The Effects of Long-Term Administration of Recombinant Bovine Somatotropin (Posilac) and Synovex on Performance, Plasma Hormone and Amino Acid Concentration, and Muscle and Subcutaneous Fat Fatty Acid Composition in Holstein-Friesian Bull Calves[1]

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ABSTRACT: The effect of recombinant somatotropin (rbST), Synovex (Syn), and their combination (rbST+Syn) on intact male calves was examined in an experiment that lasted an average of 238 d. Holstein-Friesian bull calves were allotted to one of four subtreatments (n = 14/treatment) in a factorial arrangement. There were two levels of rbST (0; rbST) and two levels of the estrogenic growth promoter Synovex (0; Syn). The rbST was administered once every 2 wk as injections of 500 mg of Posilac. Synovex (C and S) was implanted at 90-d intervals. The animals were fed for ad libitum consumption a diet with a metabolizable energy concentration of 11.7 MJ/kg DM and 15% crude protein. The hot carcasses were weighed after the removal of kidney, pelvic, and cod fats, which were weighed separately. The 12th rib cut was saved for analysis. Average daily gain and feed conversion efficiency were increased by rbST treatment by 9% ($P < .005$) and 10% ($P < .016$), respectively. There was no significant effect of Syn treatment, nor was there a rbST × Syn interaction. The proportion of the fat of the large depots in the carcass was reduced by 34% ($P < .0001$) and in the longissimus muscle by 32% ($P < .16$) owing to the rbST treatment. The plasma concentrations of GH, insulin, and thyroxin were increased by rbST treatment ($P < .001$, $P < .01$, and $P < .03$, respectively). The concentration of IGF-I was not affected. Synovex had no effect on plasma hormone concentration. Plasma essential and nonessential amino acid concentrations were reduced by 14 and 9%, respectively, when rbST was injected. Concentrations of cholesterol and fatty acids in muscle and subcutaneous fat were not affected ($P > .072$) by the rbST treatment. Synovex increased the monounsaturated fatty acids (MUFA), and the combinaton of Syn with rbST reduced polyunsaturated fatty acid (PUFA) concentration in the longissimus muscle (at the 12th rib). The reduced muscle fat content of the rbST-treated animals was associated with a trend toward an increase in polyunsaturated fatty acids.

Key Words: Males, Calves, Beef, Somatotropin, Estrogens

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Introduction

The biotechnical synthesis of somatotropin for farm animals has greatly affected livestock production. Bovine somatotropin (**bST**) was reviewed by Bauman (1992) with an emphasis on dairy production and by Enright (1989) with an emphasis on cattle growth. Administration of GH from pituitary or recombinant sources to cattle increases growth rate by 12%, feed efficiency by 9%, and carcass lean content by 5%, while decreasing carcass fat content by 15%.

Studies with this new technology, carried out with steers (Enright et al., 1990; Dalke et al., 1991, 1992; Moseley et al., 1992; Preston et al., 1995; Rumsey et al., 1996), have invariably demonstrated a shift in the partitioning of nutrients toward a considerable increase in protein and decrease in fat deposits. Elsasser et al. (1994) and Rumsey et al. (1996) administered rbST and Synovex (estradiol benzoate and progesterone) to young steers and found that both materials have the potential to cause muscle hypertrophy. They found that daily protein gain was always greater when a combination of the two materials was used, com-

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pared with the control or when only one of the materials was used. Preston et al. (1995) and Rumsey et al. (1996) compared the anabolic effects of steroids and bST in feedlot steers, as did Enright et al. (1990) with young dairy steers, and found the compounds to be additive. Hawkins et al. (1995) did not find enhanced growth in a 56-d bST treatment regimen in yearling bulls at 393 d of age.

To the best of our knowledge, no long-term experiments have been done with young, intact males that are naturally at the peak of their growth potential. Thus, the objectives for this experiment were to study, in a long-term administration experiment, the effects of rbST and(or) Synovex on performance, plasma hormone and amino acid concentrations, and fatty acid composition of muscle and subcutaneous fat in young Holstein-Friesian male calves.

Materials and Methods

Animals and Housing. Fifty-six Holstein-Friesian bull calves were purchased from dairy farms and raised on a total of 20 kg of milk replacer per calf, a commercial calf starter, and some hay. They were housed in an open shed on concrete slatted floors in pens of seven allowing a space of 2.4 m^2 per calf. They were 165 ± 5.4 d old and of an average weight of 193 ± 10.8 kg at the start of the experiment.

Experimental Design and Treatments. The design was a randomized complete block with a 2 × 2 factorial arrangement of treatments (n = 14 calves per group). There were two levels of recombinant bovine growth hormone (0 and Posilac, **rbST**) and two levels of the estrogenic growth promoter Synovex (0 and **Syn**). Two pens of seven animals each were alotted to each of the following treatments: 1) control, one injection (s.c.) of placebo (bicarbonate/saline) every 2-wk; 2) bovine somatotropin (rbST), one injection of 500 mg of Posilac every 2 wk; 3) synovex ear implants at 90- to 95-d intervals; and 4) both rbST and Syn treatment.

The first ear implantation of the Synovex calves was with Synovex-C (100 mg of progesterone and 10 mg of estradiol benzoate), and the other two, at d 92 and 185 of the experiment, were with Synovex-S (200 mg of progesterone and 20 mg of estradiol benzoate).

Posilac was injected in the neck region just anterior to the shoulders. Posilac was supplied by Monsanto (St. Louis, MO) and Synovex by Syntex (Maidenhead, Berks., U.K.).

Diet. The animals were fed a diet of a metabolizable energy concentration of 11.7 MJ/kg DM and 15% crude protein. The components of the diet and the calculated ME and protein content are presented in Table 1. The diet was prepared in a mixing wagon and fed as a total mixed ration. All calves had free access to feed and water. Refusals, which were approximately 5% of the offered amounts, were collected and weighed once a week. Live weights were recorded every month, and feed intake was summarized for each period between two weighings.

Table 1. Components (% DM) and nutrient composition of the experimental diet

Ingredient, %	Content
Ground barley	33.0
Ground maize	26.0
Soybean meal	11.0
Vetch hay	6.0
Wheat silage	21.6
Minerals and vitamins[a]	2.4
Metabolizable energy, MJ/kg DM	11.71
Crude protein, %	15.00
NDF	31.23
ADF	21.25
Calcium, %	.80
Phosphorus, %	.42

[a]Premix of vitamins, microelements, and monensin (Vitopar 2000, Kofolk, Ltd., Tel Aviv, Israel). One kilogram of diet DM provides the following: vitamin A, 6,000 IU; vitamin D_3, 1,200 IU; vitamin E, 3 IU; monensin, 22 mg; NaCl, 5.5 g; Ca, 8 g; P, 4 g; Mn, 18 mg; Fe, 18 mg; Cu, 7 mg; I, 5 mg; Co, .12 mg; and Se, .18 mg.

Slaughter Technique. The animals were shipped to a commercial slaughterhouse 1 d before slaughter and, upon arrival, were housed in individual pens on concrete floors and allowed free access to water. At slaughter, the hot carcasses were weighed after removal of the kidney, pelvic, and cod fats, which were weighed separately and expressed as a percentage of the hot carcass.

A slice of the longissimus muscle from the 12th rib region, with its subcutaneous fat cover, was taken from the right side of each carcass and frozen at −20°C for chemical analyses.

Laboratory Evaluation. Blood for analysis was collected in heparinized vacutainers, ice-cooled, and centrifuged, and the plasma was separated and stored at −20°C until analysis. The blood collection was made, from all experimental calves, by jugular venipuncture, on d 133 of the experiment, 7 d after the current Posilac injection, before feeding.

Hormones were quantified with RIA: GH according to Gluckman et al. (1979), with intra- and interassay CV of 6.4 and 10.2%, respectively; IGF-I according to Breier et al. (1991), with intra- and interassay CV of 8.5 and 12.3%, respectively; insulin with INSIK-5 kits (Sorin Biomedica, Rome, Italy); and total triiodothyronine and thyroxine with Coat-A-Count kits (DPC, Los Angeles, CA).

Plasma urea concentration was determined according to Coulombe and Favreau (1963) after precipitating the plasma proteins according to Somogyi (1945).

Amino acid analyses of the plasma were carried out according to FMOC Precolumn HPLC Chemistry, using Merck Hitachi instrumentation (Tokyo, Japan). Chemical analyses of feed and meat were carried out according to the AOAC (1990).

Table 2. Effects of recombinant bovine somatotropin (rbST) and Synovex (Syn) on growth and feed efficiency of bull calves

						Main effects		
Treatment	Control	rbST	Syn	rbST+Syn	SEM	rbST	Syn	rbST+Syn
Initial age, d	165.5	165.2	165.7	166.3	1.52	.900	.689	.783
Initial weight, kg	193.4	193.0	194.2	192.4	3.06	.711	.967	.820
Final weight, kg	512.5	535.7	522.4	532.5	7.44	.030	.624	.381
Days on experiment	238.5	236.3	241.6	233.7	5.34	.347	.944	.595
ADG, g	1,339	1,454	1,362	1,464	36.9	.005	.650	.854
Daily DM intake, kg	8.85	8.75	9.15	8.60	.29	.326	.809	.482
Daily ME intake, MJ	103.8	102.1	107.5	101.0	3.33	.288	.704	.511
Gain efficiency, g/kg	152	167	148	170	4.56	.016	.849	.506
g/MJ	12.90	14.24	12.67	14.49	.44	.011	.207	.106

Slices of the longissimus muscle from the 12th rib region were thawed and separated into muscle cross-section and the surrounding depot fat. Moisture was determined in both tissues in approximately 10-g subsamples, freeze-dried at –20°C under vacuum in 50-mL jars that were sealed after drying with an aluminum-lined cap, and stored for further analyses at –10°C in a nitrogen atmosphere. Lipids were extracted from subsamples of 1.0 g of dry sample of muscle cross-section and of subcutaneous fat with chloroform:methanol (2:1 vol/vol) according to the procedure of Folch et al. (1957). Aliquots of the chloroform layer were transferred to glass vials and stored at –10°C in a nitrogen atmosphere. Chloroform was dried under nitrogen, and total fat was quantified gravimetrically. Cholesterol was quantified on another aliquot of the chloroform extract using the method of Abell et al. (1952) and calculated as milligrams per 100 g of wet tissue. Fatty acid composition of the lipid fraction of muscle and subcutaneous fat (**SF**) were performed as described by Aharoni et al. (1995). Fatty acids were analyzed by GLC (Varian 3300, Varian, Palo Alto, CA), in a capillary column (DB1, 30 m, i.d. .25 mm). Temperature conditions for the column were 160°C for 2 min, 169 to 205°C in 2 min, and 205°C for 1 min. The injector and detector were kept at 265°C and 280°C, respectively. The injection was split, 1:50, and linear velocity of H_2 was 40 cm/s. Fatty acids were calculated as a percentage of total fatty acids. Unidentified peaks accounted for less than 1% of total fatty acids.

Tenderness Evaluation. The muscle samples were prepared for evaluation as described by Morris et al. (1995) and subjected to Warner-Bratzler shear force determination as described by Taylor and Cornell (1985).

Analysis of Data. Gain efficiency was calculated by relating daily growth rate to DMI. Carcass weight gain was calculated in individual calves as the difference between the carcass weight and the initial shrunk body weight multiplied by a mean dressing proportion, which had been derived by extrapolation from a previous experiment on similar calves (Levy et al., 1968).

Statistical Analysis. All variables were analyzed using Genstat 5, release 3.2 (Lawes Agricultural Trust, 1995), with the model consisting of rbST, Syn, and the rbST × Syn interaction. The differences between means were tested with Duncan's Multiple Range Test. Means for DMI and efficiency were analyzed by one-way analysis of variance, random block design (n = 2); four pens, one for each treatment, constituted a block. The probability level of less than .01 was considered highly significant, and of less than .05, significant.

Results and Discussion

The performance of the young bulls treated with rbST, Synovex, or both throughout the experiment and their slaughter data are described and presented in Tables 2 and 3, respectively. The effects of rbST on performance were significant. Average daily gain was increased by approximately 9% ($P < .005$) and gain efficiency by 10% ($P < .016$). No significant effects on performance that could be attributed to the effect of Syn alone or the rbST × Syn interaction were observed. Among the four treatment groups, the rbST+Syn calves had a growth rate similar to that of the rbST calves, and the Syn calves gained similarly to controls. Because only the rbST main effect was significant, neither synergism nor antagonism between the growth hormone and steroid treatments, occurred. Because Syn had no effect on the growth rate of our male calves, probably due to the endogenous concentration of androgens, unlike in experiments on steers in which the responses to exogenous growth hormone and steroids were significant and additive (Preston et al., 1995; Rumsey et al., 1996), rbST seems to be a proper growth enhancer for male calves and no additivity of effects of GH and estrogens should be expected. Intact males were found to be superior to castrated males in the economically important traits of rate of gain, feed efficiency, and yield of edible product (Field, 1971; Kay and Houseman, 1975; Ford and Gregory, 1983). Because Synovex implants seem to return to the castrated calves

Table 3. Effects of recombinant bovine somatotropin (rbST) and Synovex (Syn) on the slaughter data for bull calves

						Main effects		
Treatment	Control	rbST	Syn	rbST+Syn	SEM	rbST	Syn	rbST+Syn
Shrunk weight, kg	486.9	509.0	496.3	505.9	7.06	.030	.624	.381
Dressing, %	56.31	55.39	57.44	56.62	.38	.031	.003	.883
Carcass daily gain, g	703	746	740	777	19.8	.046	.092	.899
Forequarter, %	56.42	55.78	57.14	56.37	.23	.004	.006	.781
Hindquarter, %	43.48	44.11	42.61	43.50	.26	.007	.007	.623
Kidney and pelvic fat, % of carcass	3.40	2.36	2.99	2.12	.16	.001	.048	.600
Cod fat, % of carcass	.896	.728	.841	.726	.04	.001	.473	.530
Total large fat depots, % of carcass	4.296	3.089	3.828	2.846	.19	.001	.065	.565
Carcass gain efficiency, g/MJ	6.77	7.31	6.88	7.69	.26	.017	.075	.112

their male productivity potential, it seems to be needless to implant them into intact males. It seems that the effect of rbST alone on intact males and steers is similar, like that of porcine somatotropin on boars and castrated pigs (Klindt et al., 1995).

As Lobley (1992) reported for GH, real responses may not be observed unless additional inputs of protein are available; we fed the animals, during the entire experiment, with a diet containing 15% crude protein, so protein was not limiting in these bull calves. Feed efficiency was significantly higher with the rbST treatment.

It has been shown by Peters (1986) that plane of nutrition may have a large effect on response attained by GH administration. Sufficient nutrients must be present for GH to effect a net decrease in lipid accretion. Breier et al. (1988a,b) have demonstrated that adequate nutrition is necessary to achieve optimal use of GH. Relative to maintenance-fed steers, well-fed steers have higher basal and GH-induced concentrations of somatomedin-C (i.e., IGF-I) and affinity of hepatic GH receptors, both of which are considered to be very important for full biological participation of GH in the growth process. The daily ME intake of above 100 MJ/d in this experiment seemed to be adequate for GH to express its effects.

Weight of the large fat depots (kidney, pelvic, and cod fats) as a percentage of the carcass was decreased by 34% ($P < .001$) owing to rbST treatment. The Syn had no significant effect, and there was no Syn × rbST interaction. These results obtained for intact males exceed by far the reduction observed by Preston et al. (1995) for steers. Fat depots were not affected when smaller rbST doses (160 mg/wk) were administered (Dalke et al., 1992). Similarly, Schwarz et al. (1993) found that rbST treatment led to a dose-dependent reduction of kidney fat.

Dressing percentage was reduced by rbST and increased by Syn. This can be explained by the difference between these materials in their effect on the fatness of the carcasses. However, no effect of rbST on dressing percentage was found in steers (Dalke et al., 1992) or heifers (Schwarz et al., 1993); again, no interaction existed between the two materials.

The composition of the longissimus muscle is presented in Table 4. The treatments did not affect the proportion of protein or water in the longissimus muscle. The rbST treatment reduced the proportion of fat by 32%, but the difference was not significant. Still, the numerical reduction is consistent with the findings of Dalke et al. (1992) and Moseley et al. (1992) for steers, and of many others, as mentioned in the Introduction.

Table 4. Composition of the longissimus muscle of bull calves

						Main effects		
Treatment	Control	rbST[a]	Syn[b]	rbST+Syn	SEM	rbST	Syn	rbST+Syn
Protein, %	20.63	21.32	21.07	20.98	.318	.363	.876	.229
Fat, %	4.31	2.93	3.77	3.81	.465	.160	.718	.136
Water, %	73.90	74.58	73.98	74.02	.453	.433	.601	.474
Ash, %	1.165	1.172	1.177	1.202	.0312	.618	.503	.782
Warner-Bratzler shear values, kg F/ 1.4-cm diameter core	7.63	9.02	7.96	7.69	.970	.565	.613	.397

[a]rbST = recombinant bovine somatotropin.
[b]Syn = Synovex.

Table 5. Plasma hormone concentrations in bull calves

Treatment	Control	rbST[a]	Syn[b]	rbST+Syn	SEM	Main effects		
						rbST	Syn	rbST+Syn
GH, ng/mL	13.2	53.9	9.0	85.6	11.31	.001	.266	.122
IGF-I, ng/mL	310.0	257.0	303.0	293.0	22.9	.171	.556	.350
Thyroxine, mg/dL	10.70	11.99	11.04	11.97	.483	.028	.729	.710
Triiodothyronine, ng/dL	161.6	163.6	156.7	144.1	18.18	.773	.519	.690
Insulin, m*M*	17.03	35.3	17.43	24.29	4.62	.010	.285	.226
Urea N, ng/mL	2.61	2.74	2.91	2.68	.245	.835	.595	.468

[a]rbST = recombinant bovine somatotropin.
[b]Syn = Synovex.

There were no significant effects on tenderness, as measured with Warner-Bratzler shear values, either by rbST, which elicited a small increase, or by Synovex treatments. A small increase in the Warner-Bratzler shear value of the rbST treatment, similar to the one seen in our experiment, was found by Sejrsen et al. (1986). The values measured in our experiment, on young Holstein-Friesian bulls, are of a similar magnitude to those measured on longissimus steaks of 2-yr-old Holstein females (Solomon et al., 1997).

Of the plasma hormones (Table 5), only the concentrations of GH and insulin were affected by the treatments. The concentration of GH was increased 408% ($P < .001$) by rbST treatment and 648% by the combination of rbST and Syn. Synovex numerically increased the effect of rbST on the concentration of the plasma GH, but, because the variation within the combined treatment was very large, the effect was not significant.

The concentration of insulin was doubled in the rbST-treated animals ($P < .01$). The results agree with previous observations in growing ruminants (Eisemann et al., 1989; Crooker et al., 1990). This probably reflects a decreased response of organs and tissues to insulin in somatotropin-treated animals (Boisclair et al., 1997).

No significant differences in the concentration of IGF-I or triiodothyronine were observed. The lack of change in the concentration of IGF-I is rather surprising, because it contradicts the findings of McLaughlin et al. (1993) for sheep and of Dalke et al. (1992) and Elsasser et al. (1989) for steers. Thyroxine concentration was affected ($P < .05$) by rbST treatment.

Synovex had no effect on the plasma hormone concentrations of the bull calves in the present experiment. The effects on steers were different. Preston et al. (1995) reported increased plasma concentrations of somatotropin and IGF-I, and Rumsey et al. (1996, 1997) found increased GH and thyroid-stimulating hormone in Syn-treated feedlot steers.

Unlike the findings of McLaughlin et al. (1993) for sheep, urea N was not affected by any of the treatments. This could be attributed to the surplus of protein in the diet.

The concentration of essential and nonessential amino acids in plasma declined significantly as influenced by rbST (Table 6). There was a decrease of ~ 14% in the essential amino acids and of ~ 9% in the nonessential amino acids concentration in the rbST-treated animals compared with the controls. The Syn treatment did not have a significant effect. The change in the free amino acid concentration was negatively associated with the average daily gain. Our results with bull calves as regards the rbST effect were similar to the results of Preston et al. (1995) with steers. In contrast to our results, steroidal implants increased total nonessential amino acids in the latter study. We agree with the supposition of Preston et al. (1995) that the decrease in amino acid concentrations in the bST-treated animals may have been related to an increased demand for protein synthesis. Several studies have demonstrated enhanced nitrogen retention in cattle when treated with somatotropin (Eisemann et al., 1989; Crooker et al., 1990; Houseknecht et al., 1992). Plasma amino acid profiles (Table 6) did not change considerably as a result of rbST or Syn treatment. It is not possible to point to a specific amino acid as having a higher demand for protein synthesis. Nevertheless, two nonessential amino acids (hydroxyproline and tyrosine) increased significantly as a result of rbST, and one essential amino acid (phenylalanine) and two nonessential amino acids (glycine and serine) decreased significantly as a result of Synovex treatment. The results for the above-mentioned amino acids in steers (Preston et al., 1995) were different. Hydroxyproline and tyrosine did not increase significantly as a result of rbST treatment, phenylalanine was slightly changed, and glycine and serine increased significantly as a result of a steroidal implant. This may indicate a difference in amino acid demand for protein deposition between bulls and steers.

The concentrations of cholesterol and fatty acids in the muscle or subcutaneous fat (Tables 7 and 8, respectively) were not significantly affected by the rbST treatment. The Syn treatment significantly

Table 6. Plasma amino acid concentrations (percentage of total amino acids) in bull calves

Item	Control	rbST[a]	Syn[b]	rbST+Syn	SEM	Main effects		
						rbST	Syn	rbST+Syn
Essential amino acid (EAA)								
Arginine	6.71	6.12	6.75	7.26	.363	.899	.130	.139
Histidine	2.741	2.742	2.900	2.940	.132	.877	.188	.884
Isoleucine	5.468	5.193	5.261	5.239	.183	.423	.636	.495
Leucine	7.47	7.12	7.14	7.47	.265	.976	.986	.206
Lysine	4.489	4.237	4.351	4.398	.196	.603	.985	.450
Phenylalanine	1.164	1.161	1.156	1.220	.042	.477	.580	.437
Methionine	2.477	2.433	2.182	2.312	.098	.664	.038	.385
Threonine	3.48	3.53	3.39	3.69	.188	.362	.869	.497
Valine	9.06	9.10	9.21	9.38	.301	.729	.490	.830
Total EAA, μM	1.152.1	989.1	1,144.8	991.4	69.0	.028	.967	.944
Nonessential amino acid (NEAA)								
Alanine	12.00	12.34	12.47	12.12	.428	.997	.746	.423
Acidic amino acids[c]	15.70	16.04	17.30	15.87	.567	.343	.187	.126
Glycine	9.54	9.43	8.81	8.29	.467	.502	.056	.666
Hydroxyproline	2.466	2.920	2.439	2.646	.161	.048	.377	.448
Ornithine	2.420	2.308	2.582	2.413	.087	.117	.130	.748
Proline	4.87	5.49	4.92	4.98	.292	.254	.451	.348
Serine	7.29	7.01	6.62	6.85	.227	.917	.067	.263
Tyrosine	2.65	2.83	2.52	2.92	.124	.024	.860	.379
Total NEAA, μM	1,508.0	1,369.0	1,554.0	1,257.0	66.8	.002	.669	.246
Total amino acids, μM	2,661.3	2,358.0	2,700.3	2,247.9	129.6	.006	.808	.571
Nonessential/essential	1.774	1.825	1.818	1.746	.068	.877	.833	.370

[a]rbST = recombinant bovine somatotropin.
[b]Syn = Synovex.
[c]Acidic amino acids = aspartic acid, glutamic acid, asparagine, and glutamine.

reduced the concentration of myristic and palmitic acids and increased the oleic acid ($P < .02$) in the longissimus muscle.

Synovex increased ($P < .029$) the monounsaturated fatty acid (**MUFA**) concentration, and the combined treatment of Syn with rbST led to a decrease ($P < .039$) in the polyunsaturated fatty acid (PUFA) concentration in the longissimus muscle (at the 12th rib). Yet, a trend toward an increase in PUFA in the animals treated with rbST or Syn alone can be seen. Linolenic acid (C18:3) in the muscle was 2.3-fold higher in the rbST-treated animals than in the control animals. This may have positive implications for the beef industry. The question of how the composition of either the muscular or the subcutaneous fat is affected by the treatments is very interest-

Table 7. Cholesterol and fatty acids concentrations in muscle from bull calves

Treatment	Control	rbST[a]	Syn[b]	rbST+Syn	SEM	Main effects		
						rbST	Syn	rbST+Syn
Cholesterol	63.7	59.7	64.2	51.0	5.84	.150	.485	.438
C14:0 myristic	5.47	5.50	4.63	4.87	.348	.696	.043	.762
C16:0 palmitic	36.82	37.50	33.87	35.36	1.083	.323	.024	.707
C16:1 palmitoleic	3.95	3.82	3.98	4.08	.282	.961	.611	.681
C18:0 stearic	12.62	13.26	13.78	13.58	.623	.728	.245	.499
C18:1 oleic	32.18	29.95	33.61	33.57	1.072	.297	.024	.316
C18:2 linoleic	7.49	8.18	7.76	6.96	.540	.922	.388	.175
C18:3 linolenic	.125	.196	.229	.087	.0632	.583	.967	.101
C20:4 arachidonic	1.35	1.59	2.08	1.47	.286	.524	.292	.142
MUFA[c]	36.13	33.77	37.59	37.65	1.173	.334	.029	.310
PUFA[d]	8.96	9.97	10.08	8.52	.598	.651	.781	.039

[a]rbST = recombinant bovine somatotropin.
[b]Syn = Synovex.
[c]MUFA = monounsaturated fatty acids.
[d]PUFA = polyunsaturated fatty acids.

Table 8. Cholesterol and fatty acid concentrations in subcutaneous fat from bull calves

						Main effects		
Treatment	Control	rbST[a]	Syn[b]	rbST+Syn	SEM	rbST	Syn	rbST+Syn
Cholesterol	91.4	95.1	107.1	97.8	4.97	.578	.071	.200
C14:0 myristic	4.65	4.61	4.69	4.97	.355	.734	.577	.656
C16:0 palmitic	31.15	31.51	30.98	31.88	1.265	.621	.937	.831
C16:1 palmitoleic	5.02	5.99	5.00	4.57	.469	.568	.133	.146
C18:0 stearic	16.98	13.89	15.62	16.61	1.102	.349	.538	.072
C18:1 oleic	34.63	37.37	36.25	35.71	1.237	.381	.987	.193
C18:2 linoleic	6.60	4.99	5.49	5.12	1.033	.347	.638	.552
C18:3 linolenic	.45	1.04	1.01	.58	.322	.809	.876	.127
C20:4 arachidonic	.48	.49	.97	.55	.230	.379	.241	.352
MUFA[c]	39.65	43.35	41.25	40.28	1.320	.307	.578	.085
PUFA[d]	7.53	6.52	7.47	6.26	1.201	.361	.891	.934

[a]rbST = recombinant bovine somatotropin.
[b]Syn = Synovex.
[c]MUFA = monounsaturated fatty acids.
[d]PUFA = polyunsaturated fatty acids.

ing. We checked the possibility that it might be related to the treatments indirectly, by the treatment effects on the fat accumulation. This means that if fat accumulation is selective, the composition of the accumulated fat will be changed with the increased total fat accumulation. Therefore, we regressed the fat composition (i.e., PUFA and MUFA, and each fatty acid content) on either the muscular fat content or on the large fat depots, or on both of them. Significant relations were found only between some of the muscular fat composition variables and the fat content of the muscle (Table 9). Table 9 presents only the significant, or close to significant, relationships. The MUFA content was increased with increased muscular fat accumulation, predominantly because of increased content of oleic acid (C18:1). The PUFA content tended to decrease with increased fat accumulation. This is because of a decreased content of arachidonic acid (C20:4), which is known to be a component of the fat in the cell membrane, and the fraction of membrane fat in the total fat content is decreased with increased fat accumulation. It is interesting to note that palmitic acid decreased with increased fat accumulation, suggesting that less palmitic acid, and presumably more stearic and oleic acids, are accumulated beyond an initial low muscular fat content. It is suggested, therefore, that the composition of accumulated fat in the muscle is selective. More MUFA and less PUFA and C16:0 are accumulated as the muscle accumulates more fat. Therefore, the effect of rbST on the muscular fatty acid composition is a result of its effect on total fat accumulation there. The trend toward a negative relationship, as we found here, between PUFA and muscular fat suggests that the well-recognized reduction of lipid deposition in response to bovine somatotropin is followed by a higher PUFA content, which may be associated with reduced plasma cholesterol (Mattson and Grundy, 1985) and coronary heart disease prevention, which is desirable for consumers. Generally, the results of the present paper suggest that the improvement in performance by recombinant bovine somatotropin treatment is somewhat larger in bull calves than in steers. Unlike in steers (as found in the literature), in bull calves no additive effect of rbST and Synovex was observed.

Implications

Recombinant bovine somatotropin can increase growth and feed efficiency by approximately 9%, decrease weight of depot fat by 34%, and decrease fat in longissimus muscle by 32% in Holstein-Friesian bull calves. Recombinant bovine somatotropin seems to enhance growth of bull calves. Synovex alone has little effect on bull calves. The reduced muscle fat content in recombinant bovine somatotropin-treated young bulls was associated with a trend toward an increase in polyunsaturated fatty acids in their fat.

Table 9. Linear regression[a] coefficients and significance of some variables of fat composition on muscular fat percentage

Y variable	Coefficient	*P*-value
Muscle MUFA, % total fat	1.009	.013
Muscle PUFA, % total fat	–.0311	.135
Muscle C16:0, % total fat	–.687	.072
Muscle C18:1, % total fat	1.048	.005
Muscle C20:4, % total fat	–.152	.122

[a]The model is a single linear regression model of the form Y = aX + b, where the X variable is the fat percentage of the muscle, a is the regression coefficient, and b is a constant.
MUFA = monounsaturated fatty acids.
PUFA = polyunsaturated fatty acids.

Because polyunsaturated fatty acids are related to prevention of cardiovascular diseases, an increase in polyunsaturated fatty acids may have positive implications for the beef industry.

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