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Effect of recombinant bovine somatotropin administration on milk production, composition and some hemato-biochemical parameters of lactating goats

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SUMMARY – The objectives of the present study were to evaluate the effects of recombinant bovine somatotropin (rbST) on milk production, composition and some hemato-biochemical characteristics in Damascus goats. Fifteen Damascus lactating goats in their third to fourth lactation season and at 30-40 days postpartum were divided into three equal groups. The first group was served as control, while the second and third groups were injected, once every week for 8 weeks, with low (50 mg/doe) or high (100 mg/doe) doses of rbST, respectively. Supplementation with rbST resulted in a significant (P<0.05) increase in total milk yield by 24.3 and 22.5 % for 50 mg or 100 mg of rbST, respectively compared with control. Body weight and dry matter intake of does were not affected significantly by rbST treatment. While average daily gain (ADG) of kids that were suckling rbST-treated does was higher (11 and 10.5 % for low and high doses of rbST, respectively) than for kids of control does during the treatment period. Supplementation with rbST caused insignificant (P>0.05) increase in the levels of total solids, milk protein and fat as compared with control, while lactose significantly (P<0.05) increased. On the other hand, ash, haematological parameters, plasma proteins and the activities of plasma aspartate aminotransferase (AST), alanine aminotransferase (ALT), glutathione S-transferase (GST), alkaline phosphatase (AlP), acid phosphatase (AcP), and the levels of thiobarbituric acid-reactive substances (TBARS) and cholesterol were not affected by treatment. The results of the present study suggest that rbST is efficacious in increasing milk yield and kid growth up to 50 mg/14 d without adverse effects on lactating goats.

Keywords: Somatotropin, goat, milk composition, blood metabolites.

RESUME – *"Effet de l'administration de somatotropine bovine recombinante sur la production et la composition du lait, et sur certains paramètres hémato-biochimiques de chèvres allaitantes". Les objectifs de la présente étude étaient d'évaluer les effets de la somatotropine bovine recombinante (rbST) sur la production et la composition du lait, et sur certains paramètres hémato-biochimiques de chèvres de race Damascus. Quinze chèvre Damascus allaitantes dans leur troisième ou quatrième saison de lactation et à 30-40 jours postpartum ont été divisées en trois groupes égaux. Le premier groupe servait de témoin, tandis que les deuxième et troisième groupes subissaient l'injection, une fois par semaine pendant 8 semaines, de doses faibles (50 mg/chèvre) ou élevées (100 mg/chèvre) de rbST, respectivement. La supplémentation avec rbST a donné une augmentation significative (P<0,05) de la production totale de lait de 24,3 et 22,5 % pour 50 mg ou 100 mg de rbST, respectivement par rapport au témoin. Le poids corporel et l'ingestion de matière sèche des chèvres n'étaient pas significativement influencés par le traitement de rbST. Le GMQ des chevreaux allaités par les mères traitées au rbST était plus élevé (11 et 10,5 % pour les doses faibles et élevées de rbST, respectivement) par rapport aux chevreaux des chèvres témoin pendant la période de traitement. La supplémentation avec rbST a entraîné une augmentation non significative (P>0,05) des niveaux de solides totaux, de protéines du lait et de matières grasses en comparaison avec le témoin, tandis que le lactose a augmenté significativement (P<0,05). D'autre part, les cendres, les paramètres hématologiques, les protéines du plasma et les activités de l'aspartate aminotransférase du plasma (AST), alanine aminotransférase (ALT), glutathione S-transférase (GST), alkaline phosphatase (AlP), phosphatase acide (AcP), et les niveaux de substances thiobarbituriques acido-réactives (TBARS) et de cholestérol n'étaient pas influencés par le traitement. Les résultats de la présente étude suggèrent que le rbST est efficace pour faire augmenter la production laitière et la croissance des agneaux jusqu'à 50 mg/14 j sans effets adverses sur les chèvres allaitantes.*

Mots-clés : *Somatotropine, chèvre, composition du lait, métabolites sanguins.*

Introduction

Previous studies have demonstrated that somatotropin is a key control of nutrient use. When administered exogenously bovine somatotropin (bST), markedly improves productive efficiency in lactating cows (Peel and Bauman, 1987; Bauman, 1992). Lactational responses to bST have been reported for all dairy breeds examined, including North American and European breeds as well as Murrah buffalo. In addition, animals of different parity and genetic potential are responsive to bST (Peel and Bauman, 1987). Improvement of efficiency and economic return is an important goal in dairy farming, as in any agricultural enterprise. With bST use, a unit of milk is produced with less feed and protein supplement and with a reduction in animal excreta (manure, urine, and methane). Nationally, the use of bST simply reinforces, but does not fundamentally change, dairy industry trends of increased milk yield per cow, reduced number of cows, and declining dairy farm numbers (Bauman, 1992). Administration of exogenous native pituitary or recombinant bovine somatotropin (rbST) significantly increases milk yield in dairy cattle, either in short-(Chilliard, 1988a) or long-term (Chilliard, 1988b) experiments. Bauman (1992) reported that the maximum milk response is achieved at a bST dose (daily injection) of about 30 to 40 mg/d, and no further increase occurs event at doses several fold higher. The treatment of lactating sheep and goats with rbST resulted in an increased milk yield, but the trails with sheep and goats were very short-term (<14d), which allowed a weak galactopoietic effect (Disenhaus *et al.*, 1995). From the previous studies, only few experiments have been carried out with bST on lactating goats to investigate its repeated daily doses for short-term (<14 d), but no studies have been performed to evaluate the effect of long-term and weekly or biweekly injection. Therefore, this study was carried out to investigate the effects of two different doses of rbST, supplemented every week in lactating goats on milk yield, milk composition, kids growth performance and blood metabolites of lactating goats with single kid for 8 weeks.

Materials and methods

Animals management and treatments

The experiment was carried out at the Alexandria University Experimental Farm during spring 2003. Fifteen lactating Damascus does each weighing 29.12 ± 1.34 kg with single kids at 30-40 days postpartum were used. Goats were in their third to fourth lactation season. The goats were kept in a free stall and had free access to water. They were fed on concentrate mixture and berseem hay twice daily at 0700 and 1500 h. The diet was offered in amounts calculated to provide 120% of the NRC recommended amount (NRC, 1985). Individual intakes of berseem hay and concentrate were recorded daily. Feeds refusal were recorded once daily. Feed was sampled once weekly, monthly composite dried and ground. Berseem hay and concentrate were analysed according to procedures of AOAC (1990) (Table 1). The animals were divided into 3 homogenous groups, 5 animals each, according to lactation stage, parity and milk yield. The first group was used as a control, while the second and third groups were subcutaneous injected with 50 or 100 mg weeks/doe of rbST (Somatec) for 60 day. A sustained release formulation of rbST was purchased from Elanco-Eli Lilly export S.A., Geneva.

Table 1. Chemical composition of commercial concentrate mixture and berseem hay

Parameters (%)	Concentrate	Berseem hay
Dry matter	89.44	91.45
Organic matter	83.59	80.33
Crude protein	12.45	11.05
Crude fibre	4.92	22.35
Ether extract	4.75	2.65
Ash	5.85	11.12
Nitrogen free extract (NFE)	61.47	44.28

Milk production and composition

Milk yield was recorded twice weekly at 07:00 and 16:00 h by using weigh-suckle-weigh technique (Williams *et al.*, 1979). To determine milk composition, samples were obtained 1 d each week by milking out the ewes by hand before allowing the lambs to nurse. The samples were collected into plastic vials preserved with Microtabs, stored at 4°C, and analysed for total fat, milk protein and ash; lactose was calculated by difference.

Haematological parameters

Blood samples were collected on day 7 of each treatment and continued throughout the 8-week experimental period. Blood samples were obtained in the morning before access to feed and water from the external jugular vein and were placed immediately in ice. Heparin was used as an anticoagulant and plasma was obtained by centrifugation of blood at 860 xg for 20 minutes, and stored at -60^{o}C for analyses. Non-coagulated blood was tested for haemoglobin, total erythrocyte count, packed cells volume and total leukocyte counts. Blood Hb concentration was determined by the cyanomethaemoglobin procedure (Wintrobe, (1965).

Biochemical parameters

Plasma was analysed for total protein; albumin by the Biuret method according to Henry *et al.* (1974). Globulin concentration was determined as the difference between total protein and albumin. Plasma glucose concentration, urea, creatinine total bilirubin and cholesterol were estimated according to Hyvarinen and Nikkila (1962), Patton and Crouch (1977). Plasma alanine aminotransferase and aspartate aminotransferase, alkaline phosphatase, acid phosphatase, lactate dehydrogenase, glutathione S-transferase activities were assayed by the methods of Reitman and Frankel (1957), Principato *et al.*, (1985) and Moss (1984). Thiobarbaturic acid- reactive substances (TBARS) were measured in plasma by using method of Tappel and Zalkin (1959).

Statistical analysis

Data were analyzed by General Linear Model (GLM) procedure using SAS statistical package (SAS, 1986). Variation between means were compared by Duncan's Multiple Range Test (Snedecor and Cochran, 1980). The following model was used:

$$Y_{ijk} = \mu + a_i + b_j + ab_{ij} + e_{ijk}$$

where: Y_{ijk} = experimental observation; μ = overall mean; a_i = treatment effect; b_j = week effect; ab_{ij} = interaction effect of treatment and week, e_{ijk} = random error.

Results

Body weight and feed intake

Body weight (BW) and dry matter intake (DMI) of the does were not significantly affected by rbST treatment (Table 2). Does lost weight during the beginning of the experiment when they were moving into their peak lactation period. Kids of rbST-treated does had higher average daily gain (P<0.05) than the kids of control goats by 11 and 10.5 % for 50 mg and 100 mg rbST, respectively (Table 2). There is no significant effects due to treatment, weeks or their interaction on BW and DMI, while they have significant effects (P<0.05) on ADG.

Milk yield and composition

The treatment of does with rbST rapidly increased milk yield after the onset of treatment (Fig. 1).

Average increases in milk yield for does treated with 50 mg or 100 mg of rbST were 24.3 and 22.5 % above the control group, respectively (Table 2). The improvement in milk yield was 35 % in the first 3 weeks in treated does with 50 mg rbST and start to decline from the sixth week of treatment (Fig.1). While, the enhancement in milk yield due to the supplementation of 100 mg rbST was continue until the fifth week of the treatment and then declined. No significant difference was noted between the 50 and 100 mg treatment groups. The improvement in milk yield due to rbST treatment was concomitant with slight increase in the percentages of total solids, protein and fat, but the percentages of ash did not alter with the treatment. Concentration of lactose significantly increased (P<0.05) in treated does with both 50 mg and 100 mg of rbST as compared with the control (Table 2). The improvement in milk yield and composition was approximately similar in 50 mg or 100 mg of rbST treated animals.

Table 2. Effect of rbST on body weight, dry matter intake (DMI) of lactating ewes, growth performance of their kids (ADG, average daily gain), milk yield and composition of lactating ewes (Means ± SE)

Parameter	Group		
	Control	50mg rbST	100 mg rbST
No. of does	5	5	5
Initial weight (kg)	28.60±2.8	29.75±3.1	29.00±3.8
Final weight (kg)	28.25±2.6	29.87±2.3	28.90±2.6
DMI (kg/d)	1.601±24	1.649±22	1.645±25
No. of kids	5	5	5
Initial weight (kg)	7.51±0.43	7.43±0.55	7.46±0.57
Final weight (kg)	13.76±0.76	14.41±0.42	14.37±0.7
ADG (g/d)	104.20 ±6.26 ^{b}	115.76 ±5.28 ^{a}	115.16 ±8.51^{a}
Improvement (%)	-	11.0%	10.5%
Milk yield (g/d)	783.5 ^{a}	973.5 ^{b}	959.5 ^{b}
Improvement (%)	-	24.3	22.5
Total solids	13.29±0.31	13.97±0.34	13.92±0.46
Protein	3.49±0.14	3.60±0.04	3.65±0.13
Fat	4.06±0.13	4.18±0.08	4.17±0.10
Lactose	4.83±0.15 ^{b}	5.27±0.12 ^{a}	5.20±0.13 ^{a}
Ash	0.91±0.026	0.92±0.027	0.90±0025

^{a,b} Within a row, means with different superscript letters differ significantly (P<0.05).

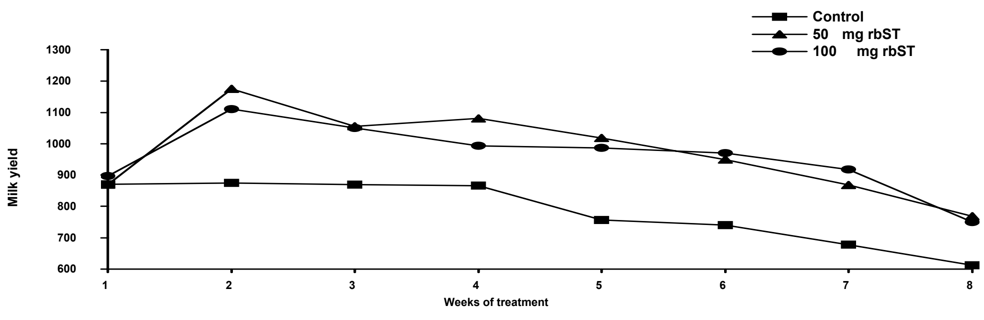

Fig. 1. Effect of rbST administration on milk yield in lactating goats.

Hemato-biochemical parameters

The present data showed that haematological parameters (Hb, TEC, PCV, and TLC), plasma proteins (TP, A and G), enzyme activities (AST, ALT, AcP, AlP, and GST) and the levels of thiobarbituric acid-reactive substances did not change in treated does with both doses of rbST as compared to the control animals (Table 3). Treatment with low or high doses of rbST caused significant (P<0.05) decrease in the levels of plasma urea and total bilirubin in a dose dependent manner. While, the concentrations of creatinine and cholesterol insignificantly (P>0.05) decreased. On the other hand, the levels of glucose significantly (P<0.05) increased in treated groups with both low and high doses of rbST compared to control (Table 4). Also, treatment had significant (P<0.05) effect on total bilirubin, ALT and AcP.

Table 3. Effect of rbST on haematological and some plasma biochemical parameters of lactating ewes (means ± SE)

Parameter†	Group		
	Control	50 mg rbST	100 mg rbST
Hb (g/dl)	14.5±0.21	14.5±0.25	14.3±0.23
PCV %	30.1±0.67	29.7±0.76	29.4±0.49
Erythrocytes ($\times10^6$)	9.4±0.29	9.6±0.47	9.2±0.41
Leukocytes ($\times10^3$)	8.9±0.49	8.7±0.31	8.6±0.54
Total protein (g/dl)	7.7±0.25	7.8±0.26	8.0±0.30
Albumin (g/dl)	4.8±0.19	5.1±0.20	4.8±0.23
Globulin (g/dl)	2.9±0.23	2.7±0.29	3.1±0.37
Glucose (mg/dl)	52.4±2.28 ^{b}	75.1±2.58 ^{a}	78.9±1.84 ^{a}
Urea (mg/dl)	55.3±1.87 ^{a}	38.9±0.97 ^{b}	36.0±1.39 ^{b}
Creatinine (mg/dl)	0.78±0.049	0.70±0.043	0.73±0.025
Total bilirubin (mg/dl)	1.44±0.15 ^{a}	1.16±0.110 ^{b}	0.88±0.074 ^{c}
Cholesterol (mg/dl)	80.8±2.96	77.5±2.5	78.6±3.55
AST (U/L)	54.5±3.88	49.5±3.48	48.9±3.63
ALT (U/L)	32.7±1.49	33.1±2.05	29.7±1.38
AcP (U/L)	4.2±0.19	4.8±0.68	4.5±0.22
AlP(U/L)	54.5±1.57	55.5±2.02	52.9±2.93
GST (μmol/hr)	0.57±0.017	0.61±0.021	0.58±0.013
TBARS (nmol/ml)	2.12±0.108	1.88±0.078	1.82±0.083

abc Within a row, means with different superscript letters differ significantly (P<0.05).
†Hb: Hemoglobine; PCV: Packed cell volume; AST: Aspartate aminotransferase; ALT: Alanine aminotransferase; AcP: Acid phosphatase; AlP: Alkaline phosphatase; GST: Glutathione S-transferase; TBARS: Thiobarbituric Acid-reactive Substances.

Discussion

The insignificant increase in body weight (BW) and dry matter intake (DMI) with rbST supplementation in the present study is in agreement with Chilliard (1988a). The present results showed that average daily gain (ADG) of kids that were suckling rbST-treated does was higher than for kids of untreated does during treatment period. Similar responses in milk yield by lactating goats and cows without corresponding increase in DMI have been reported by Peel and Bauman (1987) and McLaughlin *et al.* (1991) reported that performance responses due to treatment with bST were reflected by changes in circulating glucose, blood urea nitrogen, and insulin-like growth factor I (IGF-I) concentrations. The pattern of milk yield response to sustained-release rbST in the present study was similar to that reported due to daily injection in goats (Disenhaus *et al.*, 1995) and in cows (Chilliard, 1988b). The average response of goats injected daily with rbST at 5 mg/d/animal was 26-28.6% increase in milk production for short-term experiment (Disenhaus *et al.*, 1995). Somatotropin is a homeorhetic controller that shifts the partitioning of nutrients so that more are used for milk synthesis (Peel and Bauman, 1987). The mechanism of bST to exert its galactopietic effect is complex and involves a multiplicity of events in whole animal. The results obtained by Faulkner (1999) indicated that there were increases in the availability of glucose within the mammary epithelial cell in response to growth hormone treatment that would result in increases in the rate of lactose synthesis and hence stimulation of milk production. In addition, somatotropin appears to promote milk production by a partitioning effect on absorbed nutrients, so to supply more substances for mammary synthesis, and also the level of nutrition may influence yield responses for milk and milk composition, and nutrient flow in bST-treated lactating ruminants (Bauman and Currie, 1980).

Gross composition of milk (fat, protein, and lactose content) is not substantially altered due to bST administration (Peel and Bauman, 1987). Although the lactose content of milk is relatively constant, the content of fat and protein normally varies widely because of many factors, including genetic, breed, stage of lactation, age, diet composition, nutritional status, environment and season. The present results showed that there is no significant difference between control and treated groups of rbST in the average values of milk protein, total solids, fat and ash, while lactose levels increased.

The decrease in plasma urea (30 and 40% for low or high doses, respectively) of does treated with rbST is in agreement with the results of goats treated with bST (Disenhaus *et al.*, 1995; Min *et al.*, 1997). Since the plasma levels of urea is the index of hepatic amino acids oxidation and of ruminal ammonia fermentation, therefore its decrease may reflect a higher amino acids removed from blood for milk protein biosynthesis. Glucose homeostasis provides a clear example of the coordinated responses that occur with bST treatment of lactating cows. With bST uses, glucose production by the liver increases, and its oxidation by body tissues decreases. The present results showed that plasma glucose increased by 43% and 51 % for low or high doses of rbST. Treatment with rbST caused reduction in total bilirubin concentration. The activities of plasma AST and ALT, which are commonly used as indicators of liver cell damage and death, was not affected by the treatment with rbST (Early *et al.* (1990). It is concluded that rbST is efficacious in increasing milk yield up to 24.3% and kid growth up to 50 mg/14 days at 30-40 days postpartum without adverse effects on lactating does.

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