin (rbSTH) on Minnesota Dairy Farms

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Introduction

Growth hormone or somatotropin (STH) is produced in the adenohipophysis (pituitary gland) of animals. Technically, STH is a protein that has a molecular weight of 2200 and contains 191 amino acid residues. STH produced by one species does not always elicit similar responses in other species because of variation in the molecule. Known metabolic effects of STH include increased protein synthesis, increased fat mobilization and decreased glucose utilization. An important role for STH is stimulation of an increase in body size, but it has a stimulating effect on milk production as well. Early studies, 40 to 50 years ago, on STH were done with preparations from pituitary tissue and often contained other hormones and substances in addition to STH. Thus, responses to the preparations were not definitely attributable to STH alone. More recent technology has brought improvements in purification of STH from animal tissues. This improvement and development of procedures to produce STH in bacteria (*Escherichia coli*) via a recombinant plasmid (genetic engineering) has provided scientists with a tool to study the effects of STH in much more detail. In addition, production of STH by the latter technology has potential for commercial use in the livestock industry.

Secretion of Somatotropin by Dairy Cattle

Dairy cattle vary in their production of STH. Concentrations of circulating STH are higher in cows of high production potential as compared to lower producers. Also, STH is higher during peak lactation than during mid or late lactation and will be lower in blood of dry cows than in that of lactating cows. Research is continuing on the study of endogenous STH and factors affecting levels and subsequent responses.

Use of Exogenous Somatotropin

Experiments as early as 1937 showed that injections of crude pituitary extracts stimulated increases in milk production by cows. In the 1940's, British scientists studied the feasibility of using hormone preparations to increase milk supplies in that country during World War II. Although milk production could be increased, the attempt to improve supply by this method was abandoned because of the amount of pituitary tissue required for the hormonal

preparations.

Since the improvement of technology for purification of STH from animal tissues, identification of chemical structure and properties of STH, and production by recombinant procedures, interest has again been stimulated in the use of STH for increasing milk production in dairy cattle.

Effects on Milk Production

Most of the studies with lactating cows have been of short duration, days or weeks, and only recently have longer term studies been reported. Results of a 188 day study starting at day 84 of lactation are in Table 1. Increases in milk yield have been dramatic, up to 41%. A summary by Cornell workers of several studies (not including that in Table 1) indicate responses of 13 to 34% increase in milk production.

TABLE 1. Effects of somatotropin on milk yield, milk composition, energy intake, and balance in a 188 day study^a.

Item	methionyl bovine somatotropin — — — mg/day — — —			
	0	13.5	27.0	40.5
3.5% fat milk (lb/day)	61.4 ^b	75.7 ^c	83.6 ^c	86.7 ^c
Fat (%)	3.6	3.8	3.6	3.6
Protein (%)	3.4	3.4	3.4	3.4
Lactose (%)	4.8	4.9	4.8	4.9
Net Energy Intake (Mcal/day)	34.1	36.7	39.2	37.5
Net Energy Balance (Mcal/day)	4.7 ^b	3.7 ^{bc}	2.8 ^{bc}	1.7 ^c

Adapted from Bauman et al. 1985. J. Dairy Sci. 68:1352.

^aStudy began on day 84 of lactation with 6 cows/treatment.

^bMeans with different superscripts differ.

Effect of Stage of Lactation

Some of the shorter term studies suggested that percentage of response was greater (32.2% vs. 15.2%) during late (244 days postpartum) than during early (81 days postpartum) lactation. Similar doses of STH were administered to cows in both stages of lactation. However, recent data showed large responses in early lactation (20 to 46 days). The Cornell work indicates that the shape of lactation curve changes, showing increased persistence, with administration of STH.

Effect on Milk Composition

The effect of STH on milk composition apparently depends on the cow's energy and protein status. Cows in positive energy and nitrogen balance have generally responded to STH injections with increased milk with little or no change in percentage of fat and protein in the milk (Table 1). But, percentage milk fat increased and milk protein content decreased for cows in negative energy and nitrogen balance, although both fat and protein yield increased with STH administration. Lactose content of milk content was not changed, but yield paralleled milk production increases.

Effect on Feed Intake

Some of the short studies with STH did not show an increase in feed intake. Recently, two longer studies have shown that cows injected with STH increased and maintained voluntary intake (See Table 1) consistent with increased milk production.

Effects on Health and Reproduction

Because most of the studies have been of relatively short duration, only limited information is available on effects of health, reproductive performance, and viability of calves born to STH-treated cows. Work reported from Cornell on a 188 day study with 30 cows suggested normal health, conception, gestation and delivery of healthy calves. Information from studies that involve more than one lactation per cow are not yet available.

Mode of Action of Somatotropin

STH does not improve digestive efficiency or utilization of dietary energy. Studies using indirect calorimetry and radioisotopes led to conclusions that extra nutrients came from body stores and STH has no effect on the maintenance requirement, digestive processes or partial efficiency of milk synthesis.

The mechanism of action of STH in eliciting responses in production is complex. But, researchers have suggested two general ways in which GH produces its effect:

1. Metabolism of body tissues is altered to partition more nutrients to the mammary gland.
2. The mammary gland's ability to synthesize milk is enhanced through administration of STH.

Administration of Somatotropin

To date, most investigators have administered STH by single, daily injections. Injections more than once daily or continuous infusion of the hormone appear to be no better than single, daily injections of an identical dosage. In experiments using low dosages, extension of injection intervals beyond 24 hours resulted in lowered responses. The hormone cannot be given orally because digestive processes

would destroy it before absorption. Slow release implants would eliminate the need for daily injections, but are not yet available.

Nutritional Management

As previously stated, cows given rbSTH over an extended period (months) will increase feed intake to meet the energy demands for milk production. Data available, thus far, indicate that administration of rbSTH to dairy cattle does not increase the maintenance requirement or the nutrients required for each increment of additional milk produced. However, cows given the hormone will be more persistent in milk production, hence, rations of high nutrient concentrations probably will have to be fed for longer periods than is current practice. Feed testing and careful ration balancing will be an important component of the nutritional management program. If a producer using rbSTH maintains herdsize, total feed needed by the herd will increase, probably by 5-10%. The increase may require additional storage facilities, increased acreage of crops grown for feed or purchase of the extra feed.

Veterinary Care

High-producing cows require more veterinary care than lower producers as shown by a study of two genetically different groups of Holstein cows at the University of Minnesota's Southern Experiment Station. However, extra milk income more than compensated for the additional care. It is likely that rbSTH use will mean additional health care but probably not more than that required by other high-producing cows that are well-managed. Cows that have health problems may be severely stressed from the drive to milk from rbSTH and may react adversely. Not much is known as of yet on the effect of high environmental temperature on cows given rbSTH.

Adoption by Farmers

Adoption of rbSTH for use in dairy cattle by farmers first depends on approval by FDA. Some have indicated approval by 1988 or 1989; some later. A survey of 1% of New York's dairy farmers suggested that at least one-half of the state's cows would be receiving rbSTH within the first year after availability. Most farmers stated that they would use the product on a portion of the herd at the start. About one-eighth of those surveyed indicated they would not use rbSTH. The New York study suggests wide-spread adoption by 1995.

One company involved in research on rbSTH predicts 75% adoption by 1995. It is likely that Minnesota farmers will adopt this new technology, if approved by FDA, at a rate similar to other US dairy producers.

Economic Impact for Minnesota Farmers

Price of rbSTH to farmers has not been established. One

report has used a product cost of \$30-50 per cow per year. The Cornell survey used a cost of \$.17 per daily dose. An increase in milk production of 15% might be expected from use of rbSTH. An increase in feed intake would accompany the increased production. This may be in the order of 6% increase. Minnesota Holsteins on DHI averaged 15697 lb milk, 3.7% fat in 1985. If rbSTH were used on these cows, milk production would be increased by 2354 lb/cow (if the 15% figure is used). This amount of milk is worth \$259 (\$11/100 lb). A 6% increase in feed intake would cost about \$45 according to 1985 DHI information. If one uses a cost of \$50 for rbSTH and \$45 for feed (\$95), \$164 would remain (259 - 95 = 164) for increased labor, other costs and profit.

Summary

Use of rbSTH by Minnesota dairy farmers will depend on approval by FDA, cost-benefit ratios, convenience for use and other factors. Production responses can be expected from rbSTH and additional feed will be required for the increased milk yield. Use of rbSTH will require management that is skilled and pays attention to detail.

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