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Administration of Bovine Somatotropin in Early Lactation: A Meta-Analysis of Production Responses by Multiparous Holstein Cows[1]

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ABSTRACT

A meta-analysis was conducted to assess production responses before 90 d in milk (DIM) when bovine somatotropin (bST) administration was initiated between 5 and 35 DIM. The database was developed from 13 studies of multiparous cows that were published between 1985 and 2006 and from an unpublished study that complied with the study selection criteria. The database included results from 842 cows and provided 50 treatment means for the effect of bST on 3.5% fat-corrected milk (FCM) in early lactation. Effects of bST were investigated using mixed model procedures that included fixed (intercept and slope) and random (intercept and slope) effects for independent variables. Yields of milk (38.6 ± 1.3 kg/d) and FCM (37.6 ± 1.6 kg/d) by control cows before 90 DIM were increased by 2.6 ± 0.8 and 3.2 ± 0.6 kg/d by bST administration. Fat content in milk from bST-treated cows was 0.31 ± 0.10 percentage units greater than that from control cows (3.46 ± 0.13%) but milk protein content (2.95 ± 0.03%) was not altered by bST. Milk fat (1.39 ± 0.10 kg/d) and protein (1.15 ± 0.04 kg/d) yields by controls were increased 0.16 ± 0.03 and 0.07 ± 0.03 kg/d by bST, respectively. Dry matter intake and body weight loss were not altered by bST before 90 DIM, but duration of negative energy balance was prolonged and overall energy balance during this interval reduced when cows were treated with bST. Results are consistent with the premise that bST-treated cows partition nutrients and energy toward milk synthesis for a longer duration and thus likely need a longer interval to replenish their body reserves than cows not treated with bST. Production responses to bST were not altered when cows consumed typical early-lactation diets supplemented with fat except that supplemental fat tended to decrease the magnitude of the effect of bST on milk fat content and decreased the effect of bST on fat and protein yield. Yield of FCM increased curvilinearly with the amount of bST administered. Results indicate that initiation of bST administration to cows before 35 DIM increased FCM yield but the response was at the low end of that typically observed when bST administration is initiated in wk 9 of lactation.
Key words: bovine somatotropin, early lactation, production, meta-analysis

INTRODUCTION

Bovine somatotropin plays a clear and powerful role in the homeorhetic coordination of multiple metabolic alterations that occur in several tissues and are required for the cow to adapt successfully to the metabolic demand imposed by the onset of copious milk production (Bell and Bauman, 1997; Bauman, 1999). Reports from designed studies (Bauman et al., 1989; Hartnell et al., 1991; Stanisiewski et al., 1994), reviews (Etherton and Bauman, 1998; Dohoo et al., 2003), and commercial use (Bauman et al., 1999; Collier et al., 2001) demonstrate that administration of bST to cows in mid or late lactation increased FCM yield 3 to 6 kg/d, improved productive efficiency by partitioning nutrients toward the mammary gland for increased milk synthesis and did not alter milk composition (fat, protein, and lactose) when cows consumed sufficient nutrients and energy.

One of the most significant direct effects of bST binding to its receptor is stimulation of IGF-I synthesis (predominantly in the liver) because plasma IGF-I mediates bST actions in several tissues including the mammary gland (Cohick, 1998). Commercial use of bST for lactating cows is approved for treatment initiation in wk 9 of lactation. This is due, in part, to results that indicate milk yield response was greater and likely more economical when treatment was initiated after peak milk yield or when cows were in positive energy and nutrient balance (Chilliard, 1989; Stanisiewski et al., 1992; Bauman and Vernon, 1993). In early lactation

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when cows are in negative energy and nutrient balance, expression of the liver-specific isoform of the growth hormone receptor (**GHR**)-1A and GHR protein is reduced (Radcliff et al., 2003, 2006), which likely contributes to the reduced circulating concentrations of IGF-I in early lactation (Radcliff et al., 2006) and could help explain why milk and IGF-I (Vicini et al., 1991; McGuire et al., 1992) responses to bST are greater after cows regain positive energy and nutrient status. However, hepatic expression of GHR-1A appears to return to prepartum values by 21 DIM in well-fed cows (Radcliff et al., 2006), and bST administration can increase circulating IGF-I concentrations soon after the energy balance nadir (Weber, 1997; Carriquiry, 2006). Although bST administration in early lactation has resulted in little or no increase in milk yield (Elvinger et al., 1988; Zhao et al., 1992) and milk response has been characterized as small or negligible when bST is administered before peak milk yield (Bauman and Vernon, 1993), initiation of bST administration at 14 to 21 DIM has increased milk yield by more than 3 kg/d in early lactation (Richard et al., 1985; Weber, 1997; Moallem et al., 2000; Carriquiry, 2006). These results prompted us to conduct a meta-analysis to assess effects of bST administration to cows in early lactation.

Meta-analysis procedures use statistical methods to combine data from independent studies for a quantitative analysis. These procedures are particularly useful when there is a conflict in the results reported in the literature and when the small sample size of individual studies limits statistical power of the individual studies to detect differences (Wang and Bushman, 1999; Normand, 1999; St-Pierre, 2001). The objective of this study was to quantitatively and statistically assess the effects of initiation of bST administration between 5 and 35 DIM on production responses before 90 DIM.

MATERIALS AND METHODS

Database

Publications that reported effects of initiation of bST administration before 35 DIM on performance before 90 DIM were identified through a computerized literature search (CAB Abstracts, AGRICOLA, and PubMed) and review of citations in publications identified by the search. To be included in the analysis, publications had to be in English and describe studies that 1) randomized cows to treatment, 2) used only multiparous Holstein cows, 3) initiated administration of bST before 35 DIM, and 4) provided sufficient data to determine 3.5% FCM response before 90 DIM. The search identified 12 publications (Table 1) that fit these criteria. One publication (Hansen et al., 1994) reported results for 2 consecutive lactations and considered each lactation as a separate study. Some cows used by Burton et al. (1990) were used in their subsequent lactation by McBride et al. (1990). Results from these 2 publications were treated as separate studies. Results from an unpublished study conducted by our lab (B. A. Crooker, personal communication) met the selection criteria and provided a 14th study (Table 1). The search identified 7 other studies that initiated bST administration before 35 DIM but failed to meet selection criteria because reported data were not sufficient to determine 3.5% FCM response before 90 DIM, were means from groups composed of primiparous and multiparous cows or composed of multiple breeds, or some combination of these factors (Elvinger et al., 1988; Lormore et al., 1990; Austin et al., 1991; McGuffey et al., 1991; Zhao et al., 1992; Chalupa et al., 1996; Moallem et al., 1999).

Extracted Data

Nine outcome variables or the information needed to compute them were reported in most of these studies and were selected for evaluation in this meta-analysis (Table 1). Data (mean value and its standard error) extracted from the studies were milk and 3.5% FCM yields (kg/d), protein and fat content (%), protein and fat yields (kg/d), DMI (kg/d), BW change (kg/d), and energy balance (**EB**, Mcal of NE_L/d). Some early lactation response data were not reported specifically but were extracted from figures (Hansen et al., 1994; Moallem et al., 1997, 2000). All extracted values represented either means or differences from initiation (5 to 35 DIM) to end (before 90 DIM) of the bST evaluation interval (Table 1). For any study, if the number of cows per treatment was not balanced, the average number of cows per treatment was reported (Table 1). However, the actual number of cows per treatment was used in the analysis.

In addition to the outcome variables, the number of treatment groups, number of cows per treatment group, DIM at initiation of bST treatment, duration of treatment, delivery vehicle formulation (daily or sustained release injections), amount of bST administered, interval between injections, and type of diet were reported (Table 1). Although the overall effect of delivery vehicle formulation was assessed, extraction of study data as means per interval of measurement rather than as day within injection interval prevented an evaluation of the saw-tooth milk response plots (Bauman et al., 1989; Eppard et al., 1991) obtained frequently with sustained release formulations of bST against the usually more stable milk response plots obtained with daily administration of bST (Stanisiewski et al., 1992, 1994). Studies (n = 6) that evaluated more than one nonzero dose of bST were classified as dose-response studies. Some