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EFFECT OF EXOGENOUS BOVINE SOMATOTROPIN (rbST) ON GROWTH IN KUNDHI BUFFALO CALVES

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ABSTRACT

Recombinant Bovine somatotropin (rbST) is one of the hormones potentially used as a growth promoter in feedlot animals. Present study was conducted on twelve male Kundhi buffalo calves maintained at Livestock experiment station, Faculty of Animal Husbandry and Veterinary Sciences, Sindh Agriculture University Tandojam to evaluate rbST effect on growth. The Calves were randomly divided into three groups i.e. A, B and C, each having four calves (n=4). Group A was kept as control, while group B and C were treated with rbST @ 0.5 mg and 1.0 mg/kg BW fortnightly respectively. The calves were given fattening ration ad libitum for two weeks as adaptation period and eleven weeks for treatment period. The parameters studied were body weight, feed intake, average daily gain (ADG), dry matter intake (DMI) and feed efficiency (FCR). Body weight increased significantly ($P<0.05$) in group C, followed by group B and A. Feed intake recorded showed significant difference ($P<0.05$) between rbST treated groups and control group. ADG was significantly increased ($P<0.05$) in group C and B compared to control group. DMI was recorded also showed significant difference ($P<0.05$) between rbST treated groups and control group. FCR was significantly improved ($P<0.05$) in group C and B compared to control group but the difference was non-significant between group B and C. The calves in group C and B were economically better as compared to control group. So, it has been concluded that rbST treatment is better and remarkably effective for increasing the performance of young calves in terms of body weight gain, feed intake and FCR. A dose of 1.0 mg/kg BW is more effective and better in promoting the performance of calves as compared to a dose of 0.5 mg/kg BW.

Keywords: Fattening ration, Feed conversion ratio, Hormone, Somatotropin.

1. INTRODUCTION

Meat is an important source of protein of animal origin. Pakistan stands at 7th position in meat production in the world with 125 million heads of livestock (Anonymous 2006). Buffalo meat has an important share in the total world meat. Out of 269148.5 thousand tons of total world meat, 3322.2 thousand tons comes from buffalo (Pasha and Hayat 2012). A Swamp buffalo with 592 kg average live weight yields 277 kg carcass and 215 kg meat (Thu et al. 1995). The population of human beings in the world is increasing day by day at the rate of 3% annually (Bilal et al. 2006), exerting a lot of pressure on the beef industry to produce large quantities of qualitative, healthier and lean meat. The world's dependence on beef and beef products has created a problem that could grow to cripple the beef industry. Pakistan is deficient in animal proteins to feed large human population, which at present is estimated as 139.02 million heads.

According to international recommendations, the per capita consumption of proteins should be 60.00 gm, out of which 27.40 gm should come from animal source. The per capita availability of animal proteins as reported by Ahmad et al. (2004) was only 17.40 gm and still there is shortage of 10.0 gm for human consumption. To meet the ever increasing meat demand inside the country there is need to boost up the beef industry. In addition, we can earn a handful foreign exchange by exporting buffalo meat as it is free from the worries of mad cow disease (Bovine spongiform encephalopathy (BSE)) and therefore may be recommended for export to the Gulf countries, as the Gulf countries have banned the import of the European beef because of the contamination with the BSE (Bilal et al. 2006).

The ever increasing demand for animal protein has emphasized livestock researchers to concentrate on doing studies on increasing growth and production of livestock through scientific feeding and application of growth promoters. In recent years, extensive efforts have been focused on the possible use of several natural and synthetic hormones as growth promoting agents (growth promoters) to efficiently produce leaner meat (Schlegel et al. 2006). They are given to livestock either as implants or injections or supplementation in the diet. The most extensively applied growth promoters are anabolic implants (both androgenic and estrogenic), bovine somatotropin, and ionophores (Song and Choi, 2001).

Bovine somatotropin (bST), also called bovine growth hormone (bGH) is a naturally occurring proteinous hormone secreted by somatotrophs of anterior pituitary gland, resulting in long term stimulation of growth as well as a number of short term metabolic effects. It promotes physical growth, cell division and muscle building in humans and animals. Most growth hormones in modern medicine are cloned, using recombinant DNA technology. These were developed to treat dwarfism, but have now become widely used to promote weight gain and muscle growth (Hulme 2011).

Exogenous bovine somatotropin, also known as recombinant bovine somatotropin (rbST) is a synthetically derived hormone that may be identical to naturally occurring bovine somatotropin or slightly modified by the addition of extra amino acids. As for other peptide hormones, the initial step of rbST action involves binding with receptors on target tissues. GH receptors have been described on several cell types, e.g. hepatocytes, adipocytes, lymphocytes, macrophages, fibroblasts, chondrocytes, ß islet cells and osteoblasts (Burton et al. 1994). It stimulates production of insulin-like growth factor-I (IGF-I) by the liver, which in turn stimulates the Osteoblast and Chondrocyte to promote bone growth. It increases calcium retention and strengthens and increases the mineralization of bone. It increases muscle mass through the creation of new muscle cells and it also promotes lipolysis, which results in the reduction of adipose tissue (Baumann 1992). Treatment with exogenous bovine somatotropin increases dry matter intake (DMI), improves average daily gain (ADG) and feed utilization in goats (Puchala et al. 2001) and cattle (Hulme 2011; Velauyudhan 2007; Schlegel et al. 2006; Govoni et al. 2004; Song and Choi 2001).

In almost all advanced countries rbST is not only used for enhancing milk production but also used as a growth promoter to boost the beef industry. In Pakistan rbST has largely been used in lactating animals to increase milk production and a very little attention has been given on its use as a growth promoter in young animals. Moreover, no comprehensive studies have been reported on effects of rbST on growth performance in buffalo calves. The present study is therefore designed to see the effects of rbST on growth performance of Kundhi buffalo calves fed fattening ration.

2. MATERIALS AND METHODS

2.1 Experimental Animals

A total of twelve clinically healthy male Kundhi buffalo calves approximately 4 to 6 months of age, having an average body weight of 60 kg were randomly selected for study conducted at Livestock Experiment Station (LES), Faculty of Animal Husbandry and Veterinary Sciences, Sindh Agriculture University, Tandojam. The animals were kept on same plane of nutrition and management as a single group until completion of the study. The entire period of the study was divided into: (1) adaptation period and (2) treatment period.

(a) Adaptation Period

Before commencement of the study, the calves were allowed for at least two weeks adaptation period to acclimatize themselves to nutritious feed (basal diet) and environment. During adaptation period the calves were ear tagged for identification, drenched (Deworming) with Albenzole (Albendazole) and injected subcutaneously with Ivermectin against helminths and other parasitic infestations, vaccinated against some common infectious diseases such as FMD, Anthrax and HS. The calves were also examined physically for any abnormality. The purpose of the adaptation period was to allow the calves to develop a taste for such feed gradually.

(b) Treatment Period

After a 2 weeks adaptation period, the treatment of rbST and fattening ration was started to calves according to the experimental design up to 3 months (completion of the study).The calves were fed with well balance fattening ration consisting of concentrate mixture, wheat straw and leguminous green fodder and injected rbST intramuscularly fortnightly for a period of three months.

(c) Housing Of Experimental Animals

The calves were housed in pens with free access to water. They were provided sufficient housing space and open space for exercise. All the calves were protected from severe cold through curtains especially during night time. Health record for each calf was maintained throughout the treatment period.

(d) Feeding Management

An economic experimental fattening ration (concentrate mixture) having maize crush and wheat bran as major energy ingredients was formulated (Table #1) as described by Sharma et al. (1995) and Pirzado et al. (2010-11). The chemical composition and nutritive values of components of feed ingredients such as Fats, Crude Protein, TDN, Crude Fiber and Ash of the ration were determined as per standard methods described by AOAC (2000).

Calves were fed burseem and wheat straw as main green and dry roughages. Calves were fed twice daily ad libitum with access to a total mixed ration consisting of 60% roughages. All the calves in control as well as treatment groups were fed experimental ration. The calves in treatment groups were only administered with rbST @ dose rate of 0.5mg/kg and 1.0.mg/kg fortnightly. The animals had free access to clean drinking water at all time. Daily feed intake and feed refusal were weighed and recorded on the rough record book.

(e) Parameters recorded

Growth and feedlot performance including body weight (BW), average daily gain (ADG), dry matter intake (DMI), feed conversion ratio (FCR) and economics.

- Body Weight Gain
  Before the start of experiment, the calves were allowed at least two weeks adaptation period in order to familiar with new ration. They were kept off feed and water 12 hours before recording their initial body weight. Thereafter, they were weighed weekly before feeding, till the expiry of the experiment.
- Feed Consumption
  Calves were fed and libitum consuming a ration containing 16% protein, 70% TDN, 18.21% CF, 1.05% Ca and 0.63% P. The ration was weighed and feed individually once every morning. Next morning before feeding the refusals of individual calf were weighed and recorded. Water was offered twice a day.
- Average Daily Gain
  The average daily of daily gain of each calf was determined by subtracting the weight gain in first week from weight gain in second week divided by seven. The ADG in the remaining weeks were calculated by the same method.
- Dry Matter Intake
  The daily dry matter intake of individual calf was determined by the daily feed intake multiplied by 62 (the DM in experimental fattening ration) divided by 100.
- Feed Efficiency
  The consumption of feed in kilograms for one kilogram weight gain for each calf was determined and expressed as feed efficiency or feed conversion ratio (FCR).
- Economics
  The economic analysis of the whole project was estimated by including average price of calf at the start of the experiment as per butcher's judgment, final prices of calves, feed cost, medicines cost, labor cost and net return in form of profit per buffalo calf.

2.2 Collection of Data

The data was collected on the proforma starting from day 1st of study and continued up to finishing of the study.

(a) Statistical Analysis

On completion of the study, the data collected was edited, tabulated and statistically analyzed by using computerized statistical software package MSTAT-C following complete randomized design (CRD) (Russell D-Freed and Eisensmith 1983). Tukey's significant difference test was applied to compare the difference between the treatments means. The statistical model used for all parameters was:

$Y_{ij} = \mu + t_j + Є_{ij}$

Where

μ = Over all means

t_j = Effect of treatments (1, 2, 3, …….11)

$Є_{ij}$= Difference within treatments means

(b) Experimental Design and Grouping of the Experimental Animals

The experimental units (twelve male buffalo calves) were randomly divided into three groups, i.e. A, B and C having four calves in each group with related age and weight. Each group was assigned to different treatments (4calves/treatment). These groups and their respective assignment to treatment are given below:

Group A calves were only allocated to fattening ration only and kept as control.

Group B calves were given fattening ration and rbST at the dose rate of o.5 mg/kg BW.

Group C calves were given fattening ration and rbST at the dose rate of 1mg/kg BW.

Experimental animals	Groups, N=3		
	Group A (Control) A= (n=4)	Group B B= (n=4)	Group C C= (n=4)
Kundhi buffalos calves (n=12)	Fattening ration	Fattening ration + rbST @ 0.5mg /kg	Fattening ration + rbST @ 1mg /kg

The technique, site and route of administration of rbST

The calves were injected subcutaneously in the ischiorectal fossa (depression beside the tail head) or behind the shoulder (post scapular).The volume of injectate of a commonly used formulation was used according to manufacturer's instruction and weight of the calf. The injection was repeated every 14 days.

Calculation of Daily Feed Intake:

Daily feed intake was recorded as:

Daily feed intake = weight of total feed supplied (kg) - weight of feed refusal (kg)

Feed Efficiency and Body Weight Gain

Feed efficiency was evaluated by food consumed in kilograms for one-kilogram weight gain. Body weight gain was recorded weekly throughout the experimental period. Calves were kept off feed and water 12 hrs before starting treatment of rbST recording their initial body weight. Thereafter, the calves were weighed weekly at the same time before feeding, till the expiry of the experiment. Orts (refusal feed) was weighed on weekly basis to determine DMI. FCR was calculated as ADG (Kg g)/daily DMI (Kg). The finishing weight was calculated as:

Finishing weight gain in (kg) = Present final weight (kg) – initial weight (kg) at the start.

3. RESULTS

3.1 Body Weight

The effects of exogenous bovine somatotropin (rbST) on body weight (kg) of calves, fed fattening ration during study period was examined and results are shown in Table-ii, Figure-i and in Appendix-i and ii. The table shows average body weight of calves in each group during treatment period of 11 weeks. In this period the highest body weight of calves was recorded in group C followed by in group B and A. The result revealed that the calves of group C which received rbST at the dose rate of 1.0 mg/kg body weight showed highest increase in body weight followed by group B which received rbST at the dose rate of 0.5 mg/kg body weight in comparison to control group A.

Statistically significant increase ($P<0.05$) was found in body weight of calves in group B and C compared to the control group A. Furthermore Tukey's Honestly Significant Difference Test (THSDT) of comparison of means of groups showed significant increase ($P<0.05$) in body weight of calves in group C and B in contrast to control group A respectively, While the difference in body weight was also significant ($P<0.05$) in calves of group B and C (THSDT, 0.05).

Table-ii Effect of rbST on body weight (kg) of Kundhi buffalo calves fed fattening ration during treatment period of 11 weeks.

Injections	Period	Treatments		
		A (Control)	B	C
1st	1st week	60.18 ± 1.65	64.35 ± 1.12	71.05 ± 1.15
	2nd week	61.93 ± 1.54	66.75 ± 0.90	74.60 ± 1.12
2nd	3rd week	65.23 ± 1.47	71.28 ± 1.10	81.23 ± 1.62
	4th week	68.33 ± 1.49	75.88 ± 1.29	86.35 ± 1.44
3rd	5th week	71.48 ± 1.51	80.65 ± 1.48	92.28 ± 1.88
	6th week	74.60 ± 1.62	85.30 ± 1.47	98.10 ± 2.44
4th	7th week	77.83 ± 1.89	90.03 ± 1.36	104.30 ± 3.26
	8th week	81.00 ± 1.91	94.78 ± 1.27	110.20 ± 3.78
5th	9th week	84.15 ± 1.97	99.55 ± 1.58	116.20 ± 4.23
	10th week	86.98 ± 1.89	104.48 ± 1.39	121.58 ± 4.38
	11th week	94.95 ± 1.82	110.93 ± 1.71	128.25 ± 4.03
Mean		75.15 ± 1.66[a]	85.81 ± 1.27[b]	98.56 ± 2.53[c]

Means with different superscripts in a row differ significantly ($P < 0.05$)

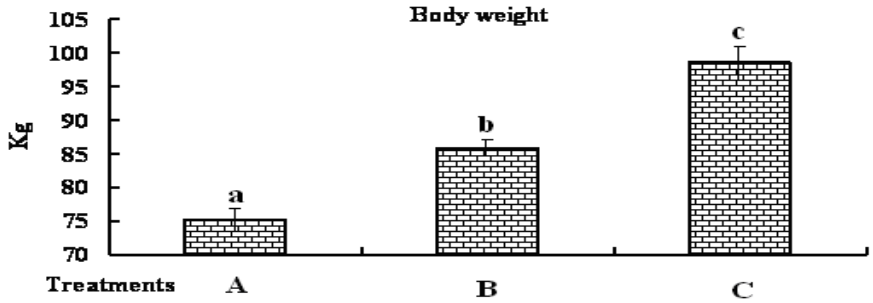


Figure-i Effect of rbST on body weight (kg) of Kundhi buffalo calves fed fattening ration during treatment period of 11 weeks.

THSDT (0.05) = 6.29
SE = ± 2.68

3.2 Feed Intake

Feed consumption in the claves during treatment period of 11 weeks was determined and results are presented in Table-iii, Figure-ii and Appendix-iii and iv. The highest feed consumption was recorded in group C followed by in group B and A. Statistical analysis showed significant difference (P<0.05) between rbST treated groups compared to control group A (Appendix-III). Moreover, the dose effect of rbST on feed intake was also compared among groups which showed significant increase (P<0.05) in feed intake of calves in group C and B in contrast to control group A respectively, While the difference was also significant (P<0.05) in calves of group B and C (THSDT 0.05).

Table-iii Effect of rbST on feed intake (kg) of Kundhi buffalo calves fed fattening ration during treatment period of 11 weeks.

Injections	Period	Treatments		
		A (Control)	B	C
1st	1st week	4.30 ± 0.09	4.73 ± 0.04	5.45 ± 0.13
	2nd week	4.46 ± 0.07	5.08 ± 0.15	5.96 ± 0.12
2nd	3rd week	4.64 ± 0.06	5.14 ± 0.05	5.91 ± 0.17
	4th week	4.72 ± 0.04	5.76 ± 0.13	6.43 ± 0.13
3rd	5th week	4.91 ± 0.06	5.90 ± 0.08	5.80 ± 0.09
	6th week	5.26 ± 0.07	6.63 ± 0.12	6.53 ± 0.08
4th	7th week	5.62 ± 0.08	6.47 ± 0.09	6.39 ± 0.16
	8th week	5.92 ± 0.09	7.14 ± 0.07	7.52 ± 0.20
5th	9th week	6.29 ± 0.08	6.94 ± 0.14	7.78 ± 0.08
	10th week	6.49 ± 0.05	7.24 ± 0.10	8.03 ± 0.06
	11th week	6.64 ± 0.07	7.17 ± 0.02	7.86 ± 0.15
Mean		5.39 ± 0.06[a]	6.20 ± 0.08[b]	6.70 ± 0.11[c]

Means with different superscripts in a row differ significantly (P < 0.05)

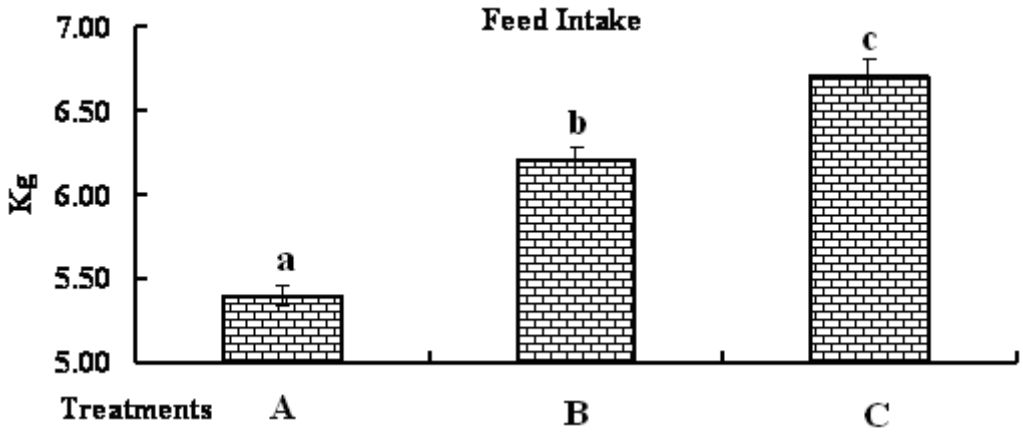


Figure-ii Effect of rbST on feed intake (kg) of Kundhi buffalo calves fed fattening ration during treatment period of 11 weeks.

THSDT (0.05) = 0.28
SE = ± 0.12

3.3 Average daily gain (ADG)

Effect of rbST treatment on average daily gain (ADG) of Kundhi buffalo calves during study period was examined and results are depicted in Table-iv, Figure-iii and in Appendix-v and vi. The table shows mean average daily gain of each group during treatment period of 11 weeks. The highest average daily gain in calves was recorded in group C followed by in group B and A. The result revealed that the calves of group C which received rbST at the dose rate of 1.0 mg/kg body weight showed highest increase in ADG followed by group C which received rbST at the dose rate of 0.5 mg/kg body weight in comparison to control group A, who gained of increased ADG.

Statistically analysis revealed significant difference (P<0.05) in ADG of calves in group C and B compared to the control group A. Furthermore Tukey's Honestly Significant Difference Test (THSDT) of comparison of means of groups showed significant increase (P<0.05) in ADG of calves in group B and C in contrast to control group A respectively, While the difference in ADG was also significant (P<0.05) in calves of group B and C (THSDT 0.05).

Table-iv Effect of rbST on ADG (kg) of Kundhi buffalo calves fed fattening ration during treatment period of 11 weeks.

Injections	Period	Treatments		
		A (Control)	B	C
1st	1st week	0.22 ± 0.01	0.37 ± 0.04	0.45 ± 0.06
	2nd week	0.25 ± 0.02	0.34 ± 0.05	0.51 ± 0.01
2nd	3rd week	0.47 ± 0.03	0.65 ± 0.06	0.95 ± 0.13
	4th week	0.44 ± 0.03	0.66 ± 0.03	0.73 ± 0.09
3rd	5th week	0.45 ± 0.02	0.68 ± 0.03	0.85 ± 0.13
	6th week	0.45 ± 0.02	0.66 ± 0.01	0.83 ± 0.09
4th	7th week	0.46 ± 0.06	0.68 ± 0.03	0.89 ± 0.12
	8th week	0.45 ± 0.00	0.68 ± 0.02	0.84 ± 0.10
5th	9th week	0.45 ± 0.03	0.68 ± 0.06	0.86 ± 0.08
	10th week	0.40 ± 0.04	0.70 ± 0.04	0.77 ± 0.09
	11th week	1.14 ± 0.17	0.92 ± 0.16	0.95 ± 0.11
Mean		0.47 ± 0.00[a]	0.64 ± 0.00[b]	0.78 ±0.04[c]

Means with different superscripts in a row differ significantly (P < 0.05)

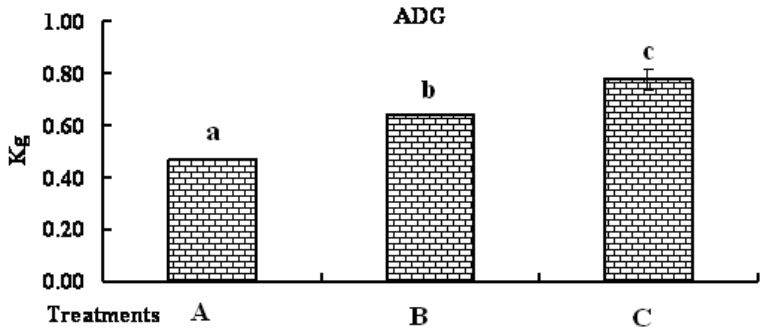


Figure-iii Effect of rbST on ADG (kg) of Kundhi buffalo calves fed fattening ration during treatment period of 11 weeks.

THSDT (0.05) = 0.073
SE = ± 0.031

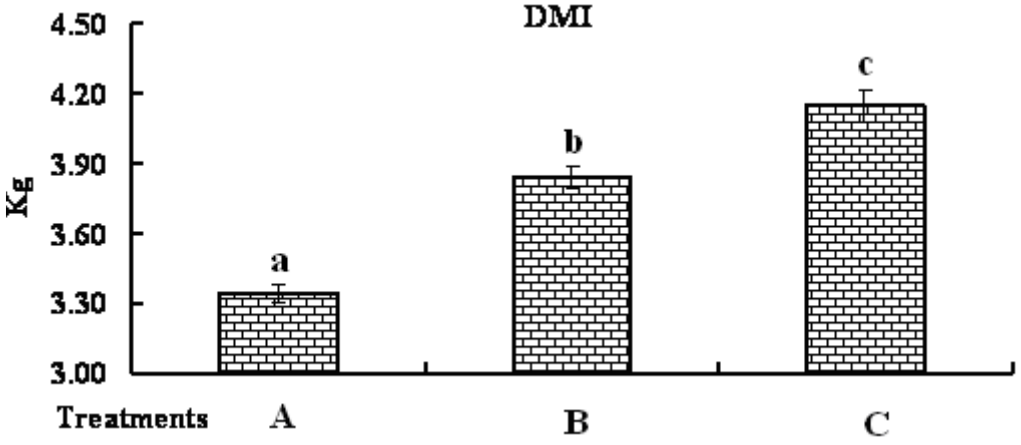
3.4 Dry Matter Intake

Dry matter intake (DMI) in the claves during treatment period was determined and results are presented in Table-v, Figure-iv, appendix-vii and viii. During treatment period highest average DMI was recorded in group C followed by in group B and A (3.34 ± 0.04 kg). Statistical analysis performed on data of dry matter intake showed significant difference (P<0.05) between rbST treated groups compared to control group (Appendix-VI). Moreover, THSDT of comparison of means of groups showed significant increase (P<0.05) in dry matter intake of calves in group B and C in contrast to control group A respectively, While the difference in DMI was also significant (P<0.05) in calves of group B and C (THSDT, 0.05).

Table-v Effect of rbST on DMI (kg) of Kundhi buffalo calves fed fattening ration during treatment period of 11 weeks.

Injections	Period	Treatments		
		A (Control)	B	C
1st	1st week	2.67 ± 0.06	2.93 ± 0.03	3.38 ± 0.08
	2nd week	2.76 ± 0.04	3.15 ± 0.09	3.70 ± 0.07
2nd	3rd week	2.88 ± 0.04	3.18 ± 0.03	3.66 ± 0.11
	4th week	2.92 ± 0.03	3.57 ± 0.08	3.99 ± 0.08
3rd	5th week	3.05 ± 0.03	3.66 ± 0.05	3.59 ± 0.06
	6th week	3.26 ± 0.04	4.11 ± 0.08	4.05 ± 0.05
4th	7th week	3.49 ± 0.05	4.01 ± 0.06	3.96 ± 0.11
	8th week	3.67 ± 0.06	4.43 ± 0.04	4.66 ± 0.13
5th	9th week	3.90 ± 0.05	4.30 ± 0.08	4.82 ± 0.05
	10th week	4.03 ± 0.03	4.49 ± 0.06	4.98 ± 0.04
	11th week	4.12 ± 0.04	4.45 ± 0.02	4.88 ± 0.09
Mean		3.34 ±0.04[a]	3.84±0.05[b]	4.15 ±0.07[c]

Means with different superscripts in a row differ significantly (P < 0.05)



THSDT (0.05) = 0.18
SE = ± 0.075

Figure-iv Effect of rbST on DMI (kg) of Kundhi buffalo calves fed fattening ration during treatment period of 11 weeks.

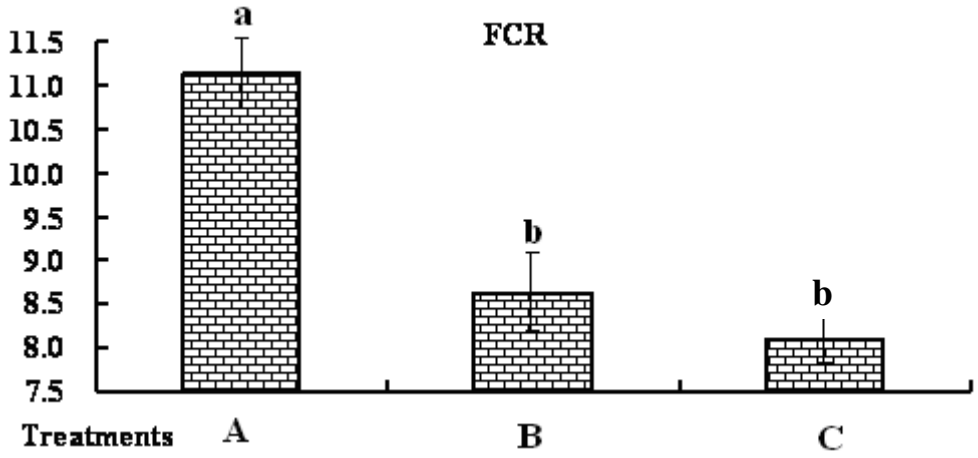
4. FEED CONVERSION RATIO (FCR)

During experimental period feed conversion ratio in Kundhi buffalo calves was determined and results are presented in Table-vi, Figure-v and Appendix-ix and x. During treatment period improved feed efficiency (FE) was recorded in group C followed by in group B and A. Statistically significant difference ($P<0.05$) in FCR between rbST treated groups compared to control group (Appendix-X). Moreover, THSDT of comparison of means of groups showed significant difference ($P<0.05$) in FCR of calves in group C and B compared to group A (control) respectively, While the difference in FCR of calves in group B and C was non significant ($P>0.05$, THSDT 0.05).

Table-vi Effect of rbST on FCR of Kundhi buffalo calves fed fattening ration during treatment period of 11 weeks.

Injections	Period	Treatments		
		A (control)	B	C
1st	1st week	19.91 ± 1.13	13.29 ± 1.42	12.78 ± 1.66
	2nd week	17.69 ± 1.77	15.39 ± 2.74	10.89 ± 0.33
2nd	3rd week	9.31 ± 0.69	7.86 ± 0.75	6.37 ± 0.96
	4th week	9.99 ± 0.60	7.69 ± 0.23	8.25 ± 0.97
3rd	5th week	9.85 ± 0.38	7.51 ± 0.21	7.57 ± 1.40
	6th week	9.98 ± 0.40	7.76 ± 0.25	7.42 ± 0.85
4th	7th week	10.17 ± 1.23	7.69 ± 0.56	7.02 ± 0.69
	8th week	9.82 ± 0.14	7.53 ± 0.43	7.39 ± 0.92
5th	9th week	10.03 ± 0.59	7.45 ± 0.43	7.10 ± 0.71
	10th week	11.59 ± 1.32	7.10 ± 0.52	7.91 ± 0.89
	11th week	4.22 ± 0.58	5.72 ± 0.78	6.32 ± 0.73
Mean		11.14 ±0.40[a]	8.64 ± 0.44[b]	8.09 ± 0.28[b]

Means with different superscripts in a row differ significantly ($P < 0.05$)



THSDT (0.05) = 1.27
SE = ± 0.54

Figure-v Effect of rbST on FCR of Kundhi buffalo calves fed fattening ration during treatment period of 11 weeks.

5. ECONOMIC ANALYSIS

The economic impact of using rbST on growth performance per buffalo calf was calculated on the basis of weight gain and feed consumption in the experimental period of 77 days and the results are depicted in Table-vii. The average daily feed intake per calf in groups A (Control), B and C was 5.39, 6.20 and 6.70 kg amounting to Rs. 2919.99, 3157 and 3303.30/calf. The ceiling cost including medication/vaccination cost, labour cost, miscellaneous cost and the estimated purchase cost of the calves at the start of the experiment was Rs. 10199.99, 11247.00 and 12573.30/calf in groups A (Control), B and C respectively.

The average final weight of the calves at the end of 77 days (11 weeks) experiment was 75.15, 85.81 and 98.56 kg/calf in groups A, B and C respectively. On average, the calves in groups A, B and C fetched a price of Rs. 11272.50, 12871.50 and 14784.00 which generated a net profit of 1072.51, 1624.50 and 2210.70/calf respectively.

It was apparent from the economic traits of the calves evaluated in the experiment that the calves in group B and C which received rbST at the dose rate of 0.5 mg and 1.0 mg/kg body weight had remarkably better beef production capabilities and produced an income of Rs. 1624.50 and 2210.70/calf as compared to Rs. 1072.51/calf of control group in 77 days (11 weeks). Hence the net profit of using rbST per calf per day was calculated as Rs. 21.10 and 28.71 in groups B and C as compared to Rs. 13.93 of control group.

Table-vii Economic analysis of rbST on growth performance of Kundhi buffalo calves fed fattening ration during treatment period of 11 weeks.

S. No	Particulars	A (Control)	B	C
A	Dry fodder/day/calf (kg)	1.76	2.08	2.28
B	Dry fodder in 77 days (kg/calf)	135.21	160.16	175.56
C	Rate of dry fodder (Rs./kg)	5.00	5.00	5.00
D	Amount of dry fodder (Rs./calf) (BXC)	676.05	800.80	877.80
E	Green fodder/day/calf (kg)	2.63	3.12	3.42
F	Green fodder in 77 days (kg/calf)	202.82	240.24	263.34
G	Rate of green fodder (Rs./kg)	3.00	3.00	3.00
H	Amount of green fodder (Rs./calf) (FX G)	608.46	720.72	790.02
I	Concentrates/day/calf (kg)	1.00	1.00	1.00
J	Concentrates in 77 days (kg/calf)	77.00	77.00	77.00
K	Rate of concentrates (Rs./kg)	21.24	21.24	21.24
L	Amount of concentrates (Rs./calf) (JXK)	1635.48	1635.48	1635.48
M	Total feed /day/calf (kg) (A+E+I)	5.39	6.20	6.70
N	Total feed in 77 days/calf (kg) (JX M)	415.03	477.40	515.90
O	Total feed cost/calf (Rs.) (D+H+L)	2919.99	3157.00	3303.30
P	Cost of medication/vaccination incl. rbST (Rs.)	125.00	365.00	605.00
Q	Labour cost/calf (Rs.)	750.00	750.00	750.00
R	Miscellaneous cost/calf (Rs.)	25.00	25.00	25.00
S	Estimated initial cost of calf (Rs.)	6380.00	6950.00	7890.00
T	Total cost /calf (Rs.) (O+P+Q+R+S)	10199.99	11247.00	12573.30
U	Initial weight of calf (kg)	58.65	61.78	67.90
V	Final weight of calf (kg)	75.15	85.81	98.56
W	Weight gain in kg/calf in 77 days	16.50	24.03	30.66
X	Estimated sale of calf (Rs.)	11272.50	12871.50	14784.00
Y	Net profit/calf (Rs.) (X-T)	1072.51	1624.50	2210.70

6. DISCUSSION

A considerable amount of research has been done previously to evaluate the effects of rbST in various domestic animals but the reports regarding the effects of rbST treatment on fattening animals are scanty. In addition, the previous studies on rbST treatment vary with dose and period of treatment. Moreover, the previous studies on effects of rbST on growth have been conducted on cows, goats, sheep and there is a little information regarding its effects on buffaloes, however, it is well established that the buffalo calves grow faster than that of cow calves. The present study was therefore aimed to evaluate the effects of rbST treatment administered fortnightly on growth and blood biochemical parameters in healthy male Kundhi buffalo calves fed fattening ration. The growth performance of calves was assessed by considering the parameters such as body weight, feed consumption, average daily gain (ADG), dry matter intake (DMI), feed efficiency (FCR) and economic analysis. The blood biochemical variables including glucose, protein, total lipids, calcium, sodium and potassium of calves were also determined and the results are discussed as follows:

(a) Growth performance

The stimulatory effects of rbST administration on growth rate were observed throughout the experiment and the responses of feedlot performance of calves were noted in the following parameters.

(b) Body weight

Recombinant bovine somatotropin (rbST) is a synthetic version of natural bovine growth hormone that stimulates growth of almost all tissues of the body of bovines that are capable of growing (Daughaday and Barbano 1990).

In the present study rbST treatment increased body weight of calves compared to non-treated calves. Moreover, the body weight of calves was higher in group C followed by B which received rbST at the dose rate of 1.0 and 0.5 mg/kg BW respectively in comparison to control group. Previous reports regarding the effects of rbST on growth are variable. The findings of the study are in close agreement with the studies conducted by Nour El-Din et al. (2009); Velauyudhan et al. (2007); Govoni et al. (2004) and Radcliff et al. (2000), who during their experiments on lambs and calves reported increased weight gain compared to that of control animals. Hubar et al. (1997); Schwarz et al. (1993); Vestergaard et al. (1993) and Moseley et al. (1992) reported that growth hormone increased BW gain by 37% in lactating cows, 10%, 8% and 15% in finishing beef steers respectively. This same effect of growth hormone on BW was also demonstrated in the current study and the increase percentage in BW was 31.11% in calves of group C and 28.04% in group B as compared to group A (21.96%) respectively. This is in agreement with previous studies by Bilal et al. (2006) who reported that the buffalo calves have capacity to grow faster than cow calves and the growth rate of buffalo calves can further be hastened by the use of some suitable growth promoters.

(c) Feed intake

Recombinant bovine somatotropin (rbST) alters the partitioning and use of absorbed nutrients with little or no effect on digestive processes. It is apparent that effects involve an orchestration that includes many physiological processes. In accordance with increased body weight gain the feed intake was higher in calves of group C followed by B which received rbST at the dose 1.0 and 0.5 mg/kg.BW in comparison to control group. The results of present study are in close agreement with the previous studies reported by Boonsanit et al. (2010); Chanchai et al. (2010) and Nascimento et al. (2003), who found increased feed consumption in rbST

treated calves. In both beef and dairy animals, supplementation with rbST has been shown to affect feed intake. However, our results disagree with the findings of Chaiyabutr et al. (2007); Sallam et al. (2005) and Chadio et al. (2000) who found no effect of rbST treatment on feed intake in lactating buffaloes, sheep and goats respectively. This discrepancy information suggested that these results probably came from the difference in experimental condition and reflected that this behavior was controlled by multiple factors. The increase in feed intake may depend on the increase in production (milk and meat), energy status, environmental condition and the nutrients of diet (particularly energy). Overall, both dairy and beef animals in production stages supplemented with rbST appear to adjust their voluntary feed intake in relation to the additional nutrient required for production.

(d) Average daily gain (ADG)

Effect of rbST treatment on average daily gain (ADG) in present study was significantly different ($P<0.05$) between rbST treated groups and control group. The highest average daily gain in calves was recorded in group C followed by in group B and control group. The difference in ADG was also significant ($P<0.05$) in calves of group B and C receiving different doses of rbST. The current findings are in accordance with those reported by Gebre et al. (2012); Mellado et al. (2012); Nour El-Din et al. (2009); Velauyudhan et al. (2007); Schlegel et al. (2006) and Rausch et al. (2002). The results reported by Song and Choi (2001) and Radcliff et al. (2000), have further confirmed the findings of the present investigation who found that ADG was significantly increased by rbST treatment in calves. The somatotropic axis is functional at birth (Granz et al. 1997) and the response to exogenous bovine somatotropin begins as early as one day of age in beef cattle (Govoni et al. 2004). The magnitude of response to rbST in beef cattle is variable and related to the age of the animal. Rumsey et al. (1996) and Radcliffe et al. (1997) reported a significant increase in rbST-induced ADG in lighter and younger cattle than heavy and older. Therefore, rbST may only be effective when the animals are young and the optimal nutrition is available, and thus formulation of diets relative to the physiological state of the animal is essential to maximize the rbST induced increase in ADG.

(e) Dry matter intake (DMI)

Dry matter intake (DMI) in the claves under the influence of rbST was increased significantly ($P<0.05$) in comparison to control calves. The highest average DMI was recorded in group C followed by in group B and control group. The difference in DMI was also significant ($P<0.05$) in calves of group B and C receiving different doses of rbST. The DMI was increased linearly by increasing dose of rbST in treated calves indicating that rbST exerts marked effect on nutrient intake by promoting appetite of animals. The results of the present study are supported by the findings of Helal and Lasheen (2008); Moallem et al. (2000) and Moseley et al. (1992). The increase in DMI in response to rbST treatment depends on nutritional status of the animal. Administration of rbST to well fed animals causes an increase in circulating IGF-I and IGFBP-3 and a decrease in IGFBP-2. Thus, when nutritional status is excellent, rbST has indirect effects on the DMI via the IGF system (Bauman 1999).

However, there are some contradictory results in the literature not supporting the current findings regarding the effect of rbST on DMI in animals. Velauyudhan et al. (2007) and Schlegel et al. (2006) reported a reduced DMI in rbST-treated cattle than in controls. In dairy goats and ewes, dry matter intake did not differ significantly between control and rbST treatment (Chadio et al. 2000; Sallam et al. 2005). DMI may depend on the stage of production, energy status, environmental condition and the nutrients of diet (particularly energy). These variations in DMI may be due to species, breed and sex differences and different environmental condition in which the experiments have been carried out.

(f) Feed conversion ratio (FCR)

In present study feed conversion ratio (FCR) of calves was better in group C followed by in group B where as the calves in control group were not equally efficient in gaining weight nor in case of the feed conversion efficiency. Thus, it was apparently visual that the calves given rbST at the dose rate of 1.0 and 0.5 mg/ kg body weight respectively were far better in all parameters as compared to control calves. Gebre et al. (2012); Mellado et al. (2012); Nour El-Din et al. (2009); Velauyudhan et al. (2007); Schlegel et al. (2006) and Rausch et al. (2002) reported that weight gain and feed conversion ratio were significantly superior in rbST treated calves against control calves. Govoni et al. (2004); Song and Choi (2001) and Hozler et al. (1999) also reported that feed efficiency was considerably efficient in calves treated with rbST as compared to those given no any rbST treatment. The improvement in FCR in rbST treated calves in the present study may be associated with increased concentrations of somatotropin, IGF-I and IGFBP-3 and decreased concentrations of IGFBP-2.

(g) Economic analysis

In present study, the calves in group C generated highest profit followed by B and A. It was apparent from the economic traits of the calves evaluated in the experiment that the calves in group B and C which received rbST at the dose rate of 0.5 mg and 1.0 mg/kg body weight respectively had remarkably better beef production capabilities and produced maximum income as compared to control group in 77 days (11 weeks). Hence the net profit of using rbST per calf per day was calculated, indicating that the use of rbST for increasing beef production is economical. The results of economic impact of using rbST in calves as a growth promoter on commercial scale, are matching with the findings of Berthiaume et al. (2006) and Sallam et al. (2005b) who reported that optimum dose of rbST is recommended in order to get ideal economic return from using rbST in both lactating and beef animals.

REFERENCES

Ahmad F, Jabbar MA, Ahmad I, Rafique M and Ahmad I (2004) Comparative efficiency of calf starter and conventional Rations in buffalo suckling calves. Pak. Vet. J. 24(4).

Anonymous (2006) Livestock Census. Agricultural Census Organization, Statistics Division, Government of Pakistan, Lahore.

AOAC (2000) Official Methods of Analysis 17th Ed. Association of Official Analytical Chemists, Arlington, V.A.

Bauman DE (1999) Bovine somatotropin and lactation: from basic science to commercial application. Domest. Anim. Endocrinol. 17:101–116.

Bauman DE (1992) Bovine somatotropin: review of an emerging animal technology. J. Dairy Sci. 75(12), 3432-3451.

Berthiaume R, Mandell I, Faucitano L and Lafreniere C (2006) Comparison of alternative beef production systems based on forage finishing or grain-forage diets with or without growth promotants: 1. Feedlot performance, carcass quality, and production costs. J Anim. Sci. vol. 84, no. 8: 2168-2177.

Bilal MQ, Suleman M and Raziq A (2006) Buffalo: Black gold of Pakistan. Livestock Research for Rural Development, 18(9).

Boonsanit D, Chanpongsang S and Chaiyabutr N (2010) Effects of Supplemental Recombinant Bovine Somatotropin (rbST) and Cooling with Misters and Fans on Renal Function in Relation to Regulation of Body Fluids in Different Stages of Lactation in Crossbred Holstein Cattle. Asian-Aust. J. Anim. Sci. Vol. 23, No. 3: 355 – 365.

Burton JL, McBride BW, Block E, Glimm DR and Kennelly JJ (1994) A review of bovine growth hormone. Can. J. Anim. Sci. 74, 167-201.

Chadio SE, Zervas G, Kiriakou K, Goulas C and Menegatos J (2000) Effects of recombinant bovine somatotropin administration to lactating goats Small Ruminant Res. Vol. 35, Issue 3, pp. 263-269.

Chaiyabutr N, Thammacharoen S, Komolvanich S and Chanpongsang S (2007) Effects of long-term exogenous bovine somatotropin on water metabolism and milk yield in crossbred Holstein. J. Agri. Sci. (Camb.). 145(02): 173-184.

Chanchai W, Chanpongsang S and Chaiyabutr N (2010) Effects of cooling and supplemental recombinant bovine somatotropin on diet digestibility, digestion kinetics and milk production of cross-bred Holstein cattle in the tropics. J. Agri. Sci. Vol. 148, Issue 02, pp. 233-242.

Daudnaday WH and Barbano DM (1990) Bovine somatotropin supplementation of dairy cows: Is the milk safe?. J. Amer. Med. Assoc. Vol. 264, No. 8.

Davis JJ, Sahlu T, Puchala R, Herselman MJ, Fernandez JM, McCann JP and Coleman SW (1999) The effect of bovine somatotropin treatment on production of lactating Angora does with kids. J. Anim. Sci. 77:17–24.

Hulme R (2011) Types of Hormonal Growth Promoters. Demand Media, Inc. eHow.com and eHow.co.uk.

Gebre BA, Gebretsadik ZT and Anal AK (2012) Effect of metabolic modifiers on meat quantity and quality. African J. F. Sci. Vol. 6(11), pp. 294-301.

Govoni KE, Hoagland TA and Zinn SA (2004) The ontogeny of the somatotropic axis in Hereford calves from birth to one year of age and its response to administration of exogenous bovine somatotropin. J. Anim. Sci. 82:1646-1655.

Granz S, Ellendorff. F, Grossmann R, Kato Y, Muhlbauer E and Elsaesser F (1997) Ontogeny of growth hormone and LH beta-, FSH beta- and alpha-subunit mRNA levels in the porcine fetal and neonatal anterior pituitary. J. Neuroendocrinol. 9:439–449.

Helal FIS and Lasheen MA (2008) The productive performance of Egyptian dairy buffaloes receiving biosynthetic bovine somatotrophin (rbST) with or without monensin. American- Eurasian J. Agric. & Environ. Sci. 3: 771.

Hubar JT, Wu Z, Fontes JR, Sullivan JL, Hoffman RG and Hartnell GF (1997) Administration of recombinant bovine somatotropin to dairy cows in four consecutive lactations. J. Anim. Sci. 80: 2355.

Mellado M, Herrera CAM, Arevalo JR, García JE and Veliz FG (2012) Effect of dietary energy intake and somatotropin administration aft er weaning on growth rate and semen characteristics of Granadina goat bucks. Turk. J. Vet. Anim. Sci. 36(4): 338-345.

Moallem U, Folman Y and Sklan D (2000) Effects of Somatotropin and dietary calcium soaps of fatty acids in early lactation on milk production, dry matter intake and energy balance of high-yielding dairy cows. J. Dairy Sci. 83:2085.

Moseley WM, Paulissen JB, Goodwin MC, Alaniz GR and Claflin WH (1992) Recombinant bovine somatotropin improves growth performance in finishing beef steers. J. Anim. Sci. 70(2): 412-425.

Nascimento WGD, Do Prado IN, Rigolon LP, Marques JDA, Wada FY, Matsishita M and Scomparin VX (2003)+Recombinant Bovine Somatotropin (rBST) on Performance and Apparent Digestibility of Heifers (½ Nellore x ½ Red Angus) in Feedlot. R. Bras. Zootec., v.32, n.2, p.456-464.

Nour El-Din ANM, El-Zarkouny SZ, Ghobashy H, Abdel-Gawad EI and Kesler DJ (2009) Growth, haematological and biochemical responses of growing lambs injected with growth hormone and supplemented with calcium soaps of fatty acids. South African J. Anim. Sci. 39 (Supplement 1).

Pasha TN and Hayat Z (2012) Present situation and future perspective of buffalo production in Asia. J. Anim. and Plant Sci. 22(3 Suppl.), pp: 250-256, ISSN: 1018-7081.

Pirzado SA, Solangi AA, Memon A, Baloch GM, Wagan MP, Baloch MH and Wagan R (2010-11) Fattening of male goat kids by feeding various levels of crude protein and total digestible nutrients. Pak. J. L. Sc. Vol. (II) No.2-2010-11.

Puchala R, Prieto I, Banskalieva V, Goetsch AL, Machica M and Sahlu T (2001) Effects of bovine somatotropin and thyroid hormone status on hormone levels, body weight gain, and mohair fiber growth of Angora goats. J. Anim. Sci. 79:2913-2919.

Radcliff RP, Vandehaar MJ, Chapin LT, Pilbeam TE, Beede DK, Stanisiewski EP and Tucker HA (2000) Effect of Diet and Injection of Bovine Somatotropin on Prepubertal Growth and First Lactation Milk yields of Holstein cows. J. Dairy Sci. Vol. 83, Issue 1, pp. 23-29.

Radcliffe RP, Vandehaar MJ, Skidmore AL, Chapin LT, Radke BR, Lloyd JW, Stanisiewski EP and Tucker HA (1997) Effects of diet and bovine somatotropin on heifer growth and mammary development. J. Dairy Sci. 80:1996–2003.

Rausch MI, Tripp MW, Govoni KE, Zang W, Webert WJ, Crooker BA, Hoagland TA and Zinn SA (2002) The influence of level of feeding on growth and serum insulin-like growth factor I and insulin-like growth factor-binding proteins in growing beef cattle supplemented with somatotropin. J. Anim. Sci. 80(1):94-100.

Rumsey TS, Elsasser TH, Kahl S, Moseley WM and Solomon MB (1996) Effects of Synovex-Sâ and Recombinant Bovine Growth Hormone (Somavuboveâ) on Growth Responses of Steers: I. Performance and Composition of Gain. J. Anim. Sci. 1996. 74:2917–2928.

Russell, D-Freed and Eisensmith (1983) MSTAT-C, Computer based statistical software package. Department of Crop and Soil Sciences, Michigan State University, USA.

Sallam SMA, Nasser MEA and Yousef MI (2005a) Effect of recombinant bovine somatotropin administration on milk production, composition and some haemato-biochemical components in Rahmani sheep. Small Ruminant Res. Vol. 56, Issues 1-3, pp. 165-171.

Sallam SMA, Nasser MEA, El-Waziry AM and Yousef MI (2005b) Economics of Using Recombinant Bovine Somatotropin in Small Ruminants. J. Appl. Sci. Res. 1(2): 156-160.

Schlegel ML, Bergen WG, Schroeder AL, VandeHaar MJ and Rust S R (2006) Use of bovine somatotropin for increased skeletal and lean tissue growth of Holstein steers. J Anim Sci. 84(5):1176-87.

Schwarz FJ, Schams D, Ropke R, Kirchgessner M, Kogel J and Matzke P (1993) Effect of somatotropin treatment on growth performance, carcass traits, and the endocrine system in finishing beef heifers. J. Anim. Sci. 71(10): 2721-2731.

Sharma DD, Sehgal JP, Singhal KK and Ghosh MK (1995) Fattening of growing male buffalo calves for quality meat production. Project Reoprt, NDRI, Haryana, India.

Song MK and Choi SH (2001) Growth Promoters and their Effects on Beef Production. Review- Asian-Aust. J. Anim. Sci. Vol. 14, No. 1 : 123-135.

Thu NV, Dong K, Preston TR and Pearson RA (1995) Exploring Approaches to Research in Animal Sciences in Vietnam. ACIAR proceedings No. 68, p. 216. ACIAR, Hue, Vietnam.

Velayudhan BT, Govoni KE, Hoagland TA and Zinn SA (2007) Growth rate and changes of the somatotropic axis in beef cattle administered exogenous bovine somatotropin beginning at two hundred, two hundred fifty, and three hundred days of age. J. Anim. Sci. 85(11):2866-72.

Vestergaard M, Sejrsen K, Foldager J, Klastrup S and Bauman DE (1993) The Effect of Bovine Growth Hormone on Growth, Carcass Composition and Meat Quality of Dairy Heifers. Acta Agriculturae Scandinavica, Section A. Anim. Sci. Vol. 43, Issue 3.

APPENDICES

Appendix-i Descriptive statistics of body weight (kg) of Kundhi buffalo calves fed fattening ration during treatment period of 11 weeks.

Period	Groups	N	Mean	Std. Error	Minimum	Maximum
1st week	A	4	60.18	1.65	56.10	63.80
	B	4	64.35	1.12	61.50	66.90
	C	4	71.05	1.15	68.40	74.00
2nd week	A	4	61.93	1.54	58.00	65.20
	B	4	66.75	0.90	64.60	69.00
	C	4	74.60	1.12	72.20	77.60
3rd week	A	4	65.23	1.47	61.30	68.00
	B	4	71.28	1.10	69.50	74.40
	C	4	81.23	1.62	77.90	84.90
4th week	A	4	68.33	1.49	64.40	71.50
	B	4	75.88	1.29	73.90	79.60
	C	4	86.35	1.44	83.00	90.00
5th week	A	4	71.48	1.51	67.60	74.90
	B	4	80.65	1.48	78.40	84.90
	C	4	92.28	1.88	89.20	97.50
6th week	A	4	74.60	1.62	70.50	78.40
	B	4	85.30	1.47	83.20	89.60
	C	4	98.10	2.44	94.00	104.80
7th week	A	4	77.83	1.89	72.90	82.00
	B	4	90.03	1.36	88.00	94.00
	C	4	104.30	3.26	99.20	113.60
8th week	A	4	81.00	1.91	76.00	85.20
	B	4	94.78	1.27	92.80	98.50
	C	4	110.20	3.78	103.20	120.50
9th week	A	4	84.15	1.97	79.20	88.60
	B	4	99.55	1.58	97.50	104.20
	C	4	116.20	4.23	107.50	127.30
10th week	A	4	86.98	1.89	82.40	91.00
	B	4	104.48	1.39	102.20	108.40
	C	4	121.58	4.38	111.40	132.50
11th week	A	4	94.95	1.82	90.00	98.40
	B	4	110.93	1.71	106.50	114.40
	C	4	128.25	4.03	120.20	138.90
Mean	A	4	75.15	1.66	70.76	78.82
	B	4	85.81	1.27	83.62	89.45
	C	4	98.56	2.53	94.49	105.60

Appendix-ii Analysis of variance of body weight (kg) of Kundhi buffalo calves fed fattening ration during treatment period of 11 weeks.

Period	Source of variation	Degree of freedom	Sum of Squares	Mean Square	F-value	P-value
1st week	Between Groups	2	240.78	120.39	16.97	0.001
	Within Groups	9	63.85	7.09		
	Total	11	304.63			
2nd week	Between Groups	2	327.41	163.71	27.57	0.000
	Within Groups	9	53.44	5.94		
	Total	11	380.85			
3rd week	Between Groups	2	522.14	261.07	32.73	0.000
	Within Groups	9	71.78	7.98		
	Total	11	593.92			
4th week	Between Groups	2	655.50	327.75	41.23	0.000
	Within Groups	9	71.54	7.95		
	Total	11	727.05			
5th week	Between Groups	2	869.28	434.64	40.73	0.000
	Within Groups	9	96.04	10.67		
	Total	11	965.33			
6th week	Between Groups	2	1107.44	553.72	38.63	0.000
	Within Groups	9	129.02	14.34		
	Total	11	1236.46			
7th week	Between Groups	2	1404.72	702.36	32.80	0.000
	Within Groups	9	192.70	21.41		
	Total	11	1597.42			
8th week	Between Groups	2	1707.10	853.55	32.75	0.000
	Within Groups	9	234.59	26.06		
	Total	11	1941.68			
9th week	Between Groups	2	2055.45	1027.72	31.81	0.000
	Within Groups	9	290.76	32.31		
	Total	11	2346.21			
10th week	Between Groups	2	2394.43	1197.21	36.47	0.000
	Within Groups	9	295.44	32.83		
	Total	11	2689.87			
11th week	Between Groups	2	2218.995	1109.51	37.04	0.000
	Within Groups	9	269.55	29.95		
	Total	11	2488.54			
Mean	Between Groups	2	1098.85	549.42	38.35*	0.000
	Within Groups	9	128.93	14.32		
	Total	11	1227.78			

Appendix-iii Descriptive statistics of feed intake (kg) of Kundhi buffalo calves fed fattening ration during treatment period of 11 weeks.

Period	Groups	N	Mean	Std. Error	Minimum	Maximum
1st week	A	4	4.30	0.09	4.07	4.51
	B	4	4.73	0.04	4.63	4.83
	C	4	5.45	0.13	5.16	5.76
2nd week	A	4	4.46	0.07	4.34	4.66
	B	4	5.08	0.15	4.69	5.37
	C	4	5.96	0.12	5.76	6.29
3rd week	A	4	4.64	0.06	4.56	4.81
	B	4	5.14	0.05	5.04	5.26
	C	4	5.91	0.17	5.47	6.30
4th week	A	4	4.72	0.04	4.63	4.81
	B	4	5.76	0.13	5.50	6.01
	C	4	6.43	0.13	6.16	6.77
5th week	A	4	4.91	0.06	4.77	5.04
	B	4	5.90	0.08	5.67	6.04
	C	4	5.80	0.09	5.66	6.06
6th week	A	4	5.26	0.07	5.10	5.43
	B	4	6.63	0.12	6.29	6.83
	C	4	6.53	0.08	6.39	6.76
7th week	A	4	5.62	0.08	5.51	5.86
	B	4	6.47	0.09	6.23	6.66
	C	4	6.39	0.16	5.96	6.69
8th week	A	4	5.92	0.09	5.73	6.13
	B	4	7.14	0.07	6.94	7.29
	C	4	7.52	0.20	6.93	7.86
9th week	A	4	6.29	0.08	6.06	6.41
	B	4	6.94	0.14	6.54	7.16
	C	4	7.78	0.08	7.61	7.96
10th week	A	4	6.49	0.05	6.36	6.61
	B	4	7.24	0.10	6.96	7.39
	C	4	8.03	0.06	7.86	8.17
11th week	A	4	6.64	0.07	6.51	6.80
	B	4	7.17	0.02	7.13	7.24
	C	4	7.86	0.15	7.61	8.24
Mean	A	4	5.39	0.06	5.26	5.53
	B	4	6.20	0.08	5.98	6.34
	C	4	6.70	0.11	6.45	6.93

Appendix-iv Analysis of variance of feed intake (kg) of Kundhi buffalo calves fed fattening ration during treatment period of 11 weeks.

Period	Source of variation	Degree of freedom	Sum of Squares	Mean Square	F-value	P-value
1st week	Between Groups	2	2.68	1.34	37.55	0.000
	Within Groups	9	0.32	0.04		
	Total	11	3.00			
2nd week	Between Groups	2	4.59	2.29	40.57	0.000
	Within Groups	9	0.51	0.06		
	Total	11	5.11			
3rd week	Between Groups	2	3.25	1.63	34.78	0.000
	Within Groups	9	0.42	0.05		
	Total	11	3.67			
4th week	Between Groups	2	5.96	2.98	64.35	0.000
	Within Groups	9	0.42	0.05		
	Total	11	6.37			
5th week	Between Groups	2	2.34	1.17	46.34	0.000
	Within Groups	9	0.23	0.02		
	Total	11	2.57			
6th week	Between Groups	2	4.68	2.34	66.06	0.000
	Within Groups	9	0.32	0.04		
	Total	11	5.00			
7th week	Between Groups	2	1.73	0.86	16.14	0.001
	Within Groups	9	0.48	0.05		
	Total	11	2.21			
8th week	Between Groups	2	5.50	2.80	37.36	0.000
	Within Groups	9	0.67	0.08		
	Total	11	6.26			
9th week	Between Groups	2	4.49	2.25	54.72	0.000
	Within Groups	9	0.37	0.04		
	Total	11	4.86			
10th week	Between Groups	2	4.74	2.37	108.96	0.000
	Within Groups	9	0.21	0.02		
	Total	11	4.94			
11th week	Between Groups	2	2.99	1.50	41.45	0.000
	Within Groups	9	0.32	0.04		
	Total	11	3.32			
Mean	Between Groups	2	3.49	1.74	60.30*	0.000
	Within Groups	9	0.26	0.03		
	Total	11	3.75			

Appendix-v Descriptive statistics of average daily gain (kg) of Kundhi buffalo calves fed fattening ration during treatment period of 11 weeks.

Period	Groups	N	Mean	Std. Error	Minimum	Maximum
1st week	A	4	0.22	0.01	0.20	0.24
	B	4	0.37	0.04	0.29	0.47
	C	4	0.45	0.06	0.34	0.63
2nd week	A	4	0.25	0.02	0.20	0.29
	B	4	0.34	0.05	0.21	0.44
	C	4	0.51	0.01	0.49	0.54
3rd week	A	4	0.47	0.03	0.40	0.51
	B	4	0.65	0.06	0.50	0.77
	C	4	0.95	0.13	0.66	1.27
4th week	A	4	0.44	0.03	0.37	0.50
	B	4	0.66	0.03	0.63	0.74
	C	4	0.73	0.09	0.51	0.96
5th week	A	4	0.45	0.02	0.40	0.49
	B	4	0.68	0.03	0.64	0.76
	C	4	0.85	0.13	0.49	1.07
6th week	A	4	0.45	0.02	0.40	0.50
	B	4	0.66	0.01	0.63	0.69
	C	4	0.83	0.09	0.59	1.04
7th week	A	4	0.46	0.06	0.34	0.61
	B	4	0.68	0.03	0.63	0.77
	C	4	0.89	0.12	0.74	1.26
8th week	A	4	0.45	0.00	0.44	0.46
	B	4	0.68	0.02	0.64	0.74
	C	4	0.84	0.10	0.57	0.99
9th week	A	4	0.45	0.03	0.37	0.49
	B	4	0.68	0.06	0.54	0.81
	C	4	0.86	0.08	0.61	0.97
10th week	A	4	0.40	0.04	0.31	0.50
	B	4	0.70	0.04	0.60	0.79
	C	4	0.77	0.09	0.56	0.99
11th week	A	4	1.14	0.17	0.81	1.60
	B	4	0.92	0.16	0.61	1.39
	C	4	0.95	0.11	0.71	1.26
Mean	A	4	0.47	0.00	0.46	0.48
	B	4	0.64	0.00	0.63	0.65
	C	4	0.78	0.04	0.70	0.88

Appendix-vi Analysis of variance of average daily gain (kg) of Kundhi buffalo calves fed fattening ration during treatment period of 11 weeks.

Period	Source of variation	Degree of freedom	Sum of Squares	Mean Square	F-value	P-value
1st week	Between Groups	2	0.11	0.06	7.58	0.012
	Within Groups	9	0.07	0.01		
	Total	11	0.18			
2nd week	Between Groups	2	0.14	0.07	15.26	0.001
	Within Groups	9	0.04	0.00		
	Total	11	0.18			
3rd week	Between Groups	2	0.46	0.23	7.85	0.011
	Within Groups	9	0.26	0.03		
	Total	11	0.73			
4th week	Between Groups	2	0.18	0.09	6.97	0.015
	Within Groups	9	0.12	0.01		
	Total	11	0.30			
5th week	Between Groups	2	0.32	0.16	6.99	0.015
	Within Groups	9	0.20	0.02		
	Total	11	0.52			
6th week	Between Groups	2	0.30	0.150	11.69	0.003
	Within Groups	9	0.12	0.013		
	Total	11	0.41			
7th week	Between Groups	2	0.36	0.18	6.60	0.017
	Within Groups	9	0.25	0.027		
	Total	11	0.61			
8th week	Between Groups	2	0.31	0.15	11.31	0.004
	Within Groups	9	0.12	0.01		
	Total	11	0.43			
9th week	Between Groups	2	0.33	0.17	11.80	0.003
	Within Groups	9	0.13	0.01		
	Total	11	0.46			
10th week	Between Groups	2	0.30	0.15	9.66	0.006
	Within Groups	9	0.14	0.02		
	Total	11	0.44			
11th week	Between Groups	2	0.11	0.06	0.621	0.559
	Within Groups	9	0.80	0.09		
	Total	11	0.91			
Mean	Between Groups	2	0.20	0.10	50.97*	0.000
	Within Groups	9	0.02	0.00		
	Total	11	0.21			

Appendix-vii Descriptive statistics of dry matter intake (kg) of Kundhi buffalo calves fed fattening ration during treatment period of 11 weeks.

Period	Groups	N	Mean	Std. Error	Minimum	Maximum
1st week	A	4	2.67	0.06	2.52	2.80
	B	4	2.93	0.03	2.87	2.99
	C	4	3.38	0.08	3.20	3.57
2nd week	A	4	2.76	0.04	2.69	2.89
	B	4	3.15	0.09	2.91	3.33
	C	4	3.70	0.07	3.57	3.90
3rd week	A	4	2.88	0.04	2.83	2.98
	B	4	3.18	0.03	3.13	3.26
	C	4	3.66	0.11	3.39	3.91
4th week	A	4	2.92	0.03	2.87	2.98
	B	4	3.57	0.08	3.41	3.73
	C	4	3.99	0.08	3.82	4.20
5th week	A	4	3.05	0.03	2.96	3.13
	B	4	3.66	0.05	3.52	3.75
	C	4	3.59	0.06	3.51	3.76
6th week	A	4	3.26	0.04	3.16	3.37
	B	4	4.11	0.08	3.90	4.23
	C	4	4.05	0.05	3.96	4.19
7th week	A	4	3.49	0.05	3.42	3.63
	B	4	4.01	0.06	3.86	4.13
	C	4	3.96	0.11	3.69	4.15
8th week	A	4	3.67	0.06	3.55	3.80
	B	4	4.43	0.04	4.30	4.52
	C	4	4.66	0.13	4.30	4.87
9th week	A	4	3.90	0.05	3.76	3.98
	B	4	4.30	0.08	4.06	4.44
	C	4	4.82	0.05	4.72	4.93
10th week	A	4	4.03	0.03	3.94	4.10
	B	4	4.49	0.06	4.31	4.58
	C	4	4.98	0.04	4.87	5.07
11th week	A	4	4.12	0.04	4.04	4.22
	B	4	4.45	0.02	4.42	4.49
	C	4	4.88	0.09	4.72	5.11
Mean	A	4	3.34	0.04	3.26	3.43
	B	4	3.84	0.05	3.70	3.93
	C	4	4.15	0.07	4.00	4.30

Appendix-viii Analysis of variance of dry matter intake (kg) of Kundhi buffalo calves fed fattening ration during treatment period of 11 weeks.

Period	Source of variation	Degree of freedom	Sum of Squares	Mean Square	F-value	P-value
1st week	Between Groups	2	1.04	0.51	37.19	0.000
	Within Groups	9	0.12	0.01		
	Total	11	1.15			
2nd week	Between Groups	2	1.76	0.88	40.37	0.000
	Within Groups	9	0.20	0.02		
	Total	11	1.99			
3rd week	Between Groups	2	1.25	0.62	34.74	0.000
	Within Groups	9	0.16	0.02		
	Total	11	1.41			
4th week	Between Groups	2	2.30	1.15	63.59	0.000
	Within Groups	9	0.16	0.02		
	Total	11	2.46			
5th week	Between Groups	2	0.91	0.45	46.03	0.000
	Within Groups	9	0.09	0.01		
	Total	11	0.99			
6th week	Between Groups	2	1.81	0.91	65.84	0.000
	Within Groups	9	0.12	0.01		
	Total	11	1.92			
7th week	Between Groups	2	0.66	0.33	16.23	0.001
	Within Groups	9	0.18	0.02		
	Total	11	0.85			
8th week	Between Groups	2	2.15	1.08	37.54	0.000
	Within Groups	9	0.26	0.03		
	Total	11	2.41			
9th week	Between Groups	2	1.73	0.86	54.99	0.000
	Within Groups	9	0.14	0.02		
	Total	11	1.87			
10th week	Between Groups	2	1.82	0.91	106.38	0.000
	Within Groups	9	0.08	0.01		
	Total	11	1.91			
11th week	Between Groups	2	1.15	0.58	41.81	0.000
	Within Groups	9	0.12	0.01		
	Total	11	1.28			
Mean	Between Groups	2	1.34	0.67	59.17*	0.000
	Within Groups	9	0.10	0.01		
	Total	11	1.44			

Appendix-ix Descriptive statistics of feed conversion ratio (FCR) of buffalo calves fed fattening ration during treatment period of 11 weeks.

Period	Groups	N	Mean	Std. Error	Minimum	Maximum
1st week	A	4	19.91	1.13	16.76	21.64
	B	4	13.29	1.42	9.82	16.60
	C	4	12.78	1.66	8.20	16.17
2nd week	A	4	17.69	1.77	15.11	22.64
	B	4	15.39	2.74	10.71	22.67
	C	4	10.89	0.33	10.05	11.65
3rd week	A	4	9.31	0.69	8.42	11.36
	B	4	7.86	0.75	6.59	9.89
	C	4	6.37	0.96	4.27	8.78
4th week	A	4	9.99	0.60	9.11	11.77
	B	4	7.69	0.23	7.02	8.02
	C	4	8.25	0.97	6.15	10.83
5th week	A	4	9.85	0.38	9.28	10.96
	B	4	7.51	0.21	7.08	8.07
	C	4	7.57	1.40	5.67	11.74
6th week	A	4	9.98	0.40	9.26	10.96
	B	4	7.76	0.25	7.02	8.09
	C	4	7.42	0.85	5.90	9.85
7th week	A	4	10.17	1.23	7.23	12.58
	B	4	7.69	0.56	6.17	8.61
	C	4	7.02	0.69	4.97	7.79
8th week	A	4	9.82	0.14	9.53	10.19
	B	4	7.53	0.43	6.31	8.36
	C	4	7.39	0.92	6.06	10.08
9th week	A	4	10.03	0.59	9.15	11.77
	B	4	7.45	0.43	6.49	8.50
	C	4	7.10	0.71	6.27	9.23
10th week	A	4	11.59	1.32	8.97	13.95
	B	4	7.10	0.52	6.20	8.60
	C	4	7.91	0.89	5.77	10.00
11th week	A	4	4.22	0.58	2.74	5.54
	B	4	5.72	0.78	3.67	7.44
	C	4	6.32	0.73	4.36	7.86
Mean	A	4	11.14	0.40	10.40	11.96
	B	4	8.64	0.44	7.73	9.75
	C	4	8.09	0.28	7.52	8.84

Appendix-x Analysis of variance of feed conversion ratio (FCR) of Kundhi buffalo calves fed fattening ration during treatment period of 11 weeks.

Period	Source of variation	Degree of freedom	Sum of Squares	Mean Square	F-value	P-value
1st week	Between Groups	2	126.71	63.36	7.85	0.011
	Within Groups	9	72.62	8.07		
	Total	11	199.33			
2nd week	Between Groups	2	95.81	47.91	3.35	0.082
	Within Groups	9	128.80	14.31		
	Total	11	224.61			
3rd week	Between Groups	2	17.32	8.66	3.311	0.084
	Within Groups	9	23.54	2.62		
	Total	11	40.86			
4th week	Between Groups	2	11.54	5.77	3.21	0.089
	Within Groups	9	16.23	1.80		
	Total	11	27.77			
5th week	Between Groups	2	14.22	7.11	2.48	0.139
	Within Groups	9	25.81	2.87		
	Total	11	40.02			
6th week	Between Groups	2	15.47	7.73	6.13	0.021
	Within Groups	9	11.35	1.26		
	Total	11	26.82			
7th week	Between Groups	2	21.98	10.99	3.58	0.072
	Within Groups	9	27.59	3.07		
	Total	11	49.58			
8th week	Between Groups	2	14.89	7.45	5.31	0.030
	Within Groups	9	12.62	1.40		
	Total	11	27.51			
9th week	Between Groups	2	20.54	10.27	7.38	0.013
	Within Groups	9	12.53	1.39		
	Total	11	33.07			
10th week	Between Groups	2	45.81	22.91	6.11	0.021
	Within Groups	9	33.72	3.75		
	Total	11	79.53			
11th week	Between Groups	2	9.32	4.66	2.37	0.149
	Within Groups	9	17.69	1.97		
	Total	11	27.01			
Mean	Between Groups	2	21.19	10.60	18.33*	0.001
	Within Groups	9	5.20	0.59		
	Total	11	26.39			