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Bovine somatotropin hormone (BST). I. Milk yield responses from crossbred Sahiwal-Friesian dairy cattle

[Hormon bovin somatotropin (BST). I. Respons terhadap pengeluaran susu daripada lembu tenusu kacukan Sahiwal-Friesian]

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Key words: bovine somatotropin, milk yield, Insulin-like growth factor-I

Abstrak

Dua ujikaji telah dijalankan bagi menilai keberkesanan suntikan formulasi hormon bovin (BST) somatotropin yang dilepaskan secara perlahan-lahan dan berpanjangan terhadap pengeluaran susu, kandungan susu, profil darah, berat badan, kepekatan BST dan faktor-I pertumbuhan yang menyerupai insulin (IGF-I) dalam sampel darah dan susu lembu tenusu kacukan Sahiwal Friesian (SF) yang sedang dalam laktasi di Malaysia.

Suntikan BST dapat meningkatkan pengeluaran susu lembu tenusu kacukan SF sebanyak 1.3–2.1 kg/ekor/hari. Suntikan BST juga mengakibatkan peningkatan kepekatan BST dan IGF-I dalam serum darah lembu, namun kepekatannya dalam susu, kandungan susu, berat badan dan kesihatan lembu tidak terjejas. Kajian ini mengesahkan bahawa BST sememangnya mampu dapat meningkatkan pengeluaran susu lembu tenusu kacukan SF di Malaysia.

Abstract

Two experiments were conducted to evaluate the effect of prolonged release formulation of recombinant bovine somatotropin (BST) on milk production, milk composition, blood profile, body weight, BST and insulin-like growth factor-I (IGF-I) concentration in blood and milk samples of lactating crossbred Sahiwal Friesian (SF) dairy cows in Malaysia.

The administration of BST increased milk yield of crossbred SF dairy cows by 1.3–2.1 kg/cow/day. While the administration of BST significantly increased serum BST and IGF-I concentration, milk BST and IGF-I, milk composition, body weight and general health of the cows were not affected. The studies confirmed the efficacy of BST in enhancing milk production of crossbred SF dairy cows in Malaysia.

Introduction

It has been established that recombinant BST, a protein hormone developed through recombinant DNA technology, significantly increased milk yield in dairy cows. Most of the studies conducted to determine the mode of action, efficacy and safety of using BST in lactating cows were carried out on *Bos taurus* dairy breeds managed under favorable temperate environment (Peel and Bauman 1987; Chilliard 1989; Hartnell 1994). Under these conditions the

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administration of BST usually resulted in a large and significant milk response with no major changes in milk composition and no adverse health effects. Although increases in milk yield response of up to 50% have been described from some BST trials, 10–20% increases are more typical (Bauman 1992; Burton et al., 1994).

In contrast, only a limited number of studies have been carried out in tropical environment using crossbred dairy cattle. In these conditions the administration of BST has produced a significant milk yield response in crossbred dairy cows. A 16-week BST trial carried out by Phipps et al. (1991) in Zimbabwe on Mashona x Friesian crossbred dairy cows showed a significant increased in milk yield response from 8.6–11.0 kg/day, a 28% improvement in milk production. In a trial conducted over a 24-week period, Fontes et al. (1993) also reported a significant increased in milk yield response from 11.6–14.2 kg/day in BST-treated Brazilian crossbred dairy cows. Thus, the prospect of utilizing BST to increase milk yield of crossbred dairy cows in the tropics appears to offer substantial potential.

The present paper reports the effect of BST on milk yield response of crossbred SF dairy cows managed under tropical environmental conditions in Malaysia.

Materials and methods

Two experiments were conducted. One at MARDI's research station in Serdang, Selangor and the other at smallholder farms in Banting, Selangor. Both studies were carried out over a 16-week period using multiparous lactating SF crossbred dairy cows. In these studies, treated cows received eight subcutaneous injection of 500 mg of Sometribove (Monsanto's prolonged-release formulation of BST) administered at 14-day intervals into the ischio-rectal fossa, which lies lateral to and on either side of the anus.

In the first trial (E1), 48 multiparous lactating SF crossbred cows at three stages of lactation (90–120, 121–150 and 151–180 days in milk) were paired according to their initial milk production and then randomly allocated to two treatment groups (control and BST treatment). Cows were housed in tie-stalls during the day and grazed Leucaena-*Brachiaria decumbens* pasture at night. Cows received a concentrate supplement containing 246 g CP (crude protein) per kg DM (dry matter) and 11.3 MJ ME (metabolisable energy) per kg of DM at the rate of 2, 4, 6 and 8 kg/head/day for cows producing < 5, 5–10, 10–15 and >15 kg of milk/day, respectively.

In the second trial (E2), 38 lactating SF cows (90–150 days in milk) were paired according to their initial milk yield and then randomly allocated to two treatment groups (control and BST treatment). Cows were housed in tie-stalls during the night and were allowed to graze in oil palm plantation between the morning and evening milking. Wet brewers grain (285 g CP/kg DM and 10.3 MJ ME/kg DM), palm oil sludge (138 g CP/kg DM and 8.5 MJ ME/kg DM) and cut forages were the main ration ingredients. Cows also received concentrate containing 166 g CP/kg DM and 11.2 MJ ME/kg DM offered at the rate of 1 kg/2 kg of milk produced.

In both trials, individual milk yield was recorded twice daily. Milk and blood samples were taken on day 2 and 9 of cycles 2, 5 and 8 (BST 14-day injection cycles). All milk samples were analyzed for milk fat, protein and lactose. Blood samples were analyzed for pack cell volume (PCV), total red blood cell (TRBC), haemoglobin (Hb) and plasma protein (PP) concentrations. In addition, fat free milk and serum blood samples, from day 2 and 9 of cycle 8 and day-14 of post-treatment, were also analyzed for BST and insulin-like growth factor-I (IGF-I). BST was determined by the radio-immunoassay (RIA) double antibody method (Gardner et al., 1974). The anti-sera (GH1/7) were raised in New Zealand White rabbits. The second anti-sera against rabbit serum were raised in sheep. IGF-I was analysed by the acid-ethanol cryo-

precipitation method as described by Breier et al. (1991). The within assay variations for BST and IGF-I were calculated to be 3.8% and 7.5%, respectively. The binding sensitivity for BST assay was 1.5–2.2 μg/mL and for IGF-I assay, 0.3–1.26 μg/mL. Live weight measurement was taken every two weeks for E1 only. Lack of facilities (crushes and portable platform weighing scales) at the smallholder farms makes it impossible to measure live weight of the experimental animals in E2.

Milk yield and live weight data were analyzed by Statistical Analysis System (SAS) using generalized linear model (GLM) procedure for covariate analysis and the linear model was as follows:

$$Y_{ijk} = U + A_i + B_j + AB_{ij} + B^*PRE_{ijk} + E_{ijk}$$

where:

- Y_{ijk} = variable for cow $_k$ in treatment $_i$ and $_j$ lactation stage
- U = overall mean
- A_i = treatment $_i$ effect
- B_j = stage of lactation $_j$ effect
- AB_{ij} = treatment $_i$ by stage of lactation $_j$ interaction effect
- B^* = linear regression coefficient for covariate PRE_{ijk}
- PRE_{ijk} = covariate (cow $_k$ in treatment $_i$ and $_j$ lactation stage)
- E_{ijk} = residual error

Blood profile, milk composition, BST and IGF-I concentration in milk and serum samples were not covariately adjusted but were analyzed by SAS using GLM procedure with the following linear model:

$$Y_{ijk} = U + A_i + B_j + AB_{ij} + E_{ijk}$$

where:

- Y_{ijk} = variable for cow $_k$ in treatment $_i$ and $_j$ lactation stage
- U = overall mean
- A_i = treatment $_i$ effect
- B_j = stage of lactation $_j$ effect
- AB_{ij} = treatment $_i$ by stage of lactation $_j$ interaction effect
- E_{ijk} = residual error

Results and discussion

In E1, there was no significant (p >0.05) effect of stage of lactation on the milk yield response of BST-treated cows. This result supports findings by Meyer et al. (1988) who concluded that response of BST did not depend on the stage of lactation provided the treatment began 30 days post-partum. Nevertheless, the use of BST significantly (p <0.01) increased milk yield of SF crossbred cows from 7.7–9.0 kg/day *(Table 1)*. This result however, markedly lower than the milk yield response of 2.4 and 2.5 kg/cow/day recorded by Phipps et al. (1991 and 1993). The lower milk yield response in E1 may be associated with a lower plane of nutrition. Problems were encountered in providing sufficient quantity of good quality forages because demand for forages by livestock at the Institute was high and the occasional long dry spell made it harder to maintain good forage quality. Even though the milk yield response obtained in

Table 1. Mean milk yield and milk yield response for control and BST-treated crossbred SF dairy cows

Study	Treatment groups	Mean milk yield (kg/day)	Milk yield response (kg/day)	Significance (p)	SE_d
E1	Control	7.7	1.3	0.0018	0.38
	BST-treated	9.0			
E2	Control	11.7	2.1	0.0007	0.56
	BST-treated	13.8			

E1 = first trial
E2 = second trial

E1 was lower than that recorded in other trials conducted with crossbred dairy cattle in the tropics, the result clearly indicates that the use of BST can significantly increase milk production of crossbred SF dairy cows by as much as 17%.

In E2, BST treatment significantly (p <0.01) increased milk yield response of crossbred SF dairy cows from 11.7–13.8 kg/day *(Table 1)*. A 2.1 kg/cow milk yield response recorded in E2 was markedly higher than that obtained in E1 but it is similar to that of 2.3 kg/cow/day obtained by Phipps and Hard (1992) in a study with Friesian crossbred dairy cows managed under smallholder production system in Zimbabwe.

In both trials, mean serum BST concentrations in cycle 8 of BST-treated cows when compared with the control were significantly (p <0.01) increased from 1.61–7.31 µg/mL for E1 and from 2.56–5.57 µg/mL for E2 *(Table 2)*. The mean serum IGF-I levels for control vs. BST-treated cows in E1 and E2 were 72.2 vs. 205.9 and 76.9 vs. 194.9 µg/mL, respectively. These differences were highly significant (p <0.01). These results which are the first to be reported for crossbred SF cows in the tropics showed a 2–3 fold increase in BST and IGF-I concentrations in the serum of BST-treated cows. Davis et al. (1987), Prosser et al. (1989) and Schams et al. (1991) also observed similar findings. According to Schams et al. (1989), when dairy cows were treated with BST, there may be 2–10 folds and 2–5 fold elevations in serum BST and IGF-I concentration, respectively. The size of the increase depended on the dose administered.

In milk, there was no significant difference (p >0.05) in mean BST concentrations for the control and BST-treated cows (0.88 vs. 0.99 and 0.47 vs. 0.46 µg/mL for E1 and E2, respectively). The mean milk IGF-I levels in E1 and E2 for control vs. BST-treated cows were 7.9 vs. 8.0 and 9.1 vs. 8.7 µg/mL, respectively *(Table 2)*. These differences were not significant (p >0.05). The BST and IGF-I in milk of crossbred cows were not appreciably altered by BST administration. Similar findings were also observed by Schams (1989, 1990), Prosser et al. (1989) and Van den Berg (1989). The lack of any appreciable change in milk BST concentration when given exogenous BST is consistent with the fact that mammary epithelial cells appear to lack of receptor, for the somatotropin hormone (Collier *et al.*, 1989). No significant alteration in the concentration of BST and IGF-I in milk of BST-treated crossbred cows confirms that the milk from BST-treated cows is presumably safe for human consumption.

At day-14 post-treatment period, BST and IGF-I serum levels were approximately half that recorded at day 9 of cycle 8 *(Table 2)*. During post-treatment period, the withdrawal of BST treatment caused a sharp decline in serum BST and IGF-I concentration. This consequently caused a swift decline in milk production. These results support the study carried out by Phipps et al. (1991) in Zimbabwe.

In E1, the mean body weight of crossbred SF dairy cows for the 16-week treatment period was not significantly (p >0.05) affected by BST treatment *(Table 3)*. This result agrees with works reported by Weller *et al.* (1990) and West *et al.* (1990) who also reported that BST had no significant effect on body weight.

Milk composition and blood profiles of the crossbred SF dairy cows in E1 and E2 were not significantly (p >0.05) affected by BST administration *(Table 4* and *Table 5*, respectively*)*. However in the two studies, milk fat and protein concentration from BST-treated cows were both higher when compared with the control. Most trials have reported that the use of BST did not affect milk composition (Baer et al. 1989; Van den Berg, 1991; Barbano et al. 1992; Laurent et al. 1992). However, milk protein content was significantly increased (0.9–1.0 g/kg) in four experiments carried out by Phipps (1987), Bauman et al. (1988), Samuels et al.

Table 2. BST and IGF-I concentration in serum and free-fat milk samples of BST-treated crossbred SF dairy cows measured at day 2 and 9 of cycle 8 and day-14 of the post-treatment period

Study	Sample	Treatment groups	Concentration (μg/mL)		
			Day 2 Cycle 8	Day 9 Cycle 8	14-day post-treatment
E1	Serum BST	Control	1.56	1.63	2.06
		BST-treated	6.15	8.18	4.13
	Significance (p)		0.0002	0.023	0.0178
	SE_d		1.09	2.75	0.88
E2	Serum BST	Control	2.65	2.47	2.47
		BST-treated	6.30	4.48	4.28
	Significance (p)		0.0018	0.0256	0.0753
	SE_d		1.0	0.98	0.96
E1	Serum IGF-I	Control	65.0	78.8	81.6
		BST-treated	151.5	260.6	111.8
	Significance (p)		0.0001	0.0009	0.0751
	SE_d		16.33	48.84	16.14
E2	Serum IGF-I	Control	77.4	76.4	100.5
		BST-treated	220.1	169.7	102.4
	Significance (p)		0.0004	0.0024	0.9364
	SE_d		34.34	27.64	24.58
E1	Milk BST	Control	0.93	0.85	0.79
		BST-treated	1.11	0.81	0.75
	Significance (p)		0.0854	0.5420	0.4379
	SE_d		1.00	0.071	0.048
E2	Milk BST	Control	0.79	0.66	0.86
		BST-treated	0.66	0.70	0.87
	Significance (p)		0.1015	0.3538	0.9171
	SE_d		0.07	0.04	0.06
E1	Milk IGF-I	Control	6.42	8.24	9.13
		BST-treated	6.47	9.04	9.49
	Significance (p)		0.9295	0.4013	0.5460
	SE_d		0.538	0.940	0.589
E2	Milk IGF-I	Control	7.2	8.5	8.8
		BST-treated	9.4	6.6	9.1
	Significance (p)		0.1966	0.1043	0.6757
	SE_d		1.60	1.08	0.90

E1 = first trial E2 = second trial

Table 3. Effect of BST administration on the overall mean body weight of crossbred SF dairy cows for the 16-week BST treatment period in E1*

Treatment groups	Initial mean body weight (kg/head)	Mean body weight (kg/head)	Significance (*p*)	SE_d
Control	379	413	0.6524	5.6
BST-treated	369	415		

*E1 = first trial

Table 4. Effect of BST administration on the mean milk fat, protein and lactose concentration of crossbred SF dairy cows for the 16-week treatment period

Study	Treatment groups	Concentration (g/kg)		
		Fats	Protein	Lactose
E1	Control	32.5	36.7	41.8
	BST-treated	35.9	38.4	43.9
	Significance (p)	0.058	0.261	0.314
	SE_d	1.80	1.35	2.19
E2	Control	35.8	35.8	42.1
	BST-treated	38.9	36.5	43.3
	Significance (p)	0.2413	0.5591	0.1646
	SE_d	2.51	1.11	0.90

E1 = first trial E2 = second trial

(1988) and White et al. (1988). According to Chalupa et al. (1987) and Burton et al. (1994), inadequate supply of dietary energy and protein results in an increase in milk fat percentage and a decrease in milk protein. Further more, cows in negative energy balance produced a higher milk fat content because of greater reliance on lipids mobilization from body store (Bauman 1992). Consequently, the higher milk fat and protein content observed in the BST-treated cows in the present studies may be due to the effect of inadequate supply of dietary energy but an adequate supply of dietary protein.

There were no cases of mastitis or metabolic disorders recorded in E1 and E2. All cows in both studies remained healthy throughout the study periods.

Conclusion

The administration of BST to crossbred SF dairy cows produced an average milk yield response of 18%. Milk composition, blood profile, body weight, BST and IGF-I concentration in milk of crossbred SF dairy cows was not substantially affected when BST was used. There were no adverse affects on cows' health associated with BST treatment. The result showed that BST could be successfully used in the smallholder or large dairy farms to increase milk production of crossbred SF dairy cows in the tropical climate of Malaysia.

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Table 5. Effect of BST treatment on the blood profile of crossbred SF dairy cows measured on day 2 and 9 of cycle 8 and day-14 of the post-treatment period

Study	Treatment groups	Day 2 Cycle 8				Day 9 Cycle 8				Day-14 post-treatment			
		PCV (%)	RBC (10^6/mm^3)	Hb (g/100 mL)	PP (g/100 mL)	PCV (%)	RBC (10^6/mm^3)	Hb (g/100 mL)	PP (g/100 mL)	PCV (%)	RBC (10^6/mm^3)	Hb (g/100 mL)	PP (g/100 mL)
E1	Control	32.4	4.9	10.2	7.3	33.3	5.5	8.8	7.4	35.2	5.5	8.4	7.6
	BST-treated	30.8	5.1	9.7	7.0	31.6	5.2	8.7	7.3	32.3	5.5	7.7	7.5
	Significance (p)	0.29	0.33	0.65	0.33	0.21	0.17	0.98	0.60	0.11	0.90	0.23	0.69
	SE_d	1.52	0.26	0.98	0.24	1.33	0.26	0.61	0.18	1.75	0.47	0.61	0.30
E2	Control	32.8	5.2	10.2	7.3	35.2	5.6	9.2	7.5	34.7	5.7	11.1	7.6
	BST-treated	33.0	5.2	10.2	7.3	35.2	5.6	9.2	7.5	34.7	5.7	10.3	7.7
	Significance (p)	0.91	0.89	0.19	0.20	0.86	0.06	0.67	0.50	0.78	0.89	0.24	0.63
	SE_d	2.57	0.24	1.25	0.27	2.03	0.27	1.12	0.31	1.80	0.32	0.70	0.22

E1 = first trial E2 = second trial PCV = Pack cell volume RBC = Red blood cell Hb = Haemoglobin PP = Plasma protein

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