Responses of Holstein Cows to Different Bovine Somatotropin (bST) Treatments during the Transition Period and Early Lactation*

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ABSTRACT : Major objective was to evaluate three doses of bST (POSILAC®) injected into Holstein cows during the transition period and through 56 d of lactation for potential to improve DMI, BCS, BW, metabolites, hormones, IGF-I and milk production. Biweekly injections of bST (0, 5.1, 10.2, or 15.3 mg bST/d) began 28 d before expected parturition and continued through 56 d postpartum. Twenty-three of the 25 multiparous Holstein cows assigned randomly to four groups completed experiment (7, 5, 6 and 5 cows/group, respectively). The DMI, BW and BCS were recorded weekly throughout the prepartum and postpartum periods and blood samples were collected thrice weekly for analyses of ST, insulin, T_4, T_3, IGF-I, glucose and NEFA. Milk yields were recorded daily through 60 d postpartum and milk components measured once weekly. Mathematical model for data analyses for prepartum and postpartum periods included treatment, calving month, and the two-factor interaction. Cows injected with 10.2 and 15.3 mg bST prepartum had greater mean prepartum concentrations of ST and IGF-I. Prepartum injections of bST did not affect prepartum BW or BCS. On average, cows injected postpartum better maintained their BCS during first 60 d of lactation (3.15±0.06, 3.12±0.007, 3.20±0.006 and 3.58±0.009). Treatments did not affect mean prepartum DMI but cows injected with 15.3 mg bST/d had greatest DMI and greatest mean daily MY during the first 3 wk and tended to be greater during first 60 d of lactation. Cows injected with two highest bST doses (10.1 and 15.2 mg/d) had greater mean postpartum concentrations of ST and T_3, but IGF-I, T_4, glucose and NEFA did not differ across groups. No adverse effects of bST treatment were observed. ***(Asian-Aust. J. Anim. Sci. 2004. Vol 17, No. 6 : 784-793)***

Key Words : Holstein Cows, Milk Production, bST Doses, DMI, Transition Period, Hormones

INTRODUCTION

The transition from pregnancy to lactation is one of the greatest challenges cows face during a lactation cycle. Management practices that lead to greater frequency of metabolic diseases during the transition period (-3 prepartum to +3 wk postpartum) have negative effects on cows' milk production and profitability (Drackley, 1999). Even with excellent management and nutritional practices during the transition period, the DMI of cows generally decreases around time of calving (Bertics et al., 1992; Garcia, 1998; Drackley, 1999). Prepartum decline in DMI coupled with a slower increase in DMI after calving may be associated with greater incidence of metabolic diseases including fatty liver, ketosis or milk fever and a decrease in milk production (Eppard et al., 1987; Drackley, 1999; Goff, 2001). Strategies to improve DMI during the transition period and to limit or completely avoid deleterious alterations in metabolism should improve milk production potential.

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It is well-documented that injections of bST increases milk production (Bauman and Vernon, 1993; Bauman, 1999). Increased milk production results from both direct and indirect effects of somatotropin (ST) via physiological changes including partitioning of nutrients to mammary tissues and on mammary cell numbers and activity (Bauman and Currie, 1980; Vicini et al., 1991; Bauman, 2000). One major indirect effect of bST is to increase synthesis and release of IGF-I and a number of binding proteins from the liver. Actions in the liver, adipose, mammary gland and other tissues mediated by IGF-I and the overall direct and indirect effects of bST results in the increased milk production (Bauman and Vernon, 1993; Jones and Clemmons, 1995; Lucy et al., 2001). Nutritional status has an important role in regulation of the somatotropic-axis in both monogastric and ruminant species (Breier et al., 1986) such that Growth Hormone Receptor (GHR) abundance and IGF-I synthesis and plasma concentrations are reduced during energy deficit (Lucy et al., 2001). During transition and early lactation, cows show reduced energy status or increased deficit because of reduced DMI, especially during early lactation and with higher producing ability (Bauman et al., 1985). Increasing DMI of dairy cows via manipulation of the endocrine system during the transition period and early lactation would be one way to improve energy balance and perhaps increase IGF-I synthesis. Importantly, greater DMI during these time periods would better allow high producing cows to meet their energy requirement for increased milk

Table 1. Dry matter concentrations and chemical composition of CUD and lactation TMRs fed to Holstein cows[1]

Ingredients	% DM	
	CUD	Lactation TMR
Corn silage	37.12	21.72
Alfalfa hay	-	9.14
Bermuda grass hay	10.70	-
Cottonseed hulls	-	5.57
Citrus pulp	-	9.94
Hominy	22.24	16.28
Distillers grains	7.44	9.19
Soybean meal (48%)	7.44	7.89
Whole cottonseeds (WCS)	7.36	14.95
Mineral mix	-	5.33
Springer minerals	6.69	-
Trace minerals	0.59	-
Dicalcium phosphate	0.42	-
Chemical composition	Percentage[2]	
DM	56.54	63.77
CP	15.28	17.67
Sol CP [3]	34.80	33.43
ADF	22.34	25.33
NDF	37.34	37.16
EE [4]	4.83	5.83
TDN	68.10	68.29
NEL (Mcal/kg)	1.58	1.68

[1] From NEDHIA Forage Laboratory, Ithaca, NY, analyses of components. [2] DM basis. [3] Percentage of the CP. [4] Ether extract.

production and reduce extent of mobilization of lipids and protein during early lactation.

It has been suggested that use of bST prepartum may be effective as a prophylactic for milk fever and other metabolic diseases (Eppard et al., 1996). The expected benefits of bST would be from reduced risk of metabolic disorders associated with lipid mobilization during the transition period (Lean et al., 1991; Eppard et al., 1996) and from the immunoenhancing activity of bST (Burvenich et al., 1999; Collier and Vicini, 1997). However, injecting high doses of bST (25 mg/d or greater) during the late dry period (Bachman et al., 1992; Eppard et al., 1996; Putnam et al., 1999) and early lactation (Moallem et al., 1997; Santos et al., 1999) gave inconsistent responses in postpartum milk production and improved health status. For example, Putnam et al. (1999) reported that when a full lactation dose of bST was injected prepartum (500 mg bST/14 d) there was a significant increase in milk production, whereas Eppard et al. (1996) reported that the same dose of bST prepartum did not increase milk production following parturition or reduce the risk of milk fever. Although cows' need for nutrients increases rapidly after calving and cannot be met by increased DMI, based upon preliminary research (Garcia, 1998; Garcia et al., 2000), we speculated that injecting a lesser dose of bST during the transition period would stimulate DMI during both prepartum and postpartum periods. Thus, this should help to minimize reduced energy balance and perhaps decrease the incidence of metabolic diseases in high producing dairy cows around the time of parturition and result in improved milk production during the subsequent lactation. Therefore, the major objective of this research was to evaluate and identify an appropriate lesser amount of bST to inject. Effects of bST amounts injected were evaluated by measuring DMI, BW, BCS, concentrations of ST, IGF-I, INS, T_3, T_4, glucose and NEFA in plasma, and subsequent milk production (0-60 d) when cows were injected during both the prepartum and postpartum periods.

MATERIALS AND METHODS

Animals and experimental design

Twenty-five multiparous Holstein cows were assigned randomly to one of four treatment groups about 5 wk prior to expected calving. Control group received no bST or excipient injection (7 cows), whereas cows injected biweekly with 0.2, 0.4 or 0.6 ml of POSILAC® (500 mg bST in 1.4 ml, Monsanto, St. Louis, MO) were provided 5.1 mg bST/d (6 cows), 10.2 mg bST/d (6 cows), or 15.3 mg bST/d (6 cows). One cow in each of the 5.1 and 15.3 mg bST/d groups was removed due to clinical mastitis and milk fever, respectively. The mean number of previous lactations for cows in the four treatment groups at the start of experiment was 2.4, 2.4, 2.4 and 2.5, respectively. Injections began 28±3 d before expected calving. Regardless of day of last injection before calving, first postpartum injection was within 24 h of calving and thereafter injections were at 2 wk intervals with last injection at 56 d. Injections of bST were subcutaneous in the post-scapular region or in the left or right ischiorectal fossa, after blood collection, but prior to a.m. feeding or milking. Body weight (BW) and BCS of the cows at start of trial ranged from 544 to 770 kg and 3.25 to 4.25, respectively and mean dry period lengths were 55.0, 55.2, 57.6 and 56.6 d, respectively. All cows calved during a 4 month time period (February to May). Sampling period prepartum differed from expected (28 d) because of early or late calving but was between 17 to 31 d and all cows in the three bST-injected groups received at least two injections of bST before calving.

Feeding program

Cows were managed in a free-stall barn with access to a dirt loafing lot where they calved. Barn was equipped with 48 Calan electronic feeding gates (American Calan, Inc., Northwood, NH) and cows were trained to use gates during first week before DMI measurements were recorded. Water was available in water troughs for free choice consumption.

Feed was offered once daily (10:00-12:00 h) and adjustments were made daily to allow 5-10% refusals.

Table 2. Least squares means and SE for DMI, BCS and BW of cows in the four treatment groups during the prepartum period[1]

	Overall (-21 to 0 d) LSM[3]±SE	Wk-3 (-21 to-14 d) LSM±SE	Wk-2 (-14 to -7 d) LSM±SE	Wk-1 (-7 to 0 d) LSM±SE
DMI (kg/d)				
No bST	13.90±0.73	15.54±0.95	14.08±0.95	12.08±0.95
5.1 mg/d	12.54±0.87	12.89±1.13	12.37±1.13	12.38±1.13
10.2 mg/d	13.51±0.78	13.92±1.01	13.77±1.01	12.85±1.01
15.3 mg/d	13.98±0.87	12.36±1.13	13.47±1.13	12.36±1.13
BCS[2]				
No bST	3.57±0.16	3.53±0.16	3.59±0.16	3.59±0.16
5.1 mg/d	3.82±0.19	3.74±0.20	3.82±0.20	3.92±0.20
10.2 mg/d	3.54±0.17	3.50±0.17	3.56±0.17	3.56±0.17
15.3 mg/d	3.81±0.19	3.77±0.20	3.79±0.20	3.87±0.20
BW (kg)				
No bST	706±28.3	696±28.3	704±28.3	717±28.3
5.1 mg/d	726±33.5	713±33.8	727±33.8	738±33.8
10.2 mg/d	717±30.1	708±30.3	715±30.3	729±30.3
15.3 mg/d	702±33.6	671±33.8	696±33.8	727±33.8

[1] Treatments=no bST; 5.1 mg bST/d; 10.2 mg bST/d; 15.3 mg bST/d. [2] BCS calculated on a 1-5 scale (Ferguson et al., 1994).
[3] LSM=Least squares means.

Starting 4 wk before expected calving, diet fed was switched from a far-off dry ration (FOD) to a close-up dry anionic ration (CUD; Table 1) to decrease the risk of postpartum hypocalcemia. After parturition, all cows were fed a TMR based on corn silage, whole cottonseeds (WCS), and grain concentrate to meet the requirements of high-producing cows (Table 1). The CUD and lactating TMR rations were sampled twice weekly, then equal portions of the four samples of TMRs (~500 g) collected during each 2 wk period were composited and a subsample was analyzed for contents of DM, CP, ADF, NDF, CP, NEL, soluble protein and ether extract (NEDHIA Forage Laboratory; Ithaca, NY).

Body condition scores and body weights

Body condition scores (1-5, thin to fat; Ferguson et al., 1994) of cows were recorded in 1/4 point intervals the same day each week (08:00 to 12:00 h) before a.m. feeding or milking. All cows were scored separately by two individuals associated with the experiment with 1/4 point agreement to minimize scoring bias. Body weight measures followed the same time schedule. Measurements began the day cows were assigned to trial (-28±3 d) and continued through 60±2 d postpartum.

Milking, milk collection and analysis

Milk yields were recorded at each of the three daily milkings from 3 to 60±2 d postpartum. Milk samples were collected one day each week at each of the three daily milkings during the first 9 wk of lactation. They were preserved using spectrum Microtab™ preservative (D&F control systems, Inc.) and analyzed for contents of fat, protein, and somatic cells (SCC) at DHI laboratory (Southeast Dairy Lab. McDonough, GA).

Blood collection, handling, storage and analyses

Blood samples were collected from the coccygeal vein of all cows three times weekly before the a.m. feeding or milking (7:30-10:00 h) by using Vacutainer® needles (2.54 cm) and 10×100 mm tubes containing sodium heparin (Becton-Dickinson, Fairlawn, NJ). Samples were placed on ice immediately after collection, centrifuged within 2 h at 3,000 rpm for 30 min at 5°C (Jouan GR 412 centrifuge, Winchester, VA) and plasma collected and stored in polypropylene tubes at -20°C until analyzed.

Double antibody radioimmunoassay procedures were used to determine concentrations of ST, T_3, T_4 (Garcia, 1998), IGF-I (Abribat et al., 1990) and INS (Malven et al., 1987) in plasma. An enzymatic colorometric procedure (NEFA C, Wako Pure Chemical Industries, Osaka, Japan) was used for quantitative determination of NEFA in plasma as described by Johnson and Peters (1993). Glucose was analyzed using glucose oxidase procedure (Kit 510, Sigma diagnostics, St. Louis, MO) as described by Raabo and Terkildsen (1960). Glucose and NEFA assays were carried out in 96 well microtiter plates.

Statistical analyses

Data were analyzed as separate prepartum and postpartum data sets using least squares analysis of variance (SAS, 1991) and Proc Mixed procedures of SAS (Littell et al., 2000). Data analyzed were DMI, BCS and BW, milk and 3.5% FCM yields, milk components, and concentrations of somatotropin, insulin, IGF-I, T_4, T_3 and NEFA in plasma. Time periods considered for the data analyses were the overall prepartum period (28 to 0 d), the

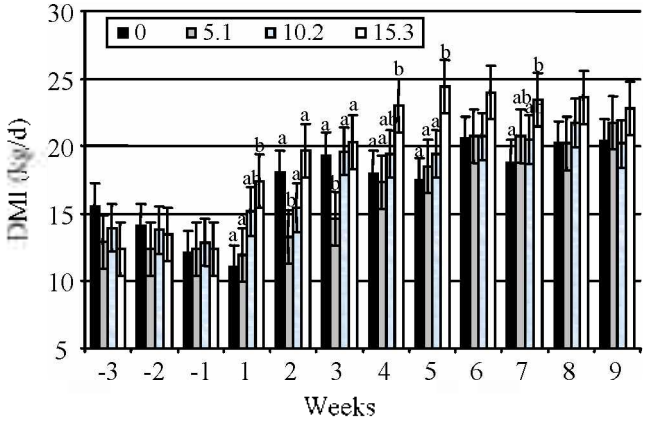

Figure 1. DMI of cows during the experiment (LSM). Treatment bars within weeks with different letters differed ($p<0.10$ or greater).

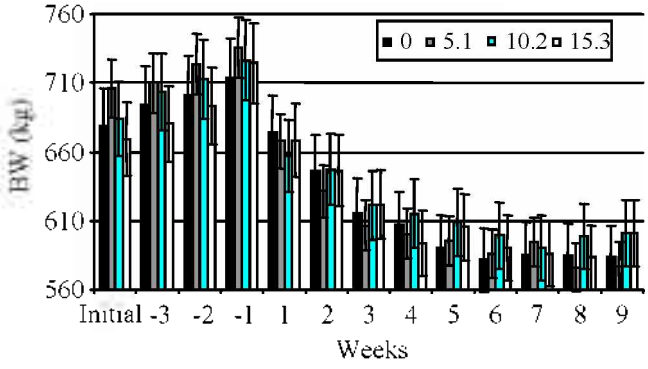

Figure 2. BW of Holstein cows during the experiment (LSM).

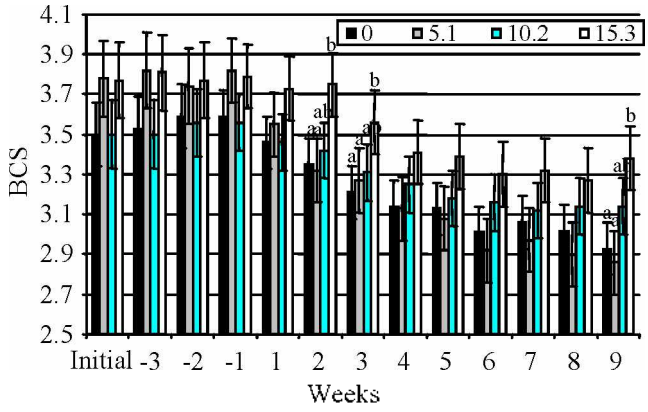

Figure 3. BCS of Holstein cows during the experiment (LSM). Treatment bars within weeks with different letters differed ($p<0.1$ or greater).

specific weeks within this period, the overall postpartum period (1 to 60 d), weeks within this period, and specifically for DMI the time periods 0-21 and 0-60 d postpartum. Data analyses were preplanned to evaluate differences among treatments for all variables measured. Models included the main effects of treatment (TRT), calving month (CMO), the two-factor interaction TRT×CMO and using cow (TRT×CMO) as the error term. Models also were used that included weeks or days to the highest order significant for overall prepartum and postpartum periods, as appropriate. Contrasts of treatment means were compared for the prepartum period and also for the postpartum period. Analyses models also included BW and BCS as covariates where appropriate. Statistical significance was declared at $p<0.05$ with trends indicated for levels up to $p<0.1$.

RESULTS

Changes in DMI, BW and BCS

Prepartum : During overall prepartum period no differences were detected among weekly group treatment means for DMI, BW or BCS (Table 2). At 3 wk before calving the mean DMI did not differ across treatments (range of 12.4 to 15.5 kg/d), although control cows did have greatest numerical mean intake (Figure 1). Mean BW of cows ranged from 647.6 to 698.4 kg when assigned to trial and mean BCS of cows in all treatment groups was greater than 3.5 and did not differ across treatments ($p>0.1$; range of 3.54 to 3.82). All cows within the treatment groups maintained their BW and BCS through calving (Figures 2 and 3). At calving there was a 22% decrease in mean DMI for cows that were not injected with bST compared to DMI at -3 wk (12.08 vs. 15.54 kg/d, $p<0.01$; Table 2) but decreases in DMI were only 4.8, 7.6 and 5.8% for the three bST-injected groups of cows.

Postpartum : Least squares analysis of variance of mean DMI for the two postpartum periods evaluated (0 to 21 d and 0 to 60 d) are in Table 3. There was a trend for a TRT effect during first 21 d postpartum ($p<0.08$) but no effects due to CMO or the two-factor interaction. During 0 to 60 d postpartum mean DMI did not differ due to TRT, CMO or the two-factor interaction. On the other hand, DMI at 1 wk ($p<0.04$) and 4 wk ($p<0.05$) were greater for cows injected with 15.3 mg bST than those not injected or injected with 5.1 mg bST/d and at 5 wk cows injected with 15.3 mg bST/d had the greatest DMI ($p<0.05$; Figure 1). No significant differences were detected among other treatments. However, cows injected with 5.1 mg bST/d tended to have the lowest intake at wk 2 and 3 ($p<0.08$) and DMI of cows not injected with bST tended to be less than cows injected with 15.3 mg bST/d ($p<0.07$; Figure 1).

Least squares analyses of variance for BW and BCS during the overall postpartum period (0 to 60 d) are in Table 3. Although no effects due to TRT, CMO or the two-factor interaction were detected for BW, a tendency for TRT effect was detected for BCS ($p<0.06$). Overall, the trends for changes in BW and BCS were essentially parallel and opposite that of DMI during the 0-60 d postpartum period (Figures 2 and 3). Non-orthogonal contrasts showed that cows injected with 10.2 and 15.3 mg bST/d maintained

Table 3. Least squares means and SE for postpartum DMI, BCS, BW, Milk and 3.5% FCM Yields and SCC of Holstein cows

Measurements	bST Treatments (mg/d)[1]			
	0	5.1	10.2	15.3
DMI (kg/d)[2]	17.7±0.34	13.6±0.37	17.8±0.33	19.7±0.44
DMI (kg/d)[3]	19.3±0.52	18.2±0.68	19.1±0.60	22.4±0.81
BCS [3]	3.15±0.00	3.12±0.00	3.20±0.00	3.58±0.00
BW (kg)[3]	614.3±0.83	612.0±0.99	618.6±0.81	591.6±1.60
Milk yield (kg)[2]	31.1±0.31	27.1±0.41	31.1±0.34	34.4±0.48
Milk yield (kg)[3]	31.8±0.25	30.4±0.31	33.1±0.27	35.4±0.37
3.5% FCM (kg)[3]	29.8±0.98	31.4±0.81	33.2±0.68	36.7±0.56
SCC[3,4]	865.4±126.7	540.6±148.6	177.9±134.6	218.6±188.8

[1] Treatments: no bST; 5.1 mg bST/d; 10.2 mg bST/d; 15.3 mg bST/d. [2] Mean for 0-21 d postpartum.
[3] Mean for 0-60 d postpartum. [4] SCC=Somatic cell count ($\times 10^3$).

Table 4. Least squares means and SE for prepartum (-21 to -1 d) hormones, IGF-I, glucose and NEFA of Holstein cows

Plasma measures [2]	bST Treatments (mg/d)[1]			
	0	5.1	10.2	15.3
ST (ng/ml)	4.8±2.62	5.3±3.13	15.2±2.80	20.2±3.13
INS (ng/ml)	0.58±0.09	0.71±0.11	0.71±0.10	0.83±0.11
IGF-I (ng/ml)	113.0±13.9	142.8±16.6	146.6±15.0	171.7±17.4
T4 (ng/ml)	45.8±0.7	40.7±0.8	53.5±0.7	56.6±1.5
T3 (pg/ml)	712.7±100.4	819.0±119.9	773.8±107.3	920.6±120.4
Glucose (mg/dl)	68.0±3.7	75.3±4.4	71.1±3.9	66.0±4.4
NEFA (μeq/l)	380.3±54.7	494.3±65.1	438.2±58.5	368.2±66.5

[1] Treatments: no bST; 5.1 mg bST/d; 10.2 mg bST/d; 15.3 mg bST/d. [2] Mean for -21 to 0 d prepartum.

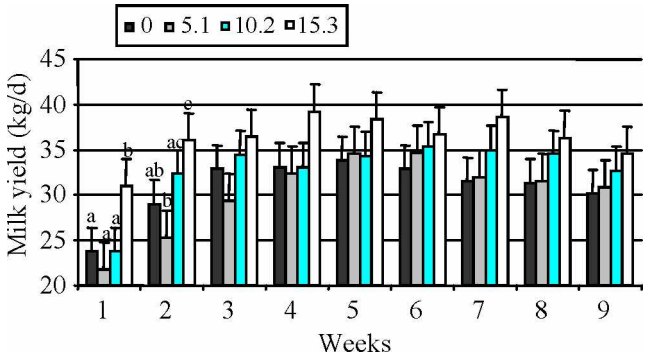

Figure 4. Milk yields of cows after calving. Treatment bars within weeks with different letters differed (p<0.1 or greater).

their BCS better during the overall postpartum period than cows not injected or injected with 5.1 mg bST/d (Table 3). Cows injected with greatest dose of bST also tended to have greater mean BCS (p<0.06) than cows in other treatments during overall postpartum period (3.46 vs. 3.15, 3.13 and 3.21, respectively).

The weekly trends for BW (Figure 2) and BCS (Figure 3) across treatments also were analyzed. Mean BW during overall postpartum period did not differ due to treatment. Cows in all four treatment groups lost BCS after calving, as expected, but recovery of BCS by cows injected with two greatest doses of bST (10.2 and 15.3 mg/d) was seen after wk 5 of lactation, but this occurred 2 wk later for cows not injected or injected with 5.1 mg bST/d. Cows injected with 15.3 mg bST/d tended to have greater BCS during wk 2 postpartum than cows not injected or injected with 5.1 mg/d (p<0.08) and greater at 3 wk than cows not injected (p<0.1). The BCS was better maintained by cows injected with greatest amount of bST (15.3 mg/d) compared to those cows not injected or injected with 5.1 mg bST/d, but no other differences were detected among weeks (Figure 3).

Milk and 3.5% FCM yields

Least squares mean daily milk and 3.5% FCM yields through 60±2 d are in Table 3 and trends for MY over the first 60 d of lactation are in Figure 4. No significant differences were detected due to TRT, CMO or the two-factor interaction. Cows injected with 15.3 mg bST/d tended to have greatest daily MY at the beginning of lactation (p<0.09) and greatest numerical mean milk and 3.5% FCM yields (35.4 and 36.7 kg/d, respectively) during first 60 d of lactation. The MY tended to be lower for cows not injected and injected with 5.1 mg/d during the overall lactation period (0 to 60 d). Cows injected with the two greatest doses of bST (10.2 and 15.3 mg/d) tended to have reduced SCC compared to those not injected or injected with 5.1 mg bST/d (198.3±103.5 vs. 703.2±119.2$\times 10^3$; p<0.08), but no differences were detected due to CMO or the two-factor interaction. Overall, milk component percentages did not differ due to treatment, CMO and no interaction was detected.

Hormones, growth factor and metabolites

Prepartum : Plasma concentrations of ST, INS, T_3, T_4,

Table 5. Least squares means and SE for postpartum (0-60 d) hormones, IGF-I, glucose and NEFA of Holstein cows

Plasma measures [2]	bST Treatments (mg/d)[1]			
	0	5.1	10.2	15.3
ST (ng/ml)	6.23±0.54	4.39±0.63	18.30±0.58	20.16±0.79
INS (ng/ml)	0.48±0.01	0.40±0.01	0.43±0.01	0.44±0.03
IGF-I (ng/ml)	73.9±2.11	70.0±2.59	85.5±2.21	83.0 ±4.47
PRL (ng/ml)	22.5±0.88	31.7±1.05	25.3±0.90	29.6±1.51
T_4(ng/ml)	45.8±0.66	40.7±0.77	53.5±0.68	56.6±1.52
T_3 (pg/ml)	524.8±14.8	503.4±17.6	598.7±16.2	992.0±21.7
Glucose (mg/dl)	52.8±0.50	52. 5±0.61	49.8±0.52	56.6±1.07
NEFA (μeq/L)	536.4±86.3	582.9±95.4	624.2±101.3	605.3±99.7

[1] Treatments: no bST; 5.1 mg bST/d; 10.2 mg bST/d; 15.3 mg bST/d. [2] LSM during 0-60 d postpartum.

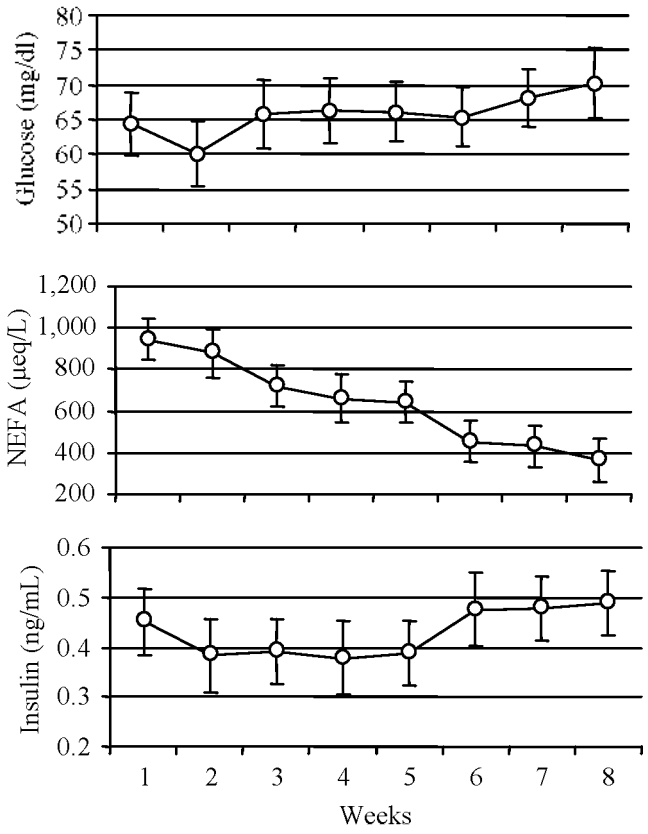

Figure 5. Postpartum concentrations of glucose, NEFA and insulin (weekly LSM).

IGF-I, glucose and NEFA were evaluated from -21 d through-1 d; means and SE are in Table 4. No differences in mean concentrations of T_3, T_4, INS, glucose or NEFA were detected during overall prepartum period due to TRT, but ST ($p<0.01$) and IGF-I ($p<0.05$) differed. Contrasts of treatment means showed that mean concentrations of ST were greater for cows injected with the two greatest doses (10.2 and 15.3 mg bST/d; 15.17 and 20.15 ng/ml) than in cows not injected and injected with 5.1 mg bST/d (4.25 and 5.27 ng/ml). Although concentrations of ST did not differ significantly among treatments at -3 wk, cows injected with the two greatest bST doses (10.2 and 15.3 mg/d) tended to have greater concentrations at both -2 wk ($p<0.06$) and -1 wk ($p<0.01$). Increases in mean concentrations of ST were 4 to 5 fold greater, respectively, during the same time interval for cows injected with 10.2 and 15.3 mg bST/d.

Mean plasma concentrations of IGF-I during the 3 wk preceding calving differed due to treatment ($p<0.05$; Table 4); there tended to be a linear increase in IGF-I as dose of bST increased. Cows not injected with bST did have lowest numerical mean plasma concentrations of IGF-I (113 ng/ml), whereas concentrations in cows injected with 5.1 and 10.2 mg bST/d were intermediate (142 and 146 ng/ml) and greatest concentrations were for cows injected with 15.3 mg/d (171 ng/ml). Overall, mean plasma concentrations of IGF-I decreased during the week preceding calving in all treatment groups of cows.

Mean concentrations of INS in plasma during the prepartum period did not differ among treatments (Table 4). Contrasts of treatment means showed that at 3 wk, cows injected with the two greatest doses (10.2 and 15.3 mg/d) had significantly higher concentrations of INS than cows not injected or injected with 5.1 mg/d ($p<0.03$), whereas concentrations of INS in cows injected with 15.3 mg bST/d was greater than in cows that had not been injected or injected with 5.1 mg bST/d at -2 wk ($p<0.02$). Mean prepartum concentrations of glucose and NEFA also are in Table 4. Mean plasma concentrations of neither of these differed due to TRT, CMO or the two-factor interaction. However, during the week of calving mean plasma NEFA concentration was numerically least for cows injected with 15.3 mg bST/d (368.2 μeq/L) and there was a non-significant trend for a progressively greater concentration of NEFA in groups of cows as amounts of bST injected decreased (395.3, 449.6 and 586.6 μeq/L, respectively).

Postpartum : For concentrations of ST, significant effects of TRT ($p<0.01$), CMO ($p<0.06$) and the two-factor interaction ($p<0.05$) were detected (Table 5). Least squares mean concentrations of ST for cows not injected or injected with 5.1 mg/d were similar (Table 5), but only about one-third of the mean concentration of cows that had been injected postpartum with either of the two greatest doses of bST (10.2 and 15.3 mg/d) (Figure 7).

Least squares mean concentrations of INS did not differ due to TRT, CMO or the two-factor interaction (Table 5).

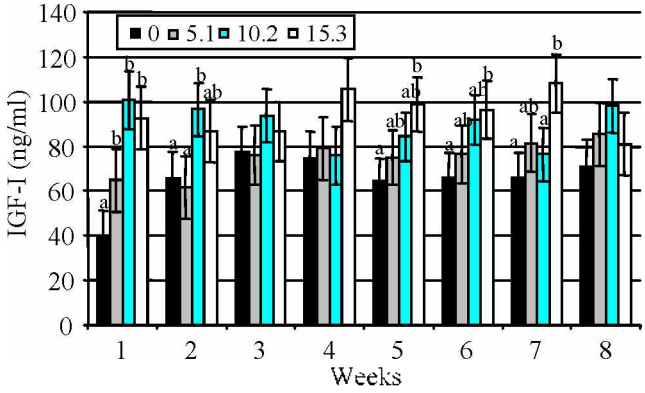

Figure 6. IGF-I concentrations of Holstein cows during postpartum period. Treatment bars within weeks with different letters differed ($p<0.1$ or greater).

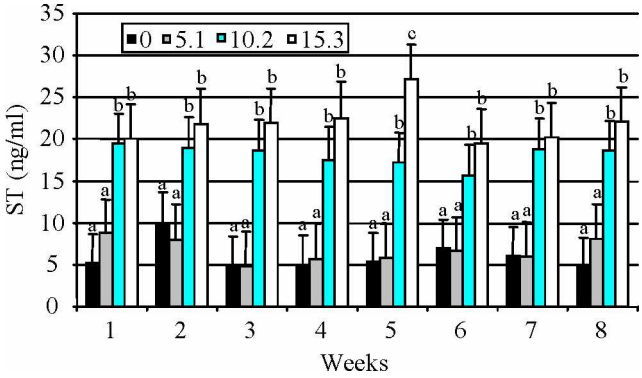

Figure 7. ST concentrations of Holstein cows during postpartum period. Treatment bars within weeks with different letters differed ($p<0.1$ or greater).

However, as expected, concentrations of INS declined after calving and remained low during the first 5 wk of lactation (Figure 5). Thereafter, an increase in INS was observed for cows in all treatments. The ST/INS ratio was greater ($p<0.03$) for cows injected with the two greatest doses of bST.

For IGF-I, no effects of TRT, CMO or the two-factor interaction were detected during early lactation (0-60 d). However, mean concentrations of IGF-I (Table 5) during this postpartum period for cows injected with the two greatest doses (10.2 and 15.3 mg bST/d) were about 30% greater than for cows not injected or injected with 5.1 mg bST/d. Trends in concentrations also differed during the first 8 wk of lactation (Figure 6).

Least squares analyses of variance for T_3 and T_4 are in Table 5. No effects of TRT, CMO or the two-factor interaction were detected for T_4. However, least squares mean concentrations of T_4 for cows injected with the two greatest doses of bST (10.2 and 15.3 mg/d) were numerically greater than for cows not injected or injected with 5.1 mg bST/d (Table 5). For T_3, means tended to differ across treatments ($p<0.08$) and the two-factor interaction was significant ($p<0.01$). Trend for mean concentrations of T_3 was similar to that for T_4. Least squares mean concentrations of T_3 were greatest for cows injected with the greatest dose of bST (15.3 mg/d) and concentrations tended to progressively decrease as amount of bST injected decreased.

For plasma glucose and NEFA, no differences were detected due to TRT, CMO or the two-factor interaction; means are in Table 5. During the early postpartum period no systematic trend was seen across weeks (Figure 5). Plasma NEFA concentrations were high for cows in all treatments during first 2 wk of lactation (~900 μeq/L) but declined afterward such that they were ~365 μeq/L at 8 wk postpartum.

DISCUSSION

Excellent management and nutrition of the transition cow are critical to obtain maximum DMI, to reduce risk of metabolic diseases, to have maximum possible milk production and to improve reproductive efficiency (Drackley, 1999). Maintenance of high DMI during prepartum and postpartum phases supports fetal and mammary growth and also provides energy and nutrients to support the rapid increase in milk yield after calving (Bell, 1995). Yet, reduced DMI during both the prepartum and early lactation phases of the transition period is well documented (Bertics et al., 1992; Garcia, 1998; Drackley, 1999; Garcia et al., 2000) and, in part, likely compromises these functions.

Doubtless, effects of bST injected during lactation on DMI are associated with the rapid increase in milk production and the flow of extra nutrients to the mammary gland to support increased milk synthesis (Bauman and Curry, 1980; Bauman, 2000). Drawing upon the known effects of bST on DMI and extent of lipid and protein mobilization seen during lactation (Bauman, 1999), reduced daily amounts of bST were provided during both the prepartum and postpartum phases of the transition period. This was undertaken to evaluate whether cows better maintained and/or improved their DMI and to perturb metabolic systems that might favor maintenance of homeostasis as cows pass through the transition period.

In the current experiment, three daily amounts of bST were evaluated (5.1, 10.2 and 15.3 mg bST/d). These amounts were only 14.3 to 42.8% of that currently used to enhance lactation (POSILAC®; 35.7 mg bST/d), but the two greater doses did tend to provoke positive responses in postpartum DMI and milk production. Cows injected with 15.3 mg bST/d also had greater DMI on average than cows that were not injected or those that received the lowest dose (5.1 mg/d) during the first 60 d postpartum. Previous

reports of use of bST during the transition period have been variable. Santos et al. (1999) reported a decrease in DMI of cows injected with full dose of bST starting 5 d postpartum, whereas DMI of Jersey cows was not improved by injecting 500 mg bST/14 d (35.7 mg bST/d) from 28 d prepartum to about 14 d postpartum (Eppard et al., 1996). Lack of positive effects on DMI due to bST injections during the dry period or during early lactation may be associated with high dose injected (Schneider et al., 1990; Eppard et al., 1996; Putnam et al., 1999).

Changes in BCS and BW during early lactation likely are a consequence of the rapid increase in peak milk production, timing of increase in DMI, the need to mobilize body reserves to support lactation, and the severity and extent of the energy deficit. In the current experiment, cows in all groups began to lose weight and body condition immediately after calving (Figures 2 and 3). Cows injected with greatest dose of bST prepartum and postpartum had mean BCS of 3.87 at calving and they had less decrease in BCS during early lactation (Figure 3), and recovery of BCS began after 5 wk of lactation. This indicated higher DMI and less mobilization of adipose tissue beyond this time, which agreed with Garcia (1998) and Moallem et al. (1997). Cows that were not injected with bST or injected with 14 mg bST/d during the first 60 d postpartum showed no increase in BW or BCS (Stanisiewski et al., 1992), whereas 5 mg bST did not cause effects on BW or BCS and cows were in negative energy balance through 70 d postpartum (Simmons et al., 1994). When a much greater dose of bST was injected (35.7 mg/d) prepartum and postpartum there was no change in BW and BCS of either control or bST-treated cows (Putnam et al., 1999), whereas Moallem et al. (1997) reported that cows not injected with bST began to gain BW sooner than cows injected with this amount of bST during the early postpartum period. Subsequently, these researchers showed that BW of cows treated with greater amounts of bST continued to decrease through 62 d of lactation (Moallem et al., 2000). During current study the greatest increases in DMI were by cows injected with greatest dose of bST (15.3 mg/d) during the postpartum period and response was similar to that seen when cows were injected with full dose of bST during lactation.

Typically, concentrations of ST in cows begin to increase during late pregnancy and are elevated at calving (Bauman and Vernon, 1993). In current study, it was important to establish an injection dose that was able to provoke an increase in concentrations of ST in plasma. Mean concentrations of ST during the overall prepartum period were greatest for cows injected with two greatest quantities of bST (10.2 and 15.3 mg/d) and the concentrations remained elevated throughout the early prepartum period. After calving the concentrations of ST remained low through 5 wk of lactation and then began to increase (Figure 6), but not in the uninjected cows or those injected with the lowest dose of bST (5.1 mg/d). Increases in ST concentrations about 2–4 fold greater were seen when 5-25 mg bST/d had been injected (Bachman et al., 1992; Lucy et al., 1993; Simmons et al., 1994). Some progressive increases in ST concentrations were seen previously in cows injected with the 5.1 mg bST/d (Garcia, 1998). Different responses among studies may have been associated with cow management, diets fed or fact that the lactation period during the current study was completed largely during the hotter more stressful months of the year. Perhaps reduced ST was seen during the hotter more humid weather because ST secretion was depressed but the amounts of bST injected were sufficient to maintain similar concentrations in plasma.

An important measure of potential benefit of bST use prepartum and/or during early postpartum periods was its ability to increase concentrations of IGF-I, which has important effects on mammary growth and function (Butler and Le Roith, 2001). Our results indicated that cows injected with the two greatest doses of bST (10.2 or 15.3 mg/d) tended to have higher concentrations of IGF-I after parturition than cows in other groups. Circulating concentrations of IGF-I are positively correlated with ST secretion during postnatal life and tissue IGF-I levels also are dependent upon ST. In addition, ST has a primary role in the hepatic expression of IGF-I and nutritional status has an important role in the regulation of the somatotropic-axis (Breier et al., 1986; Butler and Le Roith, 2001). Lower plasma concentrations of IGF-I during early lactation are associated with low DMI during this period (Ronge et al., 1988). Injections of bST (25 mg/d) increased concentrations of IGF-I during both early and late lactation (Staples et al., 1988; Lucy et al., 1993) and the response of IGF-I to bST was greater when cows were in positive energy balance (Bachman et al., 1992). Although concentrations of ST remained elevated during the final week prepartum, concentrations of IGF-I did show the expected decline during the 21 d prepartum period (21 d to 1 d) and also were lowest the week preceding calving. Results were similar to those of Simmons et al. (1994) and Bachman et al. (1992).

CONCLUSIONS

Results suggest that that the two greatest doses of bST evaluated (10.2 and 15.3 mg bST/d) during transition period and into early lactation did cause changes in concentrations of ST, metabolic hormones and IGF-I that favored positive effects on the DMI, BCS and MY of injected cows. There was no evidence that injection of bST caused additional negative energy balance or had apparent negative or positive effects on health of injected cows compared to

uninjected cows or those injected with the lowest amount of bST. Because of the positive effects on BCS and MY and no apparent detrimental effects on health and energy balance, use of lower doses of bST (10.2 or 15.3 mg bST/d) during the transition period may be a management strategy to improve performance of cows. The two greatest doses of bST should be evaluated with a larger number of cows during the transition period and early lactation to critically evaluate effects on current and subsequent milk production and other physiological responses such as incidence of diseases and reproduction.

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