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COMPARATIVE STUDY ON SOME GROWTH PROMOTERS IN MALE NEWZELAND RABBITS

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SUMMARY

The present study was conducted on male Newzeland rabbits to investigate in a comparative approach the effects of bovine somatotropin and salbutamol on growth performance, carcass traits, and biosafety-related parameters. The recorded results revealed that, bovine somatotropin increased average daily feed intake and live body gain. Both bovine somatotropin and salbutamol decreased feed conversion ratio and increased feed efficiency. While salbutamol increased dressing percentage, longissimus muscle protein concentration and plasma creatinine level, bovine somatotropin has no effect on them. However, both promoters decreased plasma urea concentrations. Bovine somatotropin and salbutamol didn't significantly alter biosafety-related plasma parameters; activities of alanine aminotransferase, aspartate aminotransferase and alkaline phosphatase, plasma total proteins, albumin, urea, glucose, sodium, chloride, total and free calcium and inorganic phosphorus. In conclusion, Growth promoters; bovine somatotropin or salbutamol are economic, profitable and safe for animals and could be used for increasing both feed efficiency and protein accretion, and decreasing fat deposition .

INTRODUCTION

Growth promoters include natural hormones such as anabolic steroids, as, trenbolone acetate (Johnson et al., 1996), estradiol-17β (Hayden et al., 1992) and zeranol (Moder et al., 1985), recombinant bovine somatotropin (Beermann et al., 1990; Rumsey et al., 1996), and hormonal agonists, as β-adrenergic agonists (Reeds and Mersmann, 1991).

Somatotropin (ST) is a protein hormone synthesized and secreted from the anterior pituitary. Somatotropin in cattle produced a decrease in

feed intake (Wagner et al., 1988), an increase in average daily gain and improvement in feed efficiency (Dalke et al., 1992). Somatotropin treatment in lambs decreased the carcass weight due to a significant reduction in the weights of the major visceral fat depots (Johnsson et al., 1987), and reduction in subcutaneous fat (Beermann et al., 1990). Also, the external and visceral non-carcass organs were increased in somatotropin treated lambs (Mclaughlin et al., 1993) and cattle (Early et al., 1990b). In addition, Somatotropin treatment increased muscle weights in virtually every site in the body in lambs (Mclaughlin et al., 1993), and vastus lateralis (Early et ., 1990b), and triceps brachii muscles in cattle (Elasser et al., 1998). The lean tissue accretion of somatotropin were dependent on species (Etherton and Bauman, 1998), breed (Sinnett-Smith et al., 1989), weight of animals (Beermann, et al., 1990), stage of the physiological development (Bell et al., 1998), and dose (Dalke et al., 1992) and variant forms of somatotropin (Mclaughlin et al., 1993).

β-adrenergic agonists are organic molecules that bind to adrenergic receptors via coupling with G protein. β-drenergic agonists that increase protein accretion are namely clenbuterol, cimaterol, isoproternol, L-644,969, ractopamine and salbutamol (Reeds and Mersmann, 1991). β-adrenergic agonists increased the weight gain, feed efficiency, carcass weight, dressing percentage in lambs (Pringle et al., 1993), cattle (Quirke et al., 1988), and rabbits (Pringle et al., 1994). In addition, β - adrenergic agonists increased protein and reduced fat content in lambs (Baker et al., 1984) and steers (Chikhou et al., 1993 b).The response to the anabolic effects of β-adrenergic agonists varies with species (Mersmann, 1998), breed (Eisen et al., 1988), and age of the animals (O'conner et al., 1991), and type (Dawson et al., 1991), dose (Sainz and Wolff, 1988) and duration of agonist supplementation (Moloney et al., 1990).The present study was conducted to investigate, in a comparative approach, the effects of growth promoters (bovine somatotropin and salbutamol) on production parameters, carcass traits and biosafety-related metabolic profile testing in male Newzeland rabbits.

MATERIALS AND METHODS

Experimental animal:

This study was conducted on 24 male Newzeland rabbits weighing 1239 ± 39.3 grams at the beginning of the experiment. Rabbits were individually kept in metal batteries and fed commercial pelted balanced growing rabbit's ration (Etmida, Mitghamr).

Rabbits were left one week for adaptation, then vaccinated with pasteurollosis vaccine (Veterinary Serum and Vaccine Research Institute, Egypt) and viral hemorrhagic disease vaccine (Rhone Mericux, France). Furthermore, Monthly prophylactic dose of Baycox as anticoccidial drug

(1ml/ 10 liters drinking water) and Ivomec (1 ml of 10% S.C., Merck Co., USA) was used.

Experimental design:

Twenty-four male Newzeland rabbits were allocated randomly into three groups of eight rabbits each. First group was kept as control. Second group (Bovine somatotropin administered group; bST) : each rabbit in this group was injected S.C. day by day with recombinant bovine somatotropin (rbST; Somatech) (Monsanto company, Switzerland) in a dose of 0.3 mg/ kg b.w. Somatotropin was diluted by using bicarbonate buffer (25 mM NaHCO3, 0.154 M Nacl, 25 mM Na2CO3) (Sillence and Etherton, 1991). Third group (Salbutamol supplemented group): each rabbit in this group was fed daily on a diet supplemented with salbutamol in a dose of 1.9 mg /kg b.w. (Miller et al., (1988). The diets of these rabbits were prepared daily. Salbutamol (Salbovent) as sulfate is produced by Alexandria Pharmaceuticals Co., Egypt. The dose of bovine somatotropin and salbutamol was adjusted according to the weekly changes in body weights. The animals of each group were treated by the previously mentioned regimes for 13 weeks.

Sampling:

At the end of the experiment, rabbits were slaughtered and individual blood samples were collected on heparin as anticoagulant (12 iu/ ml blood). Blood samples were centrifuged at 3000 rpm for 15 minutes and plasma was separated, divided into aliquots and kept in a deep freeze at -20 C° until used. Representative sample from right longissimus dorsi of each rabbit was obtained (~10 grams) and kept in a deep freeze at -20C° for estimation of longissimus muscle protein and total lipid concentrations.

Data Collection techniques:

A- Growth performance:

The initial body weight, weekly changes in live body weight and food consumption were recorded to each rabbit for calculation of the following: average daily feed intake (g/day), average daily body gain (g/day), feed conversion ratio (average daily feed intake/ average daily body gain) and feed efficiency (average daily body gain / average daily feed intake).

B- Carcass traits and carcass related metabolites:

A day before rabbit slaughtering, the preslaughter weight of each rabbit was recorded. After slaughtering rabbits were dressed and hot carcass weight was recorded and dressing percentage for each rabbit was calculated as follows: Dressing percentage = dressing weight x100/preslaughter weight. Collective and individual weights of ma-

jor non-carcass components (MNCC; head, fleece plus feet and gastrointestinal tract) were recorded.

Longissimus muscle protein concentration was determined (Lowry et al., 1951) and total lipids were extracted (Folch et al., 1957) and determined (Frings and Dunn, 1970) by kits (Cal-Tech Diagnositics, Inc. Chino, California, USA). Plasma urea concentration was measured (Fawcett and Scott, 1960), using kits (Quimica Clinica Applicada, Spain). Plasma creatinine determination was estimated (Houot, 1985) by using kits (bio-Merieux laboratory reagent, France).

C- Biosafety of the investigated promoters:

The activities of alanine aminotransferase (ALT) and aspartate aminotransferase (AST) were measured (Reitman and Frankle, 1957) using kits (Quimica Clinica Applicada, Spain). Alkaline phosphatase activity (ALP) was determined (Tietz, 1970) using kit (Bio-Analytics, Palm City, USA). Plasma total proteins (Henry, 1964) and albumin (Drupt, 1974) concentrations were determined colorimetrically (bioMerieux Laboratory reagent, France).

Determination of plasma sodium and potassium concentrations was done using flamephotometer (Varely, 1976). Plasma chloride concentration was determined spectrophotometrically (Skeggs and Hochstrasser, 1964) using kit (Quimica Clinica Applicada, Spain). Total calcium was determined (Ratliff and Hall, 1973) by kits (Bio-Analytics, Palm City, USA) and free calcium concentration was calculated according to the following equation (Puerro and Alexandre, 1995):

$$\text{Free calcium} = \frac{\text{Total calcium} \times 6 - \text{Total protein}/3}{\text{Total protein} - 6}$$

Plasma inorganic phosphorus concentration was estimated (Goodwin, 1970) by kit (Quimica Clinica Applicada, Spain). Plasma glucose concentration (Hoffman, 1966) was determined by kits (Bio-Analytics, Palm City, USA).

STATISTICAL ANALYSIS:

All data were presented as mean ± SE and were subjected to analysis of variance (ANOVA) test (Snedecor and Cochran, 1980). Treatment means were compared by the least significant difference test (L.S.D) at 5% level of probability.

RESULTS

A- Growth Performance:

Data presented in table (1) showed that the overall mean of the average daily food intake was lower in the salbutamol supplemented group than those in the control and bovine somatotropin treated groups, however, bovine somatotropin administration increased the average daily food intake than that of the control. Although the treatments

effect were time independent, there were numerical reductions in feed intake due to salbutamol supplementation, this reducing effect was apparent from the first week of the experimental period till the last week. Bovine somatotropin caused numerical increase in feed intake throughout the experimental period except the first week.

The overall mean of the average daily live body gain was higher in bovine somatotropin treated group than those of the control and salbutamol groups (Table 1). However, there was no significant difference between the control and salbutamol groups. In addition, the average daily gain was time dependent. Bovine somatotropin increased the average daily gain during the 3rd, 4th, 10th, and 12th weeks only than in control group. Salbutamol decreased the average daily gain during the 1st and 6th weeks only than in control group. The difference between bovine somatotropin and salbutamol groups was statistically significant during 1st, 3rd, 10th and 12th weeks

Feed conversion of bovine somatotropin administered and salbutamol-supplemented groups were lower than that of the control group and there was no significant difference between the first two groups (Table 2). Additionally, the effects of the treatments on feed conversion ratio were time dependent. Bovine somatotropin increased the feed conversion during the 6th, 9th, and 11th weeks and decreased it during 4th, 10th, and 12th weeks than in control group. Salbutamol decreased the feed conversion during the 4th week and increased it during 6th week than in the control. Feed conversion ratio was higher during 4th and 9th weeks and lower during 10th and 12th weeks in bovine somatotropin injected group than salbutamol supplied group.

Bovine somatotropin administration and salbutamol supplementation increased the overall means of the feed efficiency and there was no difference between them (Table 2). The changes in the feed efficiency were time dependent. Regarding the effect of bovine somatotropin, the feed efficiency was higher than those of the control during the 1st, 3rd, and 4th weeks, decreased during 6th week and then increased during 10th and 12th weeks. Salbutamol increased the feed efficiency during the 2nd, 3rd, and 4th weeks and decreased it during the 6th week than in control group. The difference between bovine somatotropin and salbutamol groups was statistically significant during 1st, 4th, 6th and 12th weeks

B- Carcass traits and carcass-related plasma metabolites:

Carcass traits and carcass-related plasma metabolites were presented in table (3). Preslaughter and carcass weights exhibited no statistical significant

difference among the control and the treated groups. Dressing percentage in salbutamol supplemented group was higher than those of control and bovine somatotropin injected groups and the difference between the last-two groups was insig-

Table (1): Effect of recombinant bovine growth hormone administration and salbutamol supplementation on average daily feed intake and average daily live body gain of male Newzeland rabbits. (n=8).

Weeks	Average daily feed intake (g/day)			Average dailylive body gain (g/day)		
	Control	bST	Salbutamol	Control	bST	Salbutamol
1	103.02 ±2.4	98.94 ±2.8	91.34 ±4.1	50.34 ±2.5	53.09 ±4.3	45.50 ±1.5
2	109.54 ±1.7	110.49 ±1.7	97.10 ±3.9	29.02 ±2.1	31.91 ±1.2	28.79 ±1.6
3	116.50 ±3.7	115.82 ±4.1	101.89 ±4.5	24.52 ±0.9	30.60 ±2.4	24.91 ±1.4
4	117.54 ±6.4	120.30 ±6.7	105.97 ±1.7	12.84 ±1.3	20.41 ±1.9	22.40 ±0.6
5	107.27 ±3.3	112.17 ±4.4	102.44 ±4.8	24.22 ±1.3	24.87 ±2.2	25.94 ±2.4
6	106.52 ±2.9	121.96 ±5.0	103.00 ±2.9	22.17 ±0.8	20.72 ±1.5	13.91 ±0.5
7	112.14 ±2.1	116.80 ±5.6	88.54 ±6.5	15.55 ±0.9	16.32 ±0.9	14.52 ±1.1
8	122.29 ±2.6	134.14 ±3.6	106.90 ±3.8	15.94 ±0.8	17.44 ±0.7	16.30 ±0.9
9	128.67 ±3.2	148.04 ±2.5	100.10 ±2.7	15.31 ±0.6	13.94 ±1.3	12.14 ±1.0
10	138.00 ±5.6	142.49 ±3.1	117.14 ±4.0	13.20 ±0.9	22.61 ±1.4	14.51 ±1.1
11	129.69 ±7.1	138.81 ±3.8	114.64 ±4.5	15.00 ±1.0	13.44 ±0.8	12.46 ±0.7
12	133.87 ±6.7	136.50 ±2.1	116.71 ±3.6	11.44 ±0.7	18.09 ±0.6	10.37 ±0.7
13	134.82 ±5.2	144.69 ±4.7	120.41 ±4.6	11.14 ±0.7	11.42 ±0.8	9.56 ±0.4
Overall mean	$119.99^{a,b}$ ±1.6	$126.24^{a,c}$ ±1.8	$105.09^{b,c}$ ±1.4	20.05^{a} ±1.1	$22.68^{a,b}$ ±1.1	19.33^{b} ±1.0
LSD	3.37			1.11		

* There was no significant treatment x time interaction of average daily feed intake.
* LSD of treatement x time interaction of average daily live body gain=3.99.
* Values having the same letter in the row are significantly different at P<0.05.

Table (2): Effect of recombinant bovine growth hormone administration and salbutamol supplementation on feed conversion ratio and feed efficiency of male Newzeland rabbits. (n=8).

Weeks	Feed Conversion Ratio			Feed Efficiency		
	Control	bST	Salbutamol	Control	bST	Salbutamol
1	2.07 ±0.09	1.94 ±0.20	2.01 ±0.05	0.488 ±0.021	0.538 ±0.039	0.500 ±0.012
2	3.91 ±0.30	3.49 ±0.10	3.45 ±0.20	0.263 ±0.020	0.289 ±0.009	0.300 ±0.021
3	4.77 ±0.10	3.88 ±0.20	4.14 ±0.20	0.211 ±0.007	0.261 ±0.010	0.245 ±0.011
4	9.55 ±0.80	6.23 ±0.60	4.74 ±0.10	0.109 ±0.008	0.171 ±0.015	0.211 ±0.004
5	4.47 ±0.10	4.68 ±0.30	4.09 ±0.30	0.225 ±0.006	0.220 ±0.013	0.251 ±0.015
6	4.87 ±0.20	6.09 ±0.50	7.43 ±0.10	0.209 ±0.011	0.170 ±0.010	0.135 ±0.003
7	7.39 ±0.50	7.20 ±0.10	6.27 ±0.60	0.139 ±0.008	0.139 ±0.002	0.169 ±0.015
8	7.82 ±0.40	7.80 ±0.50	6.68 ±0.40	0.131 ±0.007	0.1331 ±0.007	0.153 ±0.009
9	8.52 ±0.40	11.12 ±0.90	8.21 ±0.80	0.120 ±0.007	0.094 ±0.007	0.121 ±0.009
10	9.61 ±0.60	6.43 ±0.30	8.48 ±0.80	0.096 ±0.007	0.159 ±0.008	0.125 ±0.011
11	8.78 ±0.50	10.72 ±0.9	9.37 ±0.50	0.116 ±0.006	0.097 ±0.007	0.108 ±0.005
12	11.99 ±0.80	7.60 ±0.20	11.62 ±0.80	0.086 ±0.007	0.132 ±0.004	0.089 ±0.006
13	12.63 ±1.20	12.90 ±0.60	12.63 ±0.20	0.084 ±0.008	0.079 ±0.004	0.079 ±0.001
Overall mean	$7.51^{a,b}$ ±0.35	6.93^{a} ±0.33	6.89^{b} ±0.33	$0.175^{a,b}$ ±0.010	0.191^{a} ±0.012	0.191^{b} ±0.011
LSD	0.4			0.009		

* LSD treatments x time itneraction of feed conversion ratio=1.44.
* LSD treatments x time interaction of feed efficiency = 0.032.
* Values having the same letter in the row are significantly different at P 0.05.

Table (3): Effect of recombinant bovine growth hormone administration and salbutamol supplementation on carcass traits and carcass-related plasma male Newzeland rabbits. (n=8).

Observation	Control	bST	Salbutamol	LSD (P<0.05)
Preslaughter weight (g)	2977±67.3	3165±126.4	2914±116.7	--
Carcass weight (g)	1630±44.6	1715±80.8	1659±70.9	--
Dressing %	54.71^{a}±0.51	54.07^{b}±0.85	$56.87^{a,b}$±0.42	1.82
Collective weight of MNCC	1008.37^{a}±23.2	$1103.75^{a,b}$±25.5	974.00^{b}±33.3	81.03
Head weight (g)	238.25±9.5	260.00±8.4	246.00±8.8	--
Fleece & feet weight (g)	431±15.4	463^{a}±10.9	400^{a}±13.2	38.92
GIT weights (g)	333.0^{a}±5.6	$392.0^{a,b}$±10.9	313.9^{b}±13.9	31.4
Muscle Protein (mg/g)	398.80^{a}±5.40	388.19^{b}±8.20	$425.92^{a,b}$±11.85	25.99
Muscle lipid (mg/g)	$35.30^{a,b}$±1.96	$24.72^{a,c}$±1.90	$13.31^{b,c}$±0.50	4.72
Muscle protein/fat ratio	$11.61^{a,b}$±0.5	$18.40^{a,c}$±1.8	$27.30^{b,c}$±1.3	3.5
Plasma urea (mg/dl)	$47.1^{a,b}$±2.2	$25.5^{a,c}$±1.6	$11.8^{b,c}$±0.7	4.8
Palsma creatinine (mgdl)	1.02^{a}±0.03	0.94^{b}±0.07	$1.48^{a,b}$±0.12	0.23

* Values having the same letter in the row are significantly different at P<0.05.
* MNCC = major non-carcas components.
* GIT = gastrointestinal tract

nificant.

Collective weights of major non-carcass components (MNCCs) in salbutamol-fed group were significantly lower than those of bovine somatotropin and control groups and were higher in bovine somatotropin group than those of control. Results showed that there were no differences among the three groups in the head weight. The fleece and feet weights of bovine somatotropin treated group were high than those of salbutamol-fed group. Gastrointestinal tract weights of the bovine somatotropin injected group were high than those of control and salbutamol-fed groups, however, the difference between the last two groups was insignificant.

Longissimus muscle protein concentration in salbutamol-fed group was higher than that of bovine somatotropin and control groups and there was no difference between the last two groups. Total lipid concentrations of longissimus muscle of bovine somatotropin injected and salbutamol-fed groups

Table (4): Effect of recombinant bovine growth hormone administration and salbutamol supplementation on biosafety-related parameters in male Newzeland rabbits. (n=8).

Parameter	Control	bST	Salbutamol	LSD (P<0.05)
ALT (U/L)	98.9±6.0	99.2±7.4	111.1±9.2	--
AST (U/L)	115.5±1.4	105.6±6.2	106.0±3.9	--
ALP (U/L)	62.0±2.1	58.5±4.5	56.4±5.1	--
Plasma total proteins (g/dl)	7.0±0.21	7.1±0.33	7.3±0.27	--
Plasma albumin (g/dl)	3.7±0.23	4.2±0.12	4.1±0.18	--
Sodium (meq/l)	164.00±4.7	169.29±2.6	158.20±4.1	--
Potassium (meq/l)	6.3^{a}±0.44	$7.8^{a,b}$±0.16	6.3^{b}±0.08	0.6
Chloride (meq/l)	102.6±3.5	111.7±3.8	106.2±2.4	--
Total calcium (mg/dl)	14.0±0.64	12.6±0.86	12.3±0.73	--
Free calcium (mg/dl)	6.3±0.3	5.5±0.4	5.4±0.3	--
Inorganic phosphorus (mg/dl)	4.2±0.3	4.2±0.09	4.9±0.19	--
Glucose (mg/dl)	136.0±8.6	126.0±6.1	124.6±1.8	--

* Values having the same letter in the row are significantly different at P<0.05.

were lower than that of control group. Moreover, the reducing effect of salbutamol was stronger than that of bovine somatotropin.

Both treatments increased longissimus muscle protein/fat ratio when compared with control and the increment effect of salbutamol was higher than that of bovine somatotropin.

Bovine somatotropin and salbutamol treatments decreased plasma urea concentration and the reducing effect of salbutamol was higher than that of bovine somatotropin. Plasma creatinine concentration of salbutamol-fed group was higher than that of control and bovine somatotropin groups. However, bovine somatotropin didn't alter significantly creatinine concentration.

C-Biosafety-related plasma metabolites:

Data of biosafety-related plasma metabolites were recorded in table (4). There were no significant changes in alanine aminotransferase, plasma aspartate aminotransferase and plasma alkaline phosphatase activities among control and the treated groups. Plasma total proteins and plasma albumin concentration did not change among the three groups. there were no significant differences

among the three groups in their plasma sodium, chloride, total and ionized calcium and plasma inorganic phosphorus concentrations. The plasma potassium concentration in bovine somatotropin treated group was high than those of control and salbutamol-fed groups and there was no difference between the last two groups. Plasma glucose concentration didn't differ significantly among control, bovine somatotropin-injected and salbutamol-fed groups.

DISCUSSION

The future of the animal production industry depends on the efficient production of wholesome, palatable, nutritious meat that is free of excess fat. Therefore, increased profits from livestock production may be realized by increasing daily live weight gain and/ or feed efficiency.

Bovine somatotropin increased feed intake in the present study. The influence of bovine somatotropin on feed intake in animals varies, fluctuating from an increase (Sandles and Peel, 1987), only marginal increase (Johnsson et al., 1985) to a decrease (Dalke et al., 1992). On the other side, the reduction in feed intake recorded in the present investigation due to salbutamol supplementation is in accordance with the influence of clenbuterol in steers (Ricks et al., 1984). Conversely, cimaterol in rabbits increased food intake (Forsberg et al., 1989). The reduced feed intake by β-adrenergic agonists may be explained on the basis that the nervous control of food intake is adrenergically coded (Ordway et al., 1987).

In the current study, bovine somatotropin and salbutamol caused an overall improvement in the feed efficiency (9.1% for each). These findings are consistent with that for growth hormone (Dalke et al., 1992) and β-adrenergic agonists (Pringle et al., 1994). It is apparent that each one exerted its effect in a completely different way; while bovine somatotropin increased feed efficiency might be via increasing body gain, salbutamol exerted its effect via repartioning effect (Reeds and Mersmann, 1991), since salbutamol decreased feed intake while body gain was similar to that of control.

The improvement effect of the investigated promoters on feed efficiency was early for salbutamol, being so pronounced in 4th week, conversely, the improving impact of bovine somatotropin extended for longer duration. This transitory nature of the anabolic response of β-adrenergic agonist was also reported in cimaterol fed steers (Chikhou et al., 1993a). This transitory nature of chronic β-adrenergic agonist on feed efficiency may be due to a decrease in cell responsiveness with either receptor phosphorylation (Mersmann, 1998), or removal of β -adrenergic receptor from

plasma membrane (Kobilka and Hoffman, 1995).

The current study demonstrated that both bovine somatotropin and salbutamol, have anabolic activities as exhibited by reduced plasma urea levels, because plasma urea level indirectly measures the extent to which amino acids are oxidized as opposed to those deposited in body protein (Krick et al., 992). The reducing effect of bovine somatotropin on plasma urea level in the current study is in agreement with the effect of somatotropin in steers (Preston et al., 1995), lambs (Mclaughlin et al., 1993). The reducing effect of somatotropin on plasma urea level may be due to increased tissue uptake, decreased rates of mobilization and / or decreased hepatic catabolism of amino acids. Regarding salbutamol decrement effect on plasma urea level, its effect agrees with that of clenbuterol in cattle (Sillence et al., 1993), and cimaterol-supplemented steers (Quirke et al., 1988). Conversely, cimaterol in steers (Chikhou et al., 1993a) and L- 644,969 in rabbits (Pringle et al., 1994) didn't change plasma urea levels.

The reported visceral effect of somatotropin is in agreement with the observations found in somatotropin treated lambs (Johnsson et al., 1985; Johnsson et al., 1987). It is noteworthy that bovine somatotropin failed to exert any effect on the muscle size and composition. This failure at the biochemical level is reflected at gross level by no change in the dressing percentage of somatotropin-treated group. the lack of the effect of somatotropin in the current study on longissimus muscle protein concentration is in agreement with that of bST-administered steers (Eisemann et al., 1989). The absence of change in plasma creatinine concentration in the present investigation seems to be in accordance with that in rbST-treated steers (Enright et al., 1990). On the contrary, Early et al. (1990a) reported a reduction in blood creatinine in rbST-treated steers.

Salbutamol's anabolic activity is restricted to skeletal muscle. This is emphasized by the findings of increased dressing percentage, increased longissimus muscle protein concentration and increased plasma creatinine concentration, in addition to the reduction in non-carcass component especially gastrointestinal tract. The observed increase in longissimus muscle protein concentration due to salbutamol in this study agree with the findings of L-644,969-fed wether lambs (Pringle et al., 1993) and cimaterol-supplemented steers (Chikhou et al., 1993b). Moreover, the increase in creatinine concentration in the current study is consistent with the finding of Quirke et al. (1988) and Chikhou et al. (1993a) in cimaterol-fed steers. The myotropic effect of salbutamol might be achieved via increase in protein biosynthesis as indicated by a decrease in plasma urea concentration in the current study and / or decrease in protein degradation as recorded by inhibition of muscle proteoly-

sis in lamb (del Barrio et al., 1995).

Salbutamol feeding reduced non-carcass mass in this study. Generally, the weight gain of the liver, kidney, intestinal tract, and skin seems to be reduced by β-adrenergic agonist treatment (Reeds and Mersmann, 1991).

Biosafety of the investigated promoters was carried out and it is apparent that both promoters, bovine somatotropin and salbutamol, have insignificant effects on liver enzymes (ALT, AST and ALP), plasma electrolytes (sodium and chloride) and minerals (plasma total and free calcium and inorganic phosphorus). The recorded increase in plasma potassium concentration in bovine somatotropin treated rabbits in the current study may be due to the increase in food intake (Meyer et al., 1992).

Regarding the liver, the biochemical findings specially the absence of any change in the enzymatic activities measured indicate the absence of hepatocellular effect of the administered promoters.

Blood glucose level didn't change in both promoters. The effect of bovine somatotropin on blood glucose in the current finding is in agreement with those in cattle (Enright et al., 1990). However, other studies reported an increase in blood glucose level due to administration of bST in cattle (Wagner et al., 1988), lambs (Mclaughlin et al., 1993). On the other side, the lack of salbutamol's effect on blood glucose in the current study is in accordance with the findings of cimaterol-fed wether lambs (Beermann et al., 1987), and clenbuterol supplemented steers (Ricksct al., 1984). Indeed, β-agonists treatments for long period are extremely potent anti-hyperglycemic agents. The antihyperglycemic response was explained in part by increase in insulin secretion (Yang and McElligott, 1989).

In conclusion, Growth promoters; bovine somatotropin or salbutamol are economic, profitable and safe for animals and could be used for increasing feed efficiency and protein accretion and decreasing fat deposition.

REFERENCES

Baker, P. K.; Dalrymple, R. H.; Ingle, D. L. and Ricks, C. A. C. (1984): Use of a B-adrenergic agonist to alter muscle and fat deposition in lambs. J. Anim. Sci., 59: 1256.

Beermann, D. H.; Butler, W. R.; Hogue, D. E.; Fishell, V. K.; Dalrymple, R. H.; Ricks, C. A.; and Scanes, C. G. (1987): Cimaterol induced muscle hypertrophy and altered endocrine status in lambs. J. Anim. Sci., 65: 1514.

Beermann, D. H.; Hogue, D. E.; Fishell, V. K.; Aronica, S.; Dickson, H. W. and Schricker, B. R. (1990): Exogenous human growth hormone-releasing factor and ovine somatotropin improve growth performance and composition of gain in lambs. J. Anim. Sci., 68: 4122.

Bell, A. W.; Bauman, D. E.; Beermann, D. H. and Harrell, R. J. C. (1998): Nutrition, development and efficacy of growth modifiers in livestock species. J. Nutr., 128: 3605.

Chikhou, F. H.; Moloney, A. P.; Allen, P.; Quirke, J. F.; Austin, F. H. and Roche, J. F. (1993a): Long-term effects of cimaterol in Friesian steers: I- growth, feed efficiency, and selected carcass traits. J. Anim. Sci., 71:906.

Chikhou, F. H.; Moloney, A. P.; Allen, P.; Quirke, J. F.; Austin, F. H. and Roche, J. F. (1993b): Long-term effects of cimaterol in Friesian steers: II- carcass composition and meat quality. J. Anim. Sci., 71: 914.

Dalke, B. S.; Roeder, R. A.; Kasser, T. R.; Veen Huizen, J. J.; Hunt, C. W.; Hinman, D. D. and Schelling, G.T. (1992): Dose response effects of recombinant bovine somatotropin implants on feedlot performance in steers. J. Anim. Sci., 70: 2130.

Dawson, J. M.; Buttery, P. J.; Lammimann, M. J.; Soar, J. B.; Essex, C. P.; Gill , M. and Beever, D. E. (1991): Nutritional and endocrinological manipulation of lean deposition in forage-fed steers. Br. J. Nutr., 66: 171.

del Barrio, A. S.; Garcia-Calonge, M. A.; Fermandez-Quintela, A.; Simon, E.; Partillo, M. P.; Adtiasaran, I.; and Martinez, J. A. (1995): Effect of the beta-adrenergic agonist salbutamol and its withdrawal on protein metabolism of lambs. Ann. Nutr. Metab., 39: 317.

Drupt, F. (1974): Determination of albumin. Pharm. Biol., 9: 777.

Early, R. J.; McBride, B. W. and Ball, E. O. (1990a): Growth and metabolism in somatotropin-treated steers: I-Growth, serum chemistry and carcass weights. J. Anim. Sci., 68: 4134.

Early, R. J.; McBride, B. W. and Ball, R. O. (1990b): Growth and metabolism in somatotropin-treated steers: II-Carcass and noncarass tissue components and chemical composition. J. Anim. Sci., 68: 4144.

Eisemann, J. H.; Hammond, A. C.; Rumsey, T. S. and Bauman, D. E. (1989): Nitrogen and protein metabolism and metabolites in plasma and urine of beef steers treated with somatotropin. J. Anim. Sci., 67: 105.

Eisen, E. J.; Croom, W. J. and Helton, S. W. (1988): Differential response to the β-adrenergic agonist cimaterol in mice selected for rapid gain and unselected control. J. Anim. Sci., 66: 361.

Elasser, T. H.; Rumsey, T. S.; Kahl, S.; Czerwinski, S. M.; Moseley, W. M.; Ono, Y.; Solomon, M. B.; Harris, F. and Fagan, J. M. (1998): Effect of synovex-s and recombinant bovine growth hormone (somavubove) on growth responses of steers: III-muscle growth and protein responses. J. Anim. Sci., 76: 2346.

Enright, W. J.; Ourike, J. F.; Gluckman, P. D.; Breier, B. H.; Kennedy, L. G.; Hart, I. C.; Roche, J. F.; Coert, A. and Allen, P. (1990): Effects of long-term administration of pituitary-derived bovine growth hormone and estradiol on growth in steers. J. Anim. Sci., 68: 2345.

Etherton, T. D. and Bauman, D. E. (1998): Biology of somatotropin in growth and lactation of domestic animals. Physiol. Rev., 78: 745.

Fawcett, J. K. and Scott, J. E. (1960): Determination of urea. J. Clin. Pathol., 13: 156.

Folch, J.; Less, M. and Sloane-Stanely, G. H. (1957): A simple method for the isolation and purification of total lipids from animal tissues. J. Biol. Chem., 226: 497.

Forsberg, N. E.; Mian, M. A.; Ali-Bar, A.; Cheeke, P. R. and Wehr, N. B. (1989): Effects of cimaterol on rabbit growth and myofibrillar protein degradation and on calcium-dependent proteinase and calpastatin activities in skeletal muscle. J. Anim. Sci., 67: 3313.

Frings, C. S. and Dunn, R. T. (1970): Colorimetric determination of total lipid. Am. J. Clin. Path., 53: 89.

Goodwin, J. F. (1970): Direct method for determination of inorganic phosphorus. Clin. Chem., 16: 776.

Hayden, J. M.; Bergen, W. G. and Merkel, R. A. (1992): Skeletal muscle protein metabolism and serum growth hormone, insulin and cortisol concentrations in growing steers implanted with estradiol-17, trenbolone acetate, or estradiol-17β plus trenbolone-acetate. J. Anim. Sci., 70: 2109.

Henry, R. (1964): Clinical Cheimistry, Principals and Technics. Harper Row, Nw York.

Hoffman, W.S. (1966): The Biochemistry Of Clinical Medicine (3rd ed.). Yearbook Medical Publishers, Chicago.

Houot, O. (1985): Kinetic determination of creatinine. In: Interpretation Of Clinical Laboratory Tests. Henny, J.; Siest, G.; Schiele, F. and Young, D.S. (eds.). Biomedical Publications.

Johnson, B. J.; Anderson, P. T.; Meiske, J. C. and Dayton, W. R. (1996): Effect of a combined trenbolone acetate and estradiol implant on feedlot performance, carcass characteristics, and carcass composition of feedlot steers. J. Anim. Sci., 74: 363.

Johnsson, I. D.; Hart, I. C. and Butler-Hogg, B. W. (1985): The effects of exogenous bovine growth hormone and bromocriptine on growth, body development, fleece weight and plasma concentrations of growth hormone, insulin and prolactin in female lambs. Anim. Prod., 41: 207.

Johnsson, I. D.; Hathron, D. J.; Wilde, R. M.; Treacher, T. T. and Butler-Hogg, B. W. (1987): The effects of dose and method of administration of biosynthetic bovine somatotropin on live weight gain, carcass composition and wool growth in young lambs. Anim. Prod., 44: 405.

Kobilka, B. and Hoffman, B. B. (1995): Molecular characterization and regulation of adrenergic receptors. In: Laragh, J. H. and Brenner, B. M. (eds.), Hypertension: Pathophysiology, Diagnosis And Management, Raven Press, New York.

Krick, B. J.; Roneker, K. R.; Boyd, R. D.; Beermann, D. H.; David, P. J. and Meisinger, D. J. (1992): Influence of genotype and sex on the response of growing pigs to recombinant porcine somatotropin. J. Anim. Sci., 70: 3024.

Lowry, O. H.; Rosebnough, N. J.; Farr, A. L. and Randall, R. J. (1951): Protein measurement with the folin phenol reagent. J. Biol. Chem., 193: 265.

Mclaughlin, C. L.; Hedrick, H. B.; Veenhuizen, J. J.; Finn, R. F.; Hintz, R. L.; Hatmell, G. F.; Kasser, T. R. and Baile, C. A. (1993): Comparison of performance, clinical chemistry, and carcass characteristics of finishing lambs treated with recombinant ovine or bovine somatotropins. J. Anim. Sci., 71: 1453.

Mersmann, H. J. (1998): Overview of the effects of β-adrenergic receptor agonists on animal growth including mechanisms of action. J. Anim. Sci., 76: 160.

Meyer, D. J.; Coles, E. H. and Rich, L. J. (1992): Electrolytes, acid-base homeostasis and disturbances. In: Mills,

L (ed.), Veterinary Laboratory Medicine, Interpretation and Diagnosis. W.B. Saunders Company, Philadelphia.

Miller, M. F.; Gario, D. K.; Coleman, M. E.; Ekeren, P. A.; Lunt, D. K.; Wagner, K. A.; Procknor, M.; Welsh, Jr, T. H. and Smith, S. B. (1988): Adipose tissue, longissimus muscle, and anterior pituitary growth and function in clenbuterol-fed heifers. J. Anim. Sci., 66: 12.

Moder, T. L.; Clanton, D. C.; Ward, J. K.; Pankaskie, D. E. and Deutscher, G. H. (1985): Effect of pre- and post-weaning zeranol implant on steer calf performance. J. Anim. Sci., 61: 546.

Moloney, A. P.; Allen, P.; Ross, D. B.; Oslon, G. and Convey, E. M. (1990): Growth, feed efficiency and carcass composition of finishing Friesian steers fed the β-adrenergic agonist L644, 969. J. Anim. Sci., 68:1269.

O'conner, R. M.; Butler, W. R.; Houge, D. E.; and Beermann, D. H. (1991): Temporal pattern of skeletal muscle changes in lambs fed cimaterol. Domest. Anim. Endocrinol., 8: 549.

Ordway, G. A.; O'Donnell, J. M. and Frazer, A. (1987): Effects of clenbuterol on central beta-1 and beta-2 adrenergic receptors of the rat. J. Pharmacol. Exp. Ther., 241: 187.

Preston, R. L.; Bartle, S. J.; Kasser, T. R.; Day, J. W.; Veenhuizen, J. J. and Baile, C. A. (1995): Comparative effectiveness of somatotropin and anabolic steroids in feedlot steers. J. Anim. Sci., 73: 1038.

Pringle, T. D.; Calkins, C. R.; Koohmaraie, M. and Jones, S. J. (1993): Effects over time of feeding a β-adrenergic agonist to wether lambs on animal performance, muscle growth, endogenous muscle proteinase activities and meat tenderness. J. Anim. Sci., 71: 636.

Pringle, T. D.; Lonergan, S. M.; Calkins, C. R.; Jones, S. J.; Miller, P. S.; and Koohmaraie, M. (1994):Temporal response of rabbits to β-adrenergic agonist feeding: tissue weight, calins and calpastatin activities, and nucleic acid and protein concentrations. J. Anim. Sci., 72: 68.

Puerro, M. and Alexandre, M. A. (1995): Induction of acute hypocalcemia in rat. Veterinary and Human Toxicol., 37: 116.

Quirke, J. F.; Allen, P.; Moloney, A. P.; Sommer, M.; Hannahan, J. P.; Sheehan, W. and Roche, J. F. (1988): Effects of the beta agonist cimaterol on blood metabolite and hormone concentrations, growth and carcass composition in finishing Friesian steers. J. Anim. Physiol. Anim. Nutr., 60: 128.

Ratliff, C. R. and Hall, F. F. (1973):"Laboratory Manual Of Clinical Biochemistry" Vol. 1. Scott And White Memorial Hospital Publications Office, Temple, Texas.

Reeds, P. J. and Mersmann, H. J. (1991):Protein and energy requirements of animal treated with β-adrenergic agonists: A discussion. J. Anim. Sci., 69: 1532.

Reitman, S. and Frankle, F. (1957): A colorimetric method of the determination of serum glutamic oxalacetic and glutamic pyruvic transaminases. Am. J. Clin. Pathol., 28: 56.

Ricks, C. A.; Dalrymple, R. H.; Baker, P. K. and Imgle, D. L. (1984): Use of B-agonists to alter fat and muscle deposition in steers. J. Anim. Sci., 59: 1247.

Rumsey, T. S.; Elasser, T. H.; Kahl, S.; Moseley, W. and Solomon, M. B. (1996): Effects of synovex-s and recombinant bovine growth hormone (somavubove) on growth response in steers: 1-performance and composi-

tion of gain. J. Anim. Sci., 74:2917.

Sainz, R. D. and Wolff, J. E. (1988): Mechanisms of actions of repartioning agents: qualitative and dynamic evaluation of alternative hypotheses. Proceedings Of The 2nd International Symposium On The Nutrition Of Herbivores. Brisbane Australian Society of Animal Production.

Sandles, L. D. and Peel, C. J. (1987): Growth and carcass composition of pre- pubertal dairy heifers treated with bovine growth hormone. Anim. Prod., 44: 21.

Sillence, M. N. and Etherton, T. D. (1991): Cortisone arrests growth but enhances the inductive effect of porcine growth hormone on plasma IGF-1 concentrations in female rats. J. Anim. Sci., 69: 2815.

Sillence, M. N.; Hunter, R. A.; Pegg, G. G.; Brown, L.; Mathews, M. L.; Mayner, T.; Sleeman, M. and Lindsay, D. B. (1993):Growth, nitrogen metabolism, and cardiac responses to clenbuterol and ketoclenbuterol in rats and underfed cattle. J. Anim. Sci., 71: 2942.

Sinnett-Smith, P. A.; Williams, J. A.; Warris, P. D. and Enser, M. (1989): Effects of recombinant DN-derived bovine somatotropin on growth, carcass characteristics and meat quality in lambs from three breeds. Anim. Prod., 49: 281.

Skeggs, L. T. and Hochstrasser, H. C. (1964): Determination of chloride by thiocynate method. Clin. Chem., 10:918.

Snedecor, G. W. and Cochran, W. G. (1980): Statistical Methods. 7th ed., Ames: Iowa State University Press.

Tietz, N. W. (1970):\tab Fundamentals Of Clinical Chemistry. W.B. Saunders, Philadelphia.

Varely, H. (1976):Practical Clinical Biochemistry (4th ed.). Arnold-Heinemann, New Delhi.

Wagner, J. F.; Anderson, D. B.; Johnsm, P. and Mowrey, D. (1988): Effect of growth hormone (GH) and estradiol (E2β) alone and in combination on beef steer growth performance, carcass and plasma constituents. J. Anim. Sci., 66 (suppl.1): 283 (Abstr.).

Yang, Y. T. and McElligott, M. A. (1989): Multiple actions of β -adrenergic agonists on skeletal muscle and adipose tissue. Biochem. J., 261: 1.