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Responses of dairy cows to bovine somatotropin and protein sources with different rumen degradability [1]

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ABSTRACT

Interactions of bST injections with dietary protein sources of different rumen degradability were tested for their effects on milk production and N metabolism. The diet was formulated to contain either 36 or 40% of CP as ruminally undegradable protein. Supplemental CP was a combination of soybean meal and sunflower meal (control diet) or a combination of soybean meal and herring meal (low ruminally degradable protein diet). One hundred Italian Friesian dairy cows were randomly divided into four treatment groups: control diet, low ruminally degradable protein diet, control diet plus bST, low ruminally degradable protein diet plus bST. Recombinant bST in a sustained-release formulation (640 mg/28 days) was injected for two cycles. Milk production increased in response to bST but was not influenced by the low ruminally degradable protein diet. No significant bST effects on milk composition were found. Cows fed the diet low in ruminally degradable protein produced milk with lower fat and higher protein percentage. Somatotropin treatment and dietary treatment with low ruminally degradable protein showed additive effects on milk yield and quality parameters. At 7 d postinjection, bST increased plasma NEFA and decreased uric acid, and urea in cows receiving the control or the low ruminally degradable diet; however, bST increased plasma creatinine, and decrased α-amino N in cows receiving the control diet. The low ruminally degradable protein diet increased plasma uric acid, and lowered plasma NEFA.

Key words: somatotropin, protein sources, milk composition, N metabolism.

RIASSUNTO

RISPOSTA ALL'IMPIEGO DI SOMATOTROPINA BOVINA E DI FONTI PROTEICHE A DIFFERENTE DEGRADABILITÀ RUMINALE IN BOVINE IN LATTAZIONE

Sono stati studiati gli effetti delle interazioni fra trattamento con somatotropina bovina (bST) e impiego di fonti proteiche alimentari a differente degradabilità ruminale sulla produzione di latte e sul metabolismo azotato di bovine in lattazione. Le diete sono state formulate in modo da apportare una quota di proteina non degradabile a livello ruminale pari al 36% o al 40% della proteina grezza. Come fonti proteiche sono state impiegate una combinazione di farina di

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estrazione di soia e di farina di girasole (dieta di controllo) e una combinazione di farina di estrazione di soia e di farina di aringa (dieta con proteina a bassa degradabilità ruminale). Cento bovine di razza Frisona Italiana sono state suddivise in quattro gruppi omogenei: dieta di controllo, dieta con proteina a bassa degradabilità ruminale, dieta di controllo + bST, dieta con proteina a bassa degradabilità ruminale + bST. La somatotropina bovina ricombinante a lento rilascio è stata somministrata alla dose di 640 mg/capo ogni 28 giorni per 2 cicli. La produzione di latte è aumentata in seguito al trattamento con bST, ma non è stata influenzata dal trattamento alimentare. Non sono stati evidenziati effetti significativi del bST sulla composizione del latte. L'impiego della dieta con proteina a bassa degradabilità ruminale ha determinato una diminuzione del tenore lipidico ed un aumento del tenore proteico del latte. Il trattamento con bST e la dieta con proteina a bassa degradabilità ruminale hanno evidenziato effetti additivi sui parametri relativi a produzione e composizione del latte. Al 7° giorno di trattamento, il bST ha determinato un aumento dei livelli plasmatici di NEFA (acidi grassi non esterificati) ed una diminuzione dei livelli plasmatici di acido urico e di urea nelle bovine alimentate con la dieta di controllo e con la dieta a basso tenore di proteina degradabile; tuttavia il bST ha innalzato i livelli plasmatici di creatinina e ha diminuito quelli di azoto α-aminico nelle bovine che avevano ricevuto la dieta di controllo. La dieta con basso tenore di proteina degradabile a livello ruminale ha aumentato il livello plasmatico di acido urico e ha diminuito la concentrazione plasmatica di NEFA.

Parole chiave: somatotropina, fonti proteiche, composizione latte, metabolismo azotato.

Introduction

It is well established that treatment of dairy cows with bovine somatotropin (bST) enhances milk secretion, by co-ordinating a complex series of adaptations in the body (Bauman and Vernon, 1993). The exact mechanism whereby bST exerts its galactopoietic action is still uncertain, and probably different mechanisms are involved (Bertoni, 1996). Bovine somatotropin is thought to increase the synthetic capacity of the mammary gland and also to provide the nutrients necessary to support the enhanced rate of milk synthesis, by altering the metabolism in specific tissues (mainly adipose tissue and liver), so that more nutrients are available for mammary uptake (Bauman and Vernon, 1993). These metabolic adaptations are of critical importance especially during the initial period of bST treatment, when milk production has increased, but feed intake has not. These adaptations in metabolism are similar to those which support the increasing milk yield in dairy cows in early lactation, when circulating levels of endogenous somatotropin are high (Vernon, 1989). With longer-term treatment, upward adjustments of feed intake generally occur, to match the enhanced nutrient requirement (Bauman, 1992). The magnitude of milk response to bST treatment is influenced by quality of management, including the nutritional program (Bauman, 1992; Bauman and Vernon, 1993). Thus, for bST-treated cows adoption of feeding strategies similar to those for high producing cows seems necessary to supply sufficient nutrients to support the increased milk production. Energy density of diets can be increased by addition of ruminally inert forms of fat (Schneider *et al.*, 1990; Cattaneo *et al.*, 1993). For protein nutrition, CP requirements must be met and the ratio of ruminally degradable protein (RDP) to ruminally undegradable protein (RUP) balanced. The amount of soluble and degradable dietary protein must not be excessive, the avoid negative effects on animal health (Ferguson and Skindmore, 1989); yet rumen microbes must be supplied with N adequate for protein synthesis. Nevertheless, rumen microbes cannot provide sufficient protein to meet the increased demands for high milk production in bST-supplemented cows; therefore, increased amounts of RUP supplements may be necessary (Nocek and Russel, 1988), provided that RUP is digestible in the gastrointestinal tract and supplies the limiting amino acids. McGuffey *et al.* (1990) reported that, when treated with bST, cows fed diets with high (40%) versus low (33%) amounts of RUP produced an additional 4.6 versus 2.5 kg/d 3.5% FCM (3.5% fat corrected milk). In contrast, Winsryg *et al.* (1991) reported that increased RUP in the diet did not affect milk production efficiency of bST-treated cows, but did raise contents of milk protein and casein.

The objective of the present study was to examine the effects of protein sources with different rumen degradabilities (soybean meal plus sunflower meal versus soybean meal plus herring meal) on lactational performance and on selected plasma parameters of N metabolism for dairy cows administered bST.

Material and methods

One hundred Italian Friesian cows, housed in free stalls, were assigned to one of four treatments in a 2 × 2 factorial experiment. During a 14-d pretreatment period (cycle 0), cows were allowed to adapt to the experimental diets. Diets were formulated to contain different amounts of RUP and to meet nutrient requirements for milk production and body weight (NRC, 1989).

Cows were allotted to treatment groups to balance pretreatment milk production (32.8 ± 5.8 kg/d) and days in milk (DIM) (85 ± 37), recorded at the beginning of cycle 0. Treatments were 1) control diet, 2) low ruminally degradable protein diet (LDP), 3) control diet plus recombinant bST), 4) LDP plus recombinant bST.

Recombinant bST (640 mg of Somidobove®, Eli Lilly Italia SpA, Sesto Fiorentino, Firenze, Italy) was given in a sustained-release formulation as a subcutaneous injection in the ischiorectal fossa region, for two cycles of 28 days (cycle 1 and cycle 2), with an interruption of 20 days between the end of the cycle 1 and the beginning of cycle 2.

The sources of supplemental protein in the control diet were soyabean meal and sunflower meal. Herring meal (0.55 kg/d) partially replaced soybean meal (0.4 kg/d) and totally replaced sunflower meal (0.6 kg/d) as the source of supplemental protein in the LDP diet (table 1). Consequently, RUP values, expressed as a percentage of total CP, were calculated to be either 36 (control) or 40% (LDP). Values for RUP of individual feed ingredients were taken from NRC (1989) and from Sniffen and Chase (1988). All diets were fed *ad libitum* as TMR at 9.00 a.m. daily. The average DM intake were 24.06 kg/d and 23.72 kg/d, respectively for the control and the LDP diet groups. Representative samples of each diet were collected monthly and analysed for DM, CP, ether extract, NDF, Ca and P (Martillotti *et al.*, 1987). Results of chemical analysis and calculated RUP of the diets are shown in table 2. Milk production was recorded weekly. Individual milk samples were collected at two consecutive p.m. and a.m. milkings/d/week during the pretreatment and treatment periods. Samples were preserved with NaN_3 and were individually analysed for fat (Gerber method) and protein (Kjeldahl method) according to

TABLE 1. – Ingredient composition of diets.

TABELLA 1. – *Composizione delle razioni.*

		Diets - *Razioni*	
		C	LDP
Maize silage - *Insilato di mais*	% DM - *SS*	26.07	26.44
Ryegrass silage - *Insilato di loietto*	»	7.29	7.38
Maize grain high moisture - *Pastone di mais*	»	8.33	8.44
Lucerne hay - *Fieno di medica*	»	9.16	9.27
Barley - *Orzo*	»	9.16	9.27
Dried beet pulp - *Bietola polpe secche*	»	7.51	7.60
Brewers grains - *Trebbie birra secche*	»	6.25	6.32
Meadow hay - *Fieno polifita*	»	5.41	5.48
Soyabean meal - *Soia f.e.*	»	6.66	5.48
Herring meal - *Farina di aringhe*	»	—	2.10
Sunflower meal - *Girasole f.e.*	»	2.09	—
Concentrate A - *Mangime A* (1)	»	6.66	6.74
Concentrate B - *Mangime B* (2)	»	5.41	5.48

C: control - *dieta di controllo*; LDP: low ruminally degradable protein - *dieta con proteina a bassa degradabilità ruminale*.
(1) Concentrate A - *Mangime A*: 28% CP - *PG*; 15% EE; 5% CF - *FG*; 13% ash - *ceneri*; 80,000 IU/kg vitamin A; 6,000 IU/kg vitamin D_3; 100 mg/kg vitamin E; 12 mg/kg vitamin B_1; 6 mg/kg vitamin B_2; 6 mg/kg vitamin B_6; 0.10 mg/kg vitamin B_{12}; 1,500 mg/kg vitamin PP; 1,000 mg/kg coline clorure; 350 mg/kg Zn; 200 mg/kg Mn; 30 mg/kg Cu; 30 mg/kg Fe; 8 mg/kg I; 2 mg/kg Co; 0.5 mg/kg Se.
(2) Concentrate B - *Mangime B*: 22.5% CP - *PG*; 3.3% EE; 3.70% CF - *FG*; 28% ash - *ceneri*; 300,000 IU/kg vitamin A; 30,000 IU/kg vitamin D_3; 150 mg/kg vitamin E; 15 mg/kg vitamin B_1; 800 mg/kg vitamin PP; 500 mg/kg coline clorure; 2,000 mg/kg Zn; 800 mg/kg Mn; 160 mg/kg Fe; 120 mg/kg Cu; 32 mg/kg I; 8 mg/kg Co; 0.5 mg/kg Se.

TABLE 2. – Chemical analysis of the diets.

TABELLA 2. – *Analisi chimica delle razioni.*

		Diets - *Razioni*	
		C	LDP
Dry matter *Sostanza secca*	%	53.6	53.3
NDF	% DM - *SS*	37.19	37.14
Crude protein *Proteina grezza*	»	17.32	17.64
Calculated RUP *Stima proteina non degradabile a livello ruminale*	»	6.27	7.13
Ether extract *Estratto etereo*	»	4.12	4.21
Ca	»	1.01	1.02
P	»	0.64	0.62
Milk FU/kg DM *UFL/kg SS*	no. *n.*	0.88	0.88

C, LDP: see note table 1 - *vedi nota tabella 1.*

standard procedures (AOAC, 1980) and SCC, measured by a somatic cell counter (Fossomatic; Foss Electric, Hillerød, Denmark).

Separate milk samples from 10 cows per treatment were also collected at d 0 and 7 of cycle 1, for analysis of milk N distribution: total N, noncasein N and NPN. Total N and noncasein N were determined by the methods of the International Dairy Federation (1962, 1964). Casein was calculated as the difference between total protein (total N × 6.38) and noncasein N (N × 6.38). The NPN was determined, as described by Resmini *et al.* (1985). Whey protein was calculated as the difference between noncasein N (N × 6.38) and NPN (N × 6.38). True protein was calculated as the difference between total N (N × 6.38) and NPN (N × 6.38).

Jugular blood samples from 10 cows per treatment (same cows sampled for milk N distribution) were collected on d 7 of both treatment cycles, before the feeding. The samples were obtained by venipuncture using vacutainer tubes containing EDTA. Plasma was obtained by centrifugation and conserved at − 20 °C until analyzed. Plasma samples were assayed for total protein, albumin, urea, creatinine, uric acid, and NEFA by spectrophotometry, using diagnostics kits by Boehringer Mannheim Italia SpA, Milano, Italy. Plasma α-amino N was quantified as described by Goodwin (1968).

As to milk production, 4% FCM, milk fat percentage, milk protein percentage and milk SCC (log), data relative to cycle 1 and 2, covariated by DIM and pretreatment values (recorded at the beginning of cycle 0), were processed by repeated measures analysis of variance (GLM procedure) (SAS, 1988), with two factors (diet and bST) and two levels (0 or 1), including in the model the interaction between the two factors. Data relative to milk N distribution, measured at d 7 of cycle 1, were processed by analysis of variance (GLM procedure) (SAS, 1988), with two factors (diet and bST) and two levels (0, 1), using DIM and values relative to day 0 as covariants. Plasma metabolites values and related milk production and quality data (n = 40), measured at d 7 of both 28-d injection cycles, were processed by two-way ANOVA. Significance was declared at $P < 0.05$, unless otherwise indicated.

Results and discussion

Lactational response

A summary of production data (n = 100) relative to cycle 1 and cycle 2 is presented in table 3, and a summary of production data (n = 40) measured at d 7 of both 28-d injection cycles is shown in table 4.

Pretrial milk production, recorded at the beginning of cycle 0, was similar for all groups (control, 32.9 ± 6.1 kg/d; LDP, 32.8 ± 5.8 kg/d; control plus bST, 32.7 ± 6.4 kg/d; LDP plus bST, 32.7 ± 4.8 kg/d). There was a significant effect of bST on milk yield. Milk yield was higher in cows injected with bST. Milk production was not significantly affected by replacement of soyabean meal and sunflower meal with herring meal, but was higher (P = 0.08) for cows fed the LDP diets. Winsryg *et al.* (1991) and Calsamiglia *et al.* (1992) reported similar responses; however, McGuffey *et al.* (1990) observed that additional RUP in the diet enhanced the lactogenic effect of bST. The weekly response in milk production to the sustained-release form of bST, within the two 28-d injection cycles, followed a cyclic pattern, peaking at 7-d postinjection and afterward gradually decreasing (figure 1). The pattern of milk response across the treatment period was similar to that of other studies involving injection of bST in a prolonged-release formulation (Oldenbroek *et al.*, 1989; Breier *et al.*, 1991; Dell'Orto *et al.*, 1993).

Milk fat percentage was unaffected by bST administration, in agreement with results from other studies (Baer *et al.*, 1989; Van den Berg, 1991; Barbano *et al.*, 1992), but was lower when the LDP diet was fed (table 3). Daily milk fat production was not significantly influenced by treatments (1070.3, 1052.5, 1122.8 and 1092.1 g/d, respectively for control, LDP, control plus bST and LDP plus bST treatment groups). Within the 28-d injection cycles, cows treated with bST displayed a cyclic pattern in milk fat percentage, reaching a maximum at d 7 of the cycles, which agreed with results of other studies (Oldenbroek *et al.*, 1989; Dell'Orto *et al.*, 1993). The work of others (Sechen *et al.*, 1989; Breier *et*

TABLE 3. – Effects of bST and low ruminally degradable protein diet (LDP) on milk production and composition.

TABELLA 3. – *Effetti del bST (bST) e della dieta con proteina a bassa degradabilità ruminale (LDP) sulla produzione e composizione del latte.*

		Groups - *Gruppi*				Error mean square (DF) *Varianza dell'errore (GL)*	P (1)	
		C	LDP	C + bST	LDP + bST		bST	LDP
Cows *Bovine*	no. *n.*	25	25	25	25			
Milk *Latte*	kg/d	27.8	28.7	29.2	30.8	101.0 (90)	*	+
4% FCM *Latte corr. 4% grasso*	»	27.4	27.4	28.6	28.7	95.8 (86)	+	NS
Fat *Grasso*	%	3.81	3.68	3.82	3.55	1.12 (87)	NS	*
Protein *Proteine*	»	3.25	3.29	3.18	3.28	0.14 (90)	NS	*
SCC *Cell. somatiche*	log	5.28	5.44	5.26	5.35	1.52 (90)	NS	NS

* $P < 0.05$; + $P < 0.10$.
(1) The interaction between bST and LDP was not significant (P > 0.10).
(1) L'interazione bST × LDP non è risultata statisticamente significativa (P > 0,10).
C, LDP: see note table 1 - *vedi nota tabella 1.*

TABLE 4. – Effects of bST and low ruminally degradable protein diet (LDP) on milk production and composition 7 d after injection (1st and 2nd injection cycles).

TABELLA 4. – *Effetti del bST (bST) e della dieta con proteina a bassa degradabilità ruminale (LDP) sulla produzione e composizione del latte al 7° giorno del ciclo di trattamento (1° e 2° ciclo di trattamento).*

		Groups - *Gruppi*				SEM *ESM*	P		
		C	LDP	C + bST	LDP + bST		bST	LDP	bST × LDP
Cows *Bovine*	no. *n.*	10	10	10	10				
Milk *Latte*	kg/d	29.9	29.9	34.1	36.6	1.15	**	0.13	NS
Fat *Grasso*	%	3.62	3.56	3.93	3.91	0.14	*	NS	NS
Fat *Grasso*	kg/d	1.08	1.06	1.35	1.43	0.07	**	NS	NS
Protein *Proteine*	%	3.16	3.20	3.14	3.12	0.03	NS	NS	NS
Protein *Proteine*	kg/d	0.95	0.95	1.07	1.14	0.04	**	NS	NS

** $P < 0.01$; * $P < 0.05$.
C, LDP: see note table 1 - *vedi nota tabella 1.*

al., 1991) have attributed the increased milk fat content to the lipolytic effect of somatotropin. The extent to which bST controls nutrient partitioning in such a way that lipid accretion is reduced and body adipose stores are mobilised reflects the energy balance of bST-treated cows (Sechen *et al.*, 1989).

Milk protein content was not altered by somatotropin, in agreement with results of other studies (Van den Berg, 1991). When the LDP diet was fed, milk protein percentage was higher than the control diet (table 3). This result was similar to that found by Winsryg *et al.* (1991) and can be attributed to the greater amino acid availability in the small intestine, deriving from dietary protein escaped from rumen degradation (Nocek and Russel, 1988) and also to the excellent amino acid composition of fish meal. There were significant main effects of bST and diet on daily milk protein yield ($P < 0.05$). Daily milk protein production was higher for cows injected with bST and for cows receiving the LDP diet (896.5, 939.9, 930.0 and 998.1 g/d, respectively for control, LDP, control plus bST and LDP plus bST treatment groups). During the two injection cycles, percentage of milk protein gradually increased, as lactation proceeded. Milk protein content for the bST-supplemented groups showed a cyclical pattern, with the lowest value occurring at 7 d postinjection, in correspondance to the maximum milk production response.

Distribution of N in milk, measured 7 d after injection (1st injection cycle), is shown in table 5. No differences were significant for total protein, NPN, true protein, and casein contents among the groups, confirming the results of previous research (Cattaneo *et al.*, 1993) in which no effects of bST treatment on milk casein content were found. This aspect is of particular interest because a substantial portion of the Italian milk production is used for cheese manufacturing. Other workers have shown no effect of bST on milk casein percentage (Barbano *et al.*, 1992). Kindstedt *et al.* (1991), however, reported a significant decrease of total protein, true protein, and casein percentages in milk produced by Jersey cows that had been injected with bST. Nutritional status is one of the principal factors influencing milk protein and casein

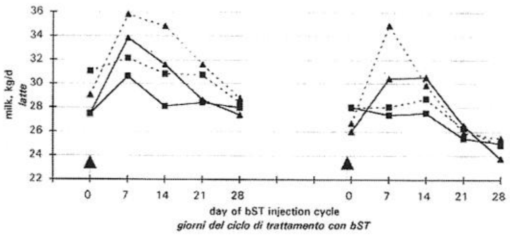

Figure 1 - Milk production of cows receiving control diet (——), LDP diet (– – –), + bST (▲), – bST (■). Recombinant bST (640 mg) was given in a sustained-release formulation (28-d injection cicle) for 2 cycles, starting at 99 ± 37 DIM, with an interruption of 20 days between the end of cycle 1 and the beginning of cycle 2, as indicated. Milk data are unadjusted means. Standard errors for least squares means were 0.75, 0.97, 0.92 and 0.97, respectively for 7, 14, 21 and 28 d of the 1st injection cycle and 1.04, 1.06, 0.93 and 0.85, respectively for 7, 14, 21 and 28 d of the 2nd injection cycle.

Figura 1 - Produzione di latte delle bovine che hanno ricevuto la dieta di controllo (——), la dieta con proteina a bassa degradabilità ruminale (– – –), + bST (▲), – bST (■). La somatotropina bovina ricombinante a lento rilascio (ciclo di trattamento di 28 giorni) è stata somministrata alla dose di 640 mg per due cicli, a partire dal giorno 99 ± 37 di lattazione, con un'interruzione di 20 giorni fra il termine del ciclo 1 e l'inizio del ciclo 2, come indicato nella figura. I valori riportati sono medie stimate. Gli errori standard sono 0,75, 0,97, 0,92 e 0,97, rispettivamente per i giorni 7, 14, 21 e 28 del 1° ciclo di trattamento e 1,04, 1,06, 0,93 e 0,85, rispettivamente per i giorni 7, 14, 21 e 28 del 2° ciclo di trattamento.

contents in bST-treated cows (Van den Berg, 1991): when cows injected with bST were in negative N balance, milk casein an total protein percentages were reduced (Baer *et al.*, 1989).

Milk SCC, indirect index of subclinical mastitis, was not influenced by bST (table 3), in agreement with results of other studies (Van den Berg, 1991).

Individual milk production records showed that 8 cows (5 of which were fed the control diet and 3 the LDP diet) did not respond to the somatotropin treatment. These non-responsive cows were either in early lactation (< 60 DIM) or had a high milk production (> 35 kg/d) prior to bST supplementation. However, other cows at the same stage of lactation or with high milk production before bST treatment were responsive to the treatment, indicating that individual factors, in addition to those cited, must be examined to explain the different responses to somatotropin.

Plasma metabolite response

Plasma metabolities were measured at the 7th d of each 28-d injection cycle, as previous research (Rosi *et al.*, 1990) indicated that galactopoietic and metabolic effects of bST administered in a prolonged-release system were maximal 1 week after the beginning of treatment. A summary of metabolite data is shown in table 6 and a summary of production data, relative to the same animals and same day of treatment is presented in table 4.

There were main effects of bST on concentrations of NEFA, urea, and uric acid; the concentration of NEFA increased, while the concentration of urea and uric acid decreased. There was a main effect of diet on concentrations of NEFA; cows receiving the LDP diet had higher uric acid ($P < 0.10$) and lower NEFA concentrations than cows fed the control diet. Exogenous bST increased plasma creatinine and protein, and decreased α-amino N in cows receiving the control diet but not the LDP diet. Interactions between treatments were significant for circulating levels of α-amino N and creatinine.

The elevated concentration of NEFA in plasma of bST-treated dairy cows, observed also in other studies with cows in negative energy balance (Sechen *et al.*, 1989; Breier *et al.*, 1991), reflects the increased rate of adipose tissue mobilization (Breier *et al.*, 1991). High levels of circulating NEFA in bST treated dairy cows increase milk fat production, predominantly from a greater uptake of preformed fatty acids (Bitman *et al.*, 1984), but also from an increase in the rate of NEFA oxidation (Bauman *et al.*, 1988), sparing other substrates (such as glucose and amino acids) from oxidation and facilitating secretion of milk lactose and protein (Breier *et al.*, 1991).

Lower levels of circulating NEFA were observed in the groups of cows fed the LDP compared to cows fed the control diet. We could hypothesize that the LDP diet, reducing N ruminal fermentation, could have modified starch ruminal degradation, allowing a higher availability of circulating glucose; this could preserve the energetic store in the adipose cell, through an inhibition of the intracellular lipase.

The work of others suggested that reduced concentrations of amino acids and urea in plasma of dairy cows receiving bST is associated with a decreased use of amino acids as energetic and gluconeogenic substrates and with an increased use of them for milk protein synthesis (Bauman *et al.*, 1988; Sechen *et al.*,

TABLE 5. – Effects of bST and low ruminally degradable protein diet (LDP) on milk N distribution 7 d after injection (1st injection cycle).

TABELLA 5. – *Effetti del bST (bST) e della dieta con proteina a bassa degradabilità ruminale (LDP) sulle frazioni azotate del latte al 7° giorno di ciclo di trattamento (1° ciclo di trattamento).*

		Groups - *Gruppi*				SEM *ESM*
		C	LDP	C + bST	LDP + bST	
Cows *Bovine*	no. *n.*	10	10	10	10	
Total protein *Proteine totali*	%	3.10	3.20	3.02	3.04	0.10
True protein *Proteina vera*	»	2.88	2.95	2.82	2.82	0.11
Casein *Caseine*	»	2.35	2.49	2.38	2.34	0.11
Whey protein *Sieroproteine*	»	0.52	0.48	0.44	0.49	0.03
Casein/total protein *Caseine/proteine totali*	»	75.67	77.51	78.51	76.56	1.13
Casein/true protein *Caseine/proteine vere*	»	81.83	83.80	84.23	82.37	1.18
NPN/total N *NPN/N totale*	»	7.46	7.87	6.93	6.57	0.81

No effects were significant ($P > 0.10$) for bST (bST), low ruminally degradable protein diet (LDP) or bST × LDP interaction.
Nessun effetto è risultato significativo ($P > 0,10$) per il trattamento con bST, la dieta con proteina a bassa degradabilità ruminale (LDP) e l'interazione bST × LDP.
C, LDP: see note table 1 - *vedi nota tabella 1.*

1989; McDowell, 1991). In the present study, at 7 d post-injection bST decreased α-amino N and urea in plasma (table 6) and increased milk protein yield (table 4). Cows fed the LDP diet, when treated with bST maintained α-amino N levels similar to control groups, even though their daily milk protein production was 200 g higher (table 4). Therefore we can suppose that the LDP diet can supply more amino acids for mammary synthesis. Exogenous bST decreased the concentration of uric acid. Lower levels of uric acid were observed in bST-treated cows receiving the control diet, at 7 d postinjection. The low level of uric acid can be due either to its greater utilisation in the rumen as a source of non specific N (probably of some value in animals in negative N balance), or to a higher salvage of purine derivatives (particularly important in tissue in rapid rate of proliferation) (McAllan, 1980).

At 7 d post-injection, somatotropin increased plasma levels of creatinine and interacted with LDP diet. The results are difficult to explain because usually this parameter is associated with whole muscle protein (Finco, 1989). Other authors observed higher levels of plasma creatinine after bST administration, but their experimental design precluded discerning whether to this effect contributed also the advancing stage of lactation (Calsamiglia *et al.*, 1992). In the present study, we suppose that at 7 d post injection, when the productive response was maximal, the higher level of creatinine in cows fed the control diet could result from an increased tissular protein catabolism to conform the amino acid pool to the extra demand for the mammary protein synthesis. The LDP diet could counteract the utilisation of body protein reserves. This hypothesis is also supported by the data relative to plasma α-amino N levels, observed in the same groups.

TABLE 6. – Effects of bST and low ruminally degradable protein diet (LDP) on plasma composition 7 d after injection (1st and 2nd injection cycles).

TABELLA 6. – *Effetti del bST (bST) e della dieta con proteina a bassa degradabilità ruminale (LDP) sulla composizione del plasma al 7° giorno del ciclo di trattamento (1° e 2° ciclo di trattamento).*

		Groups - *Gruppi*				SEM *ESM*	P		
		C	LDP	C + bST	LDP + bST		bST	LDP	bST × LDP
Cows *Bovine*	no. *n.*	10	10	10	10				
NEFA	μeq/l	292	158	1015	735	71.4	**	**	NS
α-amino N *N α-aminico*	mmol/l	2.54	2.40	2.03	2.39	0.08	**	*	**
Urea	»	6.38	6.70	5.38	5.17	0.20	**	NS	NS
Uric acid *Acido urico*	μmol/l	39.9	40.9	33.6	38.6	1.56	**	+	NS
Creatinine *Creatinina*	»	61.9	64.8	70.1	65.3	1.65	**	NS	*
Protein *Proteine*	g/l	77.3	80.5	81.7	81.0	1.23	*	NS	+
Albumin *Albumine*	»	43.10	42.30	43.70	43.40	0.79	NS	NS	NS
Albumin/protein *Albumine/proteine*	%	56.0	52.9	53.7	54.1	1.49	NS	NS	NS

** $P < 0.01$; * $P < 0.05$; + $P < 0.10$.
C, LDP: see note table 1 - *vedi nota tabella 1.*

Conclusions

Our results confirmed that administration of bST to lactating cows can significantly increase milk production. Replacement of sunflower meal and partial replacement of soyabean meal with herring tended to enhance milk production response to bST (P = 0.08). The interaction of bST and diet indicated that, in our conditions, the combination of the low ruminally degradable protein diet and bST seemed to be synergistic. Over the entire experimental period, exogenous bST did not significantly affect milk fat and protein percentages and N distribution, but significantly increased milk daily protein yield. At 7 d after injection, in correspondance to the maximal productive response, bST increased milk fat percentage and milk fat and protein daily yield. The observed bST effects on milk composition are important in Italy where most of milk produced is used for cheese manufacturing. Management of bST treatment seems to be a crucial aspect. In fact, it has been observed that cows with less than 60 DIM or with high pretreatment milk production did not responde to bST as expected. With regard to plasma metabolities, observed at 7 d post-injection, when the productive response was maximal, bST increased NEFA and decreased urea in cows receiving the control or the LDP diet; however, bST increased plasma creatinine, and decreased α-amino N in cows receiving the control diet. LDP diet increased α-amino N, decreased NEFA levels and interacted with bST in α-amino N and creatinine levels. This suggests, in conclusion, that a greater dietary availability of ruminally undegradable protein in bST treated animals could have allowed the cows to utilise more effectively the dietary N sources and to spare body fat reserves, so far as it concerns d 7 post bST injection.

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