

Effects of recombinant bovine somatotropin on fatty acid composition of milk from cows in late lactation

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To investigate the effects on milk fatty acid composition of recombinant bovine somatotropin (rBST) administered under South African conditions, 26 dairy cows were paired into two groups 84—112 days after calving. At two-weekly intervals the cows in the experimental group were injected with 500 mg of rBST in a slow-release formulation, while cows in the control group were injected with the excipient. Milk specimens taken at two-weekly intervals from 36—40 weeks *post partum* until drying off were analysed for fatty acid composition. The cows given rBST produced milk with less short-chain (C_4), more medium-chain (C_8 — C_{16}) and less long-chain (C_{18}) acids. Hexanoic acid content was unaffected. rBST administration did not affect the proportion of unsaturated fats in the milk. Differences in milk composition between cows and through time were larger than those due to rBST administration. Treated and control cows showed synchronized fluctuations in milk fatty acid composition that were larger than the differences due to rBST.

Om die effek van rekombinante beessomatotropin(rBST)-toediening op die melkvetsuursamestelling van koeie wat onder Suid-Afrikaanse toestande aangehou word te ondersoek, is 26 melkkoeie in twee groepe verdeel, 84—112 dae na kalwing. Die eksperimentele groep is met 500 mg rBST met 'n stadige vrystellingsaksie ingespuut, terwyl die kontrolegroep met 'n bindstof ingespuut is. Die inspuiting is twee-weekliks herhaal. Melkmonsters is op 'n twee-weeklikse basis geneem vanaf 36—40 weke *post partum* totdat koeie opgedroog was, en vetsuursamestelling is dan bepaal. Die koeie wat met rBST ingespuut is, het melk met minder kortketting (C_4), meer mediumketting (C_8 — C_{16})- en minder langketting (C_{18})-vetsure gelever. Die heksanoësuurinhoud is nie hierdeur beïnvloed nie. rBST-behandeling het nie die verhouding van onversadigde vetsure in die melk beïnvloed nie. Die tussen-koeivariasie en tydperkverskille in melksamestelling was groter as die wat toegeskryf kon word aan rBST-toediening. Koeie van beide die kontrole en eksperimentele groepe het gesinchroniseerde skommeling in die melkvetsuursamestelling getoon. Hierdie verskille was groter as die verskil wat toegeskryf kan word aan rBST-behandeling.

Keywords: Bovine somatotropin, BST, fat, growth hormone, lipid, milk.

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Introduction

Bovine somatotropin (BST), or its genetically engineered equivalent, recombinant bovine somatotropin (rBST), can be used to further enhance the milk production of well-managed dairy cows. The mechanism of rBST action is not completely understood (e.g. Lough *et al.*, 1989; Chilliard *et al.*, 1990), although its overall effect is a redirection of dietary energy to lactogenesis and away from depot storage (Eppard *et al.*, 1985; Bitman *et al.*, 1984; Sechen *et al.*, 1989). Changes in milk composition as a result of these metabolic alterations could affect the suitability of milk for processing, for example, milk fat rich in short-chain and unsaturated acids has a lower melting point (Middaugh *et al.*, 1988).

As part of a trial of the efficacy of rBST under South African conditions, milk samples were taken to investigate the influence of rBST administration on milk fatty acid composition. Preliminary results from this study were reported by Giesecke *et al.*, (1990).

Methods

The trial was conducted in the spring and summer of 1988—1989 at the Animal Production Institute, Irene, Transvaal (25° 8' S, 28° 12' E, altitude 1523 m). All animals were fed dairy concentrate pellets (17% crude protein, 6.8% undegradable protein, 10.9 MJ/kg, 0.8% calcium, 0.6% phosphorus) according to milk yield, and roughage (lucerne hay and Rhodes grass hay) *ad libitum*.

Between 84 and 112 days *post partum*, 26 Friesian cows were paired on the basis of pre-trial milk yield and lactation number. Two groups of 13 cows were then formed such that each group contained one member of each pair. Each cow in the experimental group was injected at two-weekly intervals with 500 mg of rBST in a slow-release formulation (Lactotropin^R, Monsanto), and each cow in the control group with the excipient, shortly after routine morning milking. On the days that rBST was injected, a composite morning milk specimen was taken from each cow, and frozen until analysis. Each

day on which specimens were collected is considered as a sampling occasion. The results presented here are for 98 control specimens and 101 experimental specimens taken during the period from 24 weeks after the start of rBST administration (36—40 weeks *post partum*) to the end of lactation.

Fatty acid composition was determined by gas chromatography of methyl esters (Apps & Willemse, 1991). Quantitative data in the form of chromatographic peak areas were processed by various routines in the SYSTAT package (Systat Inc., Leland, Illinois). In each case the null hypothesis stated that there was no difference in fatty acid composition. The Student's *t* test was used to compare group means, while treatment effects were tested for significance using an analysis of variance with repeated measures (Runyon & Haber, 1980).

Results

Analytical precision

The analytical method yielded coefficients of variation (standard deviation/mean) of 0.3—5.5% for fatty acid percentage composition (Apps & Willemse, 1991).

Effects on milk composition

Cows injected with rBST produced milk with less butanoic acid, more C₈ to C₁₆ acids and less octadecanoic and octadecenoic acid than did the control group. The hexanoic acid content was unaffected (Table 1). Despite very wide inter-sampling occasion and inter-cow variability, the differences due to rBST administration were significant ($P < 0.05$) for all except the hexanoic and pentadecanoic acids (Table 1).

An analysis of variance with rBST treatment, cow and sampling occasion as factors revealed that milk composition was affected more by cow and sampling occasion than by rBST administration, though the effects of all three factors were significant (Table 1).

The effects of rBST administration were largely consistent from sampling occasion to sampling occasion (Figure 1). A binomial test (Runyon & Haber, 1980), with the null hypothesis stating that the probability was 0.5 that a group would have the higher abundance of an acid, confirmed that the difference between the treated and control groups was significantly often in the same direction throughout the trial for all acids (Table 1). It is particularly noteworthy that the fatty acid composition of milk from the treated and control groups varied in synchrony, despite the wide variation with sampling occasion of composition within each group (Figure 1). Indeed, for 8 of the 12 acids, abundances in the treated and control groups were significantly positively correlated according to the Pearson test (Runyon & Haber, 1980) (Table 1).

Discussion

The milk specimens were collected just before each dose of rBST was administered, when levels of rBST would be at their lowest (Chilliard *et al.*, 1990). Effects on milk composition when rBST levels were higher can be expected to have been more marked than those demonstrated here.

The responses to rBST administration are consistent with those of other trials. The cows in this trial were in positive energy balance, as shown by their gaining mass, with the rBST-treated cows gaining an average of 16 kg more body mass than did the controls (Ferreira *et al.*, 1990). In addition, this gain in mass occurred in late lactation when administration of rBST increases milk production by redirecting dietary energy to milk production rather than by mobilizing body fat (Chilliard *et al.*, 1990). Increases in the abundance of the long-chain lipids is a response to a negative energy balance (Bitman *et al.*, 1984; Lough *et al.*, 1988; Sechen *et al.*, 1989). In cows more than 35 weeks *post partum*, Baer *et al.* (1989) found changes in milk composition that agree with our results for the same period.

Milk composition in the experimental and control groups varied in synchrony (Binomial and Pearson tests, Table 1),

Table 1 Percentage abundance (\pm SE) of each fatty acid in milk from control and rBST-treated cows, significance levels for *t* tests of difference between control and experimental groups, significance levels of analysis of variance with sampling occasion, cow and treatment as factors, number of sampling occasions on which each acid was more abundant in treated than in control milk and the associated binomial significance levels, and the Pearson coefficients of correlation between the control and experimental groups' values on each sampling occasion, with the associated significance levels

Acid	Abundance			Anova			Binomial		Pearson	
	Control	rBST	<i>t</i> test	Occasion	Cow	BST	BST higher	SL	Coeff	SL
C ₄	2.22 \pm 0.24	2.10 \pm 0.42	0.01	0.00	0.00	0.01	1	0.00	0.82	0.00
C ₆	1.88 \pm 0.21	1.89 \pm 0.33	0.89	0.00	0.00	0.89	5	0.09	0.80	0.00
C ₈	1.29 \pm 0.19	1.35 \pm 0.23	0.03	0.00	0.00	0.03	12	0.00	0.72	0.00
C ₁₀	3.10 \pm 0.58	3.31 \pm 0.58	0.00	0.00	0.00	0.00	12	0.00	0.62	0.02
C ₁₂	3.88 \pm 0.67	4.33 \pm 0.75	0.00	0.00	0.00	0.00	13	0.00	0.59	0.02
C _{14:1}	1.01 \pm 0.29	1.25 \pm 0.34	0.00	0.00	0.00	0.00	14	0.00	0.43	0.12
C _{14:0}	13.13 \pm 1.21	13.52 \pm 1.13	0.01	0.00	0.00	0.01	11	0.00	0.74	0.00
C ₁₅	1.48 \pm 0.22	1.43 \pm 0.28	0.10	0.00	0.00	0.10	3	0.00	0.41	0.15
C _{16:1}	1.37 \pm 0.38	1.55 \pm 0.43	0.00	0.07	0.00	0.00	12	0.00	0.25	0.38
C _{16:0}	33.15 \pm 2.10	34.37 \pm 2.40	0.00	0.00	0.00	0.00	12	0.00	0.28	0.33
C _{18:1}	23.96 \pm 2.84	23.02 \pm 2.54	0.01	0.00	0.00	0.01	3	0.00	0.81	0.00
C _{18:0}	13.54 \pm 1.85	11.87 \pm 2.18	0.00	0.00	0.00	0.00	0	0.00	0.63	0.01

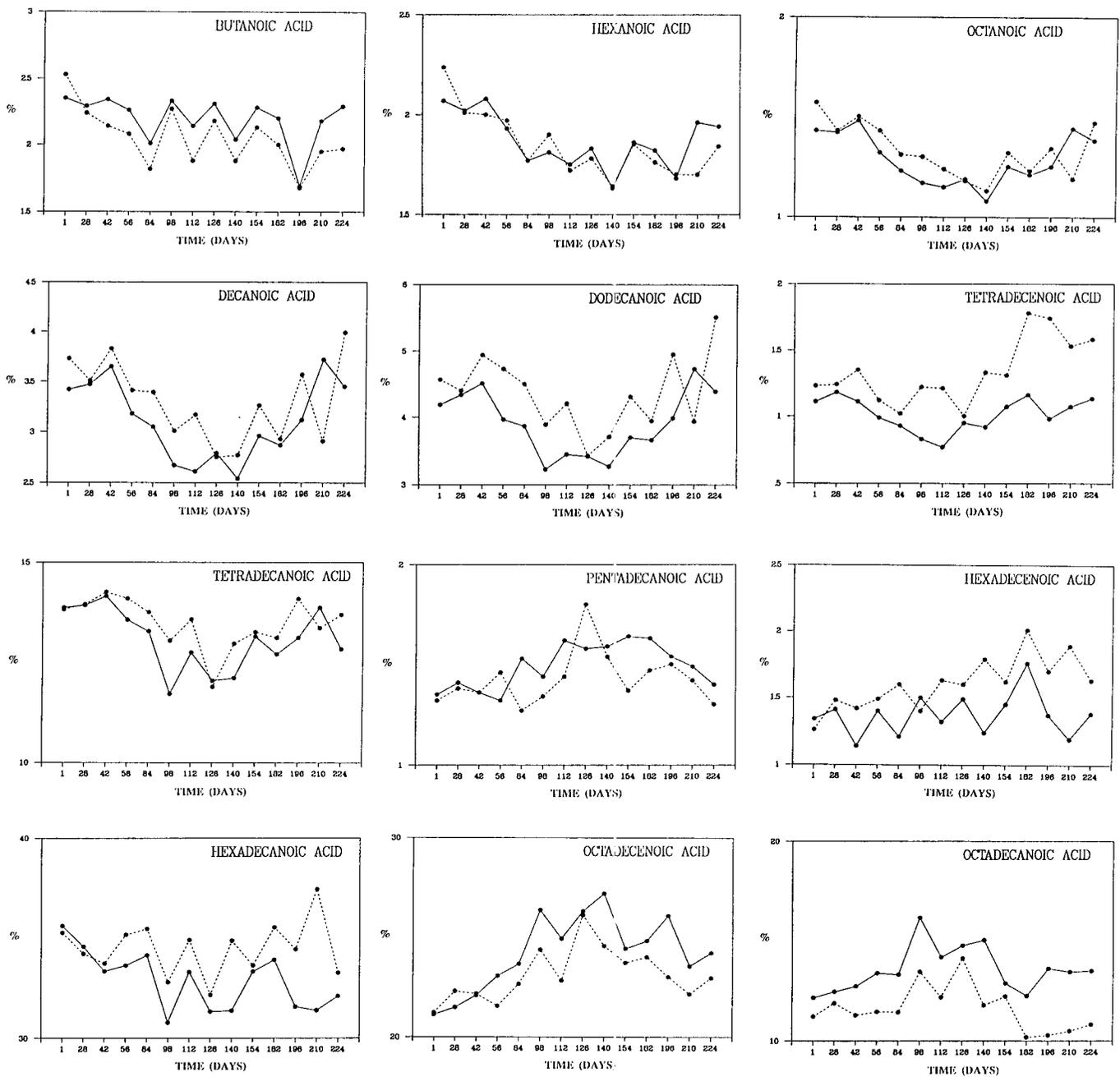


Figure 1 Changes with time (days) since the start of rBST administration in the percentage of each fatty acid in milk from rBST-injected (·-·-·) and control (—) cows in late lactation.

strongly implicating an influence affecting all the cows simultaneously as the cause of the sampling occasion to sampling occasion fluctuation. Parallel variations in milk yield due to a change in diet composition were observed by Skarda *et al.* (1990) but, since the cows in the present study enjoyed a stable diet, a more likely cause of the fluctuations is environmental or management conditions.

Conclusions

Compared to controls, cows given rBST during late lactation, when in positive energy balance, produced milk that was significantly poorer in short-chain (C_4) acid, richer in medium-chain (C_8 — C_{16}) acids and poorer in long-chain (C_{18}) acids. The effects of rBST on milk fatty acid composition are minor compared to those of other influences.

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References

- APPS, P.J. & WILLEMSE, J.J.C., 1991. Fast, high precision fingerprinting of fatty acids in milk. *J. High Resolut. Chromat.* 14, 802.
- BAER, R.J., TIESZEN, K.M., SCHINGOETHE, D.J., CASPER, D.P., EISENBEISZ, W.A., SHAVER, R.D. & CLEALE, R.M., 1989. Composition and flavour of milk produced by cows injected with recombinant bovine somatotropin. *J. Dairy Sci.* 72, 1424.
- BITMAN, J., WOOD, D.L., TYRELL, H.F., BAUMAN, D.E., PEEL, C.J., BROWN, A.C.G. & REYNOLDS, P.J., 1984. Blood and milk lipid responses induced by growth hormone administration in lactating cows. *J. Dairy Sci.* 67, 2873.

- CHILLIARD, Y., CISSE, M. & REMOND, B., 1990. Somatotropin, body reserves and adipose tissue metabolism in the lactating cow. In: Sometribove mechanism of action, safety and instructions for use, where do we stand? Monsanto, Brussels.
- EPPARD, P.J., BAUMAN, D.E., BITMAN, J., WOOD, D.L., AKERS, R.M. & HOUSE, W.A., 1985. Effect of dose of bovine growth hormone on milk composition: alpha-lactalbumin, fatty acids and mineral elements. *J. Dairy Sci.* 68, 3047.
- FERREIRA, B., SWART, C., PETZER, I.M. & PALMER, C., 1990. The use of BST to improve milk production. *Proc. S. Afr. Soc. Anim. Prod.*
- GIESECKE, W.H., APPS, P.J., PALMER, C.R., PETZER, I.M. & FERREIRA, B., 1990. Preliminary results on fatty acid composition in milk produced during summer by South African dairy cows supplemented during one lactation with recombinant bovine somatotropin. In: Sometribove mechanism of action, safety and instructions for use, where do we stand? Monsanto, Brussels.
- LOUGH, D.S., MULLER, L.D., KENSINGER, R.S., GRIEL, L.C. & AZZARA, C.D., 1989. Effect of exogenous bovine somatotropin on mammary lipid metabolism and milk yield in lactating dairy cows. *J. Dairy Sci.* 72, 1469.
- LOUGH, D.S., MULLER, L.D., KENSINGER, R.S., SWEENEY, T.F. & GRIEL, L.C., 1988. Effect of added dietary fat and bovine somatotropin on the performance and metabolism of lactating dairy cows. *J. Dairy Sci.* 71, 1161.
- MIDDAUGH, R.P., BAER, R.J., CASPER, D.P., SCHINGOETHE, D.J. & SEAS, S.W., 1988. Characteristics of milk and butter from cows fed sunflower seeds. *J. Dairy Sci.* 71, 3179.
- RUNYON, R.P. & HABER, A., 1980. Fundamentals of behavioral statistics (IVth edn.). Addison-Wesley, Reading, Mass.
- SECHEN, S., BAUMAN, D.E., TYRELL, H.F. & REYNOLDS, P.J., 1989. Effect of somatotropin on kinetics of nonesterified fatty acids and partition of energy, carbon, and nitrogen in lactating dairy cows. *J. Dairy Sci.* 72, 59.
- SKARDA, J., SKARDOVÁ, O., KREJČÍ, P., SLABA, J., MOLNÁROVÁ, K., HUSÁKOVÁ, E. & MARKALOUS, E., 1990. Czechoslovakian studies with sometribove. In: Sometribove mechanism of action, safety and instructions for use, where do we stand? Monsanto, Brussels.