EFFECT OF RECOMBINANT BOVINE SOMATOTROPIN ON MILK PRODUCTION AND MILK COMPOSITION IN DAIRY COWS

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Summary

Nine Holstein cows in mid lactation period were utilized to examine the effect of recombinant bovine somatotropin (BST) of tow companies (Company A, Company B) on milk production and milk composition under the feeding conditions of Korea. Treatments were 0 (Control), 25 mg BST/day from company A (BST A) and 25 mg BST/day from company B (BST B) injected subcutaneously, once daily beginning at 200 ± 20 days postpartum and continuing for 28 days. Cows were fed *ad libitum* a total mixed diet throughout the experimental period. BST treatments increased average 4% fat corrected milk yields and milk energy output over the 28-day treatment period. However, no differences were observed in dry matter intake, gross efficiency, energy intake and percent milk energy. Although there was a tendency for increased milk fat percent, there were no differences in milk composition and yields of major milk components except for milk fat yield with BST injection. Somatic cells of all groups were also characteristic of a well managed herd. Neither mean body condition score nor body weight was significantly ($p < 0.05$) changed before and during BST treatment. BST concentration in milk remained in the range of control animals throughout the experimental period of BST treatment. Results indicate that short-term injection of recombinant bovine somatotropin from two companies to lactating dairy cow resulted in similar increases in milk yield without alteration of major milk components or feed intake.

(Key Words: Bovine Somatotropin, Milk Production, Milk Composition, Dairy Cows)

Introduction

Injecting dairy cows with bovine somatotropin (BST) is currently evoking controversy. In 1937 Asimov and Krouze were the first to observe that injections of crude pituitary extracts increased milk production in dairy cows. This work eventually led to the identification of BST as an important hormone for lactation.

Studies utilizing highly purified BST have demonstrated that injections of exogeneous hormone increased milk yield from 10 to 40% (Bauman and McCutcheon, 1985). However, it soon become evident that this would be infeasible as a large number of animals should be slaughtered to provide relatively small quantities of BST. Interest in BST was revived in the 1980's when genetic engineers successfully used recombinant DNA technology to produce bacteria capable of synthesizing BST in relatively large quantities at reasonable cost (Kennelly and de Boer, 1988). This development was accompanied by intense interest in the commercial application of BST. Short-term studies using BST indicated daily administration significantly increased milk yield with either no change or moderate reductions in feed intake (Bauman and Collier, 1985). Furthermore, it has been proven that BST can enhance yields when given for an extended period of time. Recently, Annexstad et al. (1987) reported that long-term administration of BST was effective in enhancing milk yield when given for two consecutive lactations.

Objectives of this trial were: (1) to examine the effects of short-term administration of BST on lactational performance, milk composition and health, (2) to compare BST from two companies under Korean feeding conditions.

Materials and Methods

Nine Holsteins were assigned to three treatment groups arranged in a randomized block design:

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each group consisted of one primiparous and two multiparous cows (second to eighth lactation). Cows that were healthy and free of mastitis were assigned to treatments according to milk production. Treatments were 0 (Control), 25 mg BST/day from company A (BST A) and 25 mg BST/day from company B (BST B).

A fourteen day of dietary adjustment period to was followed by a twenty eight day period involving BST administration which was initiated at 200 ± 20 days postpartum. Daily subcutaneous injections (2 ml) were administrated at approximately 0930 h in the shoulder area in a regular alternating fashion (right or left side).

Hormone (50 mg) was dissolved in 4 ml buffered saline at a concentration of 12.5 mg/ml. Thus, daily injection volumes were 2 ml/herd for the two BST treatments. Control cows were injected with 2 ml of buffered saline daily. The dissolved hormone was stored (24 h maximum) at 5°C until it was used immediately.

Cows were milked at 0500 and 1600 h daily and individual milk yields were recorded at each milking. Milk was sampled from consecutive a.m. and p.m. milking each week and composited for analyses. Milk was analyzed for fat, protein, lactose, ash, total solids and solid non fat by Milkoscan. Somatic cell was counted by California mastitis test (PHS, 1965). Bovine somatotropin concentrations in milk were determined by radioimmuno assay (de Boer, 1988).

Cows were fed *ad libitum* a total mixed diet twice daily (0500 and 1600 h). The diet (table 1) was formulated according to NRC requirements (NRC, 1988) for mid lactation cows and was fed throughout the entire experimental period. Feed refusals were weighed and recorded daily proior to the a.m. feeding. Feeds and feed refusals were analyzed for dry matter, NDF and ADF (Georing and Van Soest, 1970). Analyses for dry matter, crude protein, calcium and phosphorus were by procedures of the Association of Official Analytical Chemists (AOAC, 1980).

Body weights were measured at two week intervals after initiation of BST administration. Individual cow weights were obtained by averaging the weight for three consecutive days. All weights were taken between 1300 and 1400 h. This was approximately 5 hours after the morning feeding and 7 hours after the morning milking. Measurements of body condition were taken at 0, 7, 14, 21 and 28 day after initial BST administration.

TABLE 1. COMPOSITION OF THE TOTAL MIXED RATION FED DURING THE EXPERIMENTAL PERIOD (%)

Ingredients and nutrients	Diet composition[1]
Ingredient	
Corn, yellow	23.4
Wheat	7.7
Defatted rice bran	1.5
Wheat bran	6.2
Soybean meal	7.0
Cotton seed meal	1.0
Limestone	1.0
Dicalcium phosphate	0.3
Tallow	1.0
Molasses	1.0
Salt	0.5
Vitamin-mineral mixture[2]	0.4
Corn silage	49.0
Nutrient	
Net energy, lactation (Mcal/kg)	1.53
Crude protein	14.3
Acid detergent fiber	21.3
Neutral detergent fiber	29.5
Calcium	0.524
Phosphorus	0.348

[1]All values presented on dry matter basis.
[2]Vitamin-Mineral mixture supplied the following per kg of diet; Vit. E, 20,000 IU; Niacin 10,000 mg; Fe, 10,000 mg; Co, 100 mg; Cu, 5000 mg; Zn, 20,000 mg; I, 300 mg; Se, 100 mg.

Means were analyzed as treatment effects by least squares analysis of varience. Statistically significant differences between treatment means were measured by Student-Newnan-Keuls test (SNK) by SAS-PC package (SAS, 1987).

Results and Discussion

The temporal pattern of daily milk production during the pretreatment and treatment periods is shown in figure 1. Prior to treatment the lactation curve was characteristic of mid-lactation cows. During the treatment period, milk yield from control cows decreased in a normal fashion, averaging approximately 7% decline per month (Bauman et al., 1985). In contrast, BST A and BST B treat-

ments altred the shape of the lactation curves. Cows receiving BST increased daily production above the control treatment.

In fact, their daily milk production remained greater than the pretreatment production for the entire 28 days of treatment, thereafter, yield for BST treated cows declined more rapidly than observed for control cows. Machlin (1973) presented results from his 10-wk study in graphic form, but increases were approximately 5 kg/day over control yields of 10 to 15 kg/day.

Daily injection of BST resulted in increased 4% fat corrected milk (FCM) yields over the 28-day treatment period (table 2). Increases ranged from 4.7 to 6.5 kg/day depending on products of the companies. Increases of 4.7 and 6.5 kg/day were approximately 25% and 35% improvement in milk production. These could be compared favourably with results of previous short-term (Lough et al., 1986; McCutcheon and Bauman, 1986) and long-term (Soderholm et al., 1986a; Soderholm et al., 1986b) injection of somatotropin. BST treatment did not significantly ($p < 0.05$) influence dry matter intake (DMI) (table 2). Increased milk production was accompanied by a slight decrease (not significant) in feed intake of the BST B group. The lack of a feed intake response to BST treatment is in good agreement with Bauman et al. (1985) who observed an increase in feed intake only after 28 days of somatotropin injection. The 28 day period of injection in this study appears not to have been long enough to show a response. Although use of BST improved gross efficiency of 4% fat corrected milk production, there was no statistical difference ($p < 0.05$) among treatments. Gross efficiencies for cows given BST A and BST B were 1.40 and 1.41 kg FCM/kg DMI, respectively, versus 1.10 for control. Effects of BST on energy intake, milk energy and percent milk energy were very similar to results of Pocius and Herbein (1986).

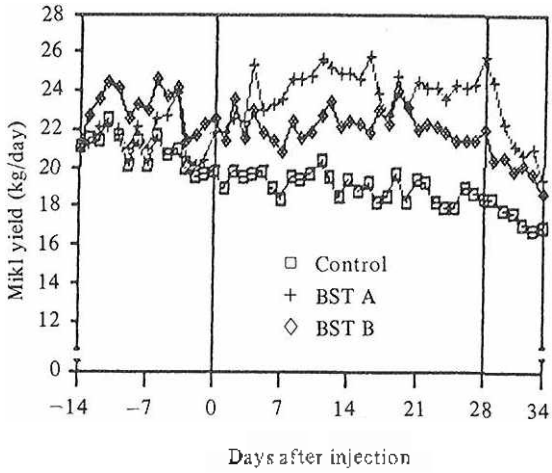

Figure 1. Mean daily milk production for CONTROL, BST A and BST B treatment groups.

TABLE 2. EFFECT OF RECOMBINANT BOVINE SOMATOTROPIN ON FEED INTAKE AND MILK OUTPUT

Variable	Control	BST A	BST B	SE[1]
4.0% FCM (kg/d)	18.5[a]	25.0[b]	23.2[b]	1.2
DM intake (kg/d)	17.1	17.8	16.7	1.1
Gross efficiency (kg FCM/kg DMI)	1.10	1.40	1.41	0.08
Energy intake[2] (Mcal/d)	26.2	27.2	25.6	0.9
Milk energy[3] (Mcal/d)	13.7[a]	18.5[b]	17.2[b]	0.9
% Milk energy[4]	53.3	67.9	67.9	0.5

[a,b]Means in the same row with different superscripts differ ($p < 0.05$).
[1]Standard error of the mean.
[2]Net energy for lactation.
[3]Calculated by method of NRC (1988).
[4]Percent of energy intake in the milk.

Effect of BST on milk composition, yield of milk components and somatic cells are shown in table 3. Although there was no significant difference, milk fat percent, lactose, total solids and solid non fat tended to be higher, and ash percent

TABLE 3. EFFECT OF RECOMBINANT BOVINE SOMATROPIN ON MILK COMPOSITION, YIELDS OF FAT, PROTEIN, LACTOSE, ASH, TOTAL SOLIDS, SOLID NON FAT AND SOMATIC CELLS

Variable	Control	BST A	BST B	SE[1]
Milk fat (%)	3.84	4.21	4.28	0.21
Milk fat yield (kg/d)	1.11[a]	1.56[b]	1.45[ab]	0.07
Milk protein (%)	3.43	3.40	3.66	0.15
Milk protein yield (Kg/d)	1.00	1.25	1.24	0.10
Milk lactose (%)	4.46	4.75	4.58	0.20
Milk lactose yield (Kg/d)	1.30	1.75	1.55	0.01
Ash (%)	0.64	0.62	0.62	0.02
Milk ash yield (Kg/d)	0.18	0.23	0.21	0.17
Total solids (%)	12.37	12.87	12.99	0.50
Milk total soilds yield (Kg/d)	2.45	3.24	3.00	0.25
Solid non fat (%)	8.53	8.78	8.86	0.33
Milk solid non fat yield (Kg/d)	3.60	4.75	4.46	0.16
Somatic cell (10^4/ml)	26.00	70.00	45.00	18.20

[a,b]Mean in the same row with different supercipts differ ($p < 0.05$).
[1]Standard error of the mean.

tended lower with BST treatment. Because cows administered with BST produced more milk (table 2), daily yields of major milk components were elevated. However, the increase in milk fat was only statistically significant ($p < 0.05$). Considering the discussion of Barbano and Lynch (1987), the tendency for increased milk fat percent with BST treatments could be related to negative energy balances of cows in BST groups. The increase in yield of milk fat with BST was very similar to the result of Peel et al. (1981). Furthermore, on the basis of milk composition, the above results show the same tendency as Peel et al. (1985), Bauman et al. (1985) and Eppard et al. (1985). However, milk composition before and during treatments would have been a more appropriate comparison, considering the low number of cows per treatment. But no difference could be seen in milk composition between before and during treatment within same group.

Somatotropin treatments did not affect ($p < 0.05$) milk somatic cells (table 3). Although there were a tendency for increased somatic cells in BST groups, average somatic cells were characteristic

TABLE 4. MEANS OF BODY CONDITION SCORE AND BODY WEIGHT BEFORE AND DURING RECOMBINANT BOVINE SOMATOTROPIN TREATMENT

Item	Week	Control	BST A	BST B	SE[1]
Body condition score	0	3.0	2.8	2.6	0.15
	2	3.5	2.8	2.8	0.23
	4	3.5	3.1	3.1	0.16
Body weight (kg)	0	584	553	584	17.0
	2	606	576	597	18.4
	4	621	576	620	19.2
Body weight change during treatment (%)		6.3	4.2	6.2	0.17

[1]Standard error of the mean.

for well managed herds (Dohoo and Meek, 1982).

Body condition score and body weight before, and during BST treatment, are shown in table 4. Neither mean body condition score nor body weight were significantly ($p < 0.05$) changed before and during BST treatment. The tendency for lower body condition scores and body weight for BST treated cows compared to controls are well in accordance with the reports of Aguilar et al. (1988) and Chalupa and Schneider (1986) respectively.

Effect of BST on milk somatotropin concentrations is depicted in table 5. BST concentrations in milk from treated cows were not significantly ($p < 0.05$) different for those observed from untreated cows. The concentrations were almost within the range of Mohammed and Johnson (1985). In addition, the observation of an effect due to BST injection was in accordance with that of Kennelly and de Boer (1988).

Results of this experiment demonstrate that short-term injection of recombinant bovine soma-

TABLE 5. EFFECT OF RECOMBINANT BOVINE SOMATOTROPIN ON MILK SOMOTOTROPIN CONCENTRATIONS

Item	Control	BST A	BST B	SE[1]
Milk somatotropin (ng/ml)	2.85	3.29	3.63	0.42

[1]Standard error of the mean.

totropin from two companies to lactating dairy cow equally increased milk production without alternations of major milk composition and feed intake.

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Literature Cited

Aguilar, A.A., D.C. Jardan, J.D. Olson, C. Bailey and G. Hartnell. 1988. A short-term study evaluating the galactopoietic effect of the administration of Somatribove (recombinant methionyl bovine somatotropin) in high producing dairy cows milked three times per day. J. Dairy Sci. 71(Suppl. 1):208.

Annexstad, R.J., D.E. Otterby, J.G. Linn, W.P. Hansen, C.G. Sodrholm and R.G. Eggert. 1987. Responses of cows to daily injections of recombinant bovine somatotropin (BST) during a second consecutive lactation, J. Dairy Sci. 70 (Suppl. 1): 176

Asimov, G.J. and N.K. Krouze. 1937. The lactogenic preparations from the anterior pituitary and increase of milk yield in cows. J. Daily Sci. 20:289.

Association of Official Analytical Chemists. 1980. Official method of analysis. 13th ed. Assoc. Offic. Anal. Chem., Washington, DC.

Barbano, D.M. and J. Lynch. 1987. National invitational workshop on bovine somatotropin. (USDA extension service). St. Louis, MO., p.66.

Bauman, D.E. and R.J. Collier. 1985. Growth hormone enhancement of lactation. page 97 in Regulation of growth and lactation in animals. Univ. WI.

Bauman, D.E., P.J. Eppard, M.J. DeGeeter and G.M. Lanza. 1985. Responses of high-producing dairy cows to long-term treatment with pituitary somatotropin and recombinant somatotropin. J. Dairy Sci. 68:1352.

Bauman, D.E. and S.N. McCutcheon. 1985. The effects of growth hormone and prolactin on metabolism. Ch. 23 in Proc. VI Int. Symp. Ruminant Physiol. Control of digestion and metabolism in ruminants. L.P. Milligan, W.L. Grovum and A. Dobson, ed. Reston Publishing Co., Inc., Reston, VA.

Chalupa, W. and P.L. Schneider. 1986. Bovine somatotropin: physiology, lactational responses, and implications for the dairy industry. Professional Anim. Sci. 2:27.

de Boer, J. 1988. Personal communication.

Dohoo, I.R. and A.H. Meek. 1982. Somatic cell counts in bovine milk. Can. Vet. J. 23:119.

Eppard, P.J., D.E. Bauman, J. Bitman, D.L. Wood, R.M. Akers and W.A. House. 1984. Effect of dose of bovine growth hormone on milk composition: α-lactalbumin, fatty acids and mineral elements. J. Dairy Sci. 68:3047.

Georing, H.K. and P.J. Van Soest. 1970. Forage fiber

analysis (apparatus, reagents, procedure, and some applications). Agric. Handbook 379, Agric. Res. Serv., US Dep. Agric., Washington, DC.

Kennelly, J.J. and G. de Boer. 1988. Bovine somatotropin: a review. 67th annual Feeder's day report. Univ. of Alberta. p.5.

Lough, D.S., L.D. Muller, L.C. Griel, Jr., R.S. Kensinger, C.D. Azzard and P.S. Dimick. 1986. Effect of exogeneous bovine growth hormone (bGH) on milk production, milk composition, and mammary lipid metabolism in lactating dairy cows. J. Dairy Sci. 69(Suppl. 1):153.

Machlin, L.J. 1973. Effect of growth hormone on milk production and feed utilization in dairy cows. J. Dairy Sci. 68:1109.

McCutcheon, S.N. and D.E. Bauman. 1986. Effect of pattern of administration of bovine growth hormone on lactational performance of dairy cows. J. Dairy Sci. 69:38.

Mohammed, M.E. and H.D. Johnson. 1985. Effect of growth hormone on milk yield and related physiological of Holstein cows exposed to heat stress. J. Dairy Sci. 68:1123.

National Research Council. 1988. Nutrient requirements of domestic animals. No.3. Nutrient requirements of dairy cattle. 6th Rev. ed. Natl. Acad. Sci., Washington, DC.

Peel, C.J., D.E. Bauman, R.C. Gorewit and C.J. Saiffen. 1981. Effect of exogeneous growth hormone on lactational performance in high yielding dairy cows. J. Nutr. 111:1662.

Peel, C.J., C.D. Sandles, K.J. Quelch and A.C. Herington. 1985. The effects of long-term administration of bovine growth hormone on the lactational performance of identical-twin dairy cows. Anim. Prod. 41: 135.

Pocius, P.A. and J.H. Herbein. 1986. Effects of *in vivo* administration of growth hormone on milk production and *in vitro* hepatic metabolism in dairy cattle. J. Dairy Sci. 69:713.

Public Health Service. 1965. Screening tests for the detection of abnormal milk. P.H.S. Pub. No. 1306, Dept. of health, education, and welfare, Washington, DC.

Soderholm, C.G., D.E. Otterby, F.R. Ehle, J.G. Linn, W.P. Hansen and R.J. Annexted. 1986a. Effects of different doses of recombinant somatotropin (rbSTH) on circulating metabolites, hormones, and physiological parameters in lactating cows. J. Dairy Sci. 69(Suppl. 1):152.

Soderholm, C.G., D.E. Otterby, F.R. Ehle, J.G. Linn, W.P. Hansen and R.J. Annexted. 1986b. Effects of different doses of recombinant bovine somatotropin (rbSTH) on milk production, body composition, and condition score in lactating cows. J. Dairy Sci. 69 (Suppl. 1):152.

Statistical Analysis System. 1987. SAS user's guide: statistics. SAS Inst., Cary, NC.