Turk. J. Vet. Anim. Sci.
2009; 33(6): 447-454

doi:10.3906/vet-0707-11

Research Article

Growth response of yearling buffalo male calves to different dietary energy levels

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Received: 09.07.2007

Abstract: To evaluate different levels of energy for optimum growth in Iranian regional buffalo male calves, a completely randomized study was conducted, using 27 yearling buffalo male calves with initial live weight of 201 ± 14 kg. Three diets were formulated to provide 90%, 100%, and 110% energy level requirements equivalent to those of steers derived from NRC beef cattle recommendations and they were fed ad libitum for 2 consecutive 90 day trial periods where the crude protein was 11.2% in the first and 10.22% in the second period. Dry matter intake of the high energy diets was significantly ($P < 0.05$) lower than those with lower energy contents in both periods. At both stages, daily gain was higher ($P < 0.05$) and feed conversion ratio improved when the animals received NRC recommended energy diets. There were no significant differences between treatments for the carcass traits with exception of abdominal fat, which was significantly affected by the energy levels ($P < 0.05$). It can be concluded that the optimum growth rate of buffalo male calves may be obtained by providing the NRC beef cattle standard dietary metabolizable energy from yearling to 18 months of age.

Key words: Buffalo male calves, growth rate, energy levels

Introduction

Buffaloes are known to be more efficient in utilizing fiber component of the coarse feed than cattle and they thrive well on crop residues and agricultural by-products (1). Punia and Sharma (2), who studied the influence of dietary energy on ruminal volatile fatty acid (VFA) production rate in buffaloes and cattle, reported higher total VFA production rate and lower turnover time in buffaloes than in cattle. The more relaxed behavior of buffaloes is thought to be the reason for lower energy requirement for maintenance and growth of buffaloes when compared to cattle fed similar diets under same conditions (3). Singh et al. (4) reported that nutrient digestibility and nitrogen balance were higher in buffalo calves when compared with cross-bred cattle calves.

The prospects for meat production from buffalo husbandry have shown to be successful under local conditions. Buffaloes reared under feedlot

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management with suitable diets have been shown to possess the potential for production of high quality carcasses (5,6). Swamp buffaloes raised on feedlot using agricultural by-products as their major feed ingredients can reach a normal growth rate of about 0.59 kg per day (7). Average daily gain was 484 g/day with a feed conversion ratio of 11.0, when raising buffalo calves fed urea treated wheat straw-based rations 58% supplemented with 42% concentrate mixtures (7). Udeybir et al. (8) reported that dry matter intake is higher in growing cattle than in growing buffaloes but buffalo calves utilized dry matter, energy, and protein more efficiently for growth than cattle calves. Texeira et al. (9) found that buffaloes and Zebu cattle had significantly lower energy and protein requirements than Holstein cattle. Baruah et al. (10) compared diets containing 100% protein and 110% energy for 0.5 kg daily gains of NRC requirements of beef cattle (11) in Murrah and Desi buffalo male calves. They reported that ADG was 17.6% higher in Murrah calves, but DM intake per 100-kg body weight was higher in Desi calves.

Improvement of growing and fattening performance of buffalo male calves could be achieved through nutritional and management manipulations. In an experiment (10) buffalo male calves, from 80-90 kg to 300-kg live weight, were given low-, medium, or high-energy diets containing 90%, 100%, and 110% requirements suggested for beef cattle (11). Results showed that the average daily gain was 516, 559, and 607 g respectively, which was significantly affected by the energy levels. Devendra (12) fed diets with constant metabolizable energy, about 10.5 MJ/kg, and crude protein (CP) of 6%, 8%, 10%, 12%, 14%, 16%, 18%, 20%, or 22% of DM to buffalo bulls with live weight of 415-521 kg. Average daily gain was maximum when the animals received 10% CP in the diet. Nitrogen balance was negative with 6% protein but increased to a maximum positive with 14% CP in the diet. Meanwhile, limited work has been reported on nutrient requirements of growing and fattening buffalo calves.

The objective of this work was to study the response of growing male calves of the Iranian regional buffalo to different levels of energy in the diet from 12 to 15 months and 15 to 18 months of age.

Materials and methods

Twenty-seven yearling buffalo male calves with initial live weight of 201 ± 14 kg were used in a 2-stage experiment. The animals were housed individually (in a 3 × 4 m shed pen) and randomly allocated into 1 of the 3 treatment groups of 9 animals each. The calves were given an adaptation period of 3 weeks in a trial of 6 months, where individual live weight changes were measured by direct weighing of the animals every month.

Since most of the reported requirements for buffalo (5,13) are estimated from beef cattle requirements (11), it was decided to use these data as the nutritional requirements for calves in this experiment. In first 90 days of the experiment, 3 diets containing 3 levels of energy (E1, E2, E3) with similar levels of crude protein (11.2%) were formulated to provide 90%, 100%, and 110% of energy requirements equivalent for 900 g expected daily body weight gain of the animals used in this study. In the second stage of the experiment (15-18 months of age), a lower amount of protein (10.22%) was used and the energy levels adjusted accordingly (Table 1).

The diets consisted of chopped (2-3 cm) alfalfa hay and wheat straw as roughage components, and barley grain, wheat bran, sugar beet pulp, sugar cane molasses, urea, and mineral supplements were used as concentrate part of the rations. Concentrate ingredients were prepared and combined bi-weekly, and roughage and concentrate were mixed manually every day and offered ad libitum as total mixed ration (TMR) 3 times daily.

Voluntary feed intake (VFI) for each animal was recorded individually and DMI was estimated from VFI percentage of DM. Feed residues were collected, weighed, and sampled every morning before feeding. Pooled feed and residual samples were ground through a 1 mm screen hammer mill separately and analyzed according to AOAC (14), to control and adjust the nutrient concentration of the experimental diets. The ME concentrations were estimated from NRC tables (15). The total body weight gain and average daily gain were calculated from the body weight changes obtained from monthly individual weighing of the animals. Feed conversion ratio was estimated based on the dry matter intake per kg of live weight gain. At the end of the second stage, all animals were slaughtered for carcass measurements.

Table 1. Formulation and nutritive value of the experimental diets.

Feed Ingredients	Diets					
	Stage-I			Stage-II		
	E1	E2	E3	E1	E2	E3
Alfalfa hay	40.2	31.7	16.9	40.71	24.82	12.68
Wheat straw	19.8	11.5	7.1	19.96	15.34	9.53
Roughage	**60.0**	**43.2**	**24.0**	**60.67**	**40.16**	**22.21**
Barley	11.1	26.4	40.0	10.38	22.04	33.25
Wheat bran	14.7	10.0	5.7	12.56	13.71	3.48
Sugar beet pulp	9.1	14.0	22.4	11.94	19.70	36.18
Sugar cane molasses	4.5	5.7	6.8	3.94	3.96	3.96
Urea	0.2	0.2	0.4	0.19	0.16	0.32
Di-calcium Phosphate	0.1	0.4	0.5	0.07	0.03	0.36
Common salt	0.3	0.3	0.3	0.26	0.26	0.26
Concentrate	**40.0**	**56.8**	**76.0**	**39.33**	**59.84**	**77.79**
TOTAL	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
Compositions						
ME(MJ/kg DM)	9.2	10.12	11.13	9.38	10.42	11.18
Crude Protein (g/100g DM)	11.2	11.2	11.2	10.22	10.22	10.22

E1= Low energy. E2= NRC recommended energy. E3= High energy

Data obtained during each stage of the experiment were analyzed according to a completely randomized design with 3 treatments and 9 replicates ($n = 3 \times 9 = 27$ animals) for parametric statistics, including analyses of variance, with 0.05 percent level of significance, by GLM procedure of SAS software (16), using the following model:

$$Y_{ijk} = \mu + T_i + K_i + e_{ij}$$

Y_{ijk} = Responses of animal k in treatment i,

μ = Overall sample mean,

T_i = Treatment i effect,

K_i = Animal k effect,

e_{jk} =Ordinary least squares residual error.

Results

Body weight changes: The initial and final weights of the animals are presented in Table 2. The mean initial body weights of the calves were not significantly different, but the final live weights were different ($P < 0.05$) at the end of each stage. The animals that received the NRC recommended energy level (E2) had the highest final live weight compared to the other diets. A similar trend was observed for the body weight during the second stage of the experiment (Table 2).

The average daily gain (Table 2) was significantly different among the treatments ($P < 0.05$) where the highest daily gain (1078 g/day) was obtained in calves that received diets containing standard NRC energy level compared with low and high energy levels; however, no significant variation was observed between the animals that received the high or low energy diets (889 and 903 g/day).

Table 2. Effects of treatments on the performance of the animals.

Items	Stage I				Stage II			
	Treatments			SEM	Treatments			SEM
	E1	E2	E3		E1	E2	E3	
IBW (kg)	201.5	200.0	202.3	0.81	291.3	294.6	282.5	3.1
FBW (kg)	283.7 b	298.7 a	285.2 b	7.91	336.7 b	378.7 a	335.7 b	7.91
ADG (g/day)	889 b	1078 a	903 b	89.0	633 b	898 a	554 b	68.5
DMI (kg)	5.77 a	5.81 a	5.56 b	0.11	5.87 b	6.52 a	4.70 c	0.31
DMI (% of BW)	2.38	2.33	2.28	0.09	1.9 ab	2.01 a	1.51 b	0.14
DMI (g/kg BW0.75)	94.0 a	93.0 a	84.6 b	4.24	78.8 b	86.6 a	62.9 c	4.5
FCR	6.53 a	5.41 b	5.80 b	0.179	9.40 a	7.27 c	8.47 b	0.36
MECR	61.74ab	57.56 b	67.02a	3.60	87.9 b	85.8c	94.2 a	3.10
CPCR	0.73 a	0.61b	0.65 b	0.06	1.0 a	0.7 c	0.9 b	0.036

Means with the different superscripts within a row for each stage are significantly ($P < 0.05$) different.
E1 = Low energy. E2 = NRC recommended energy. E3 = High energy. IBW = Initial body weight. FBW = Final body weight. ADG = Average daily gain. DMI = Dry matter intake. FCR = Feed conversion ratio = kg of DMI per kg of weight gain. MECR = Metabolizable energy conversion ratio = MJ ME consumed per kg of weight gain. CPCR = Crude protein conversion ratio = kg of crude protein intake per kg weight gain. SEM=Standard Error of Mean.

Dry matter intake: As indicated in the Table 2, the energy levels significantly ($P < 0.05$) affected dry matter intake. When the dry matter intake was calculated based on g/kg of metabolic body weight, similar trend was observed but no significant variation was found among the treatments when it was estimated as percentage of body weight. The highest amount of intake was obtained for the standard energy level (5.81 kg/day), followed by the low energy diet, but the animals on high energy diets consumed the lowest amount of DM ($P < 0.05$). Similar results were found when the DMI was estimated based on the g/kg of metabolic body weight.

Feed efficiency: The results of feed conversion ratio (FCR) and metabolizable energy conversion ratio (MECR) are presented in Table 2. The standard energy diet resulted in the lowest FCR ($P < 0.05$), followed by the high energy diet, whereas the low energy diet had the highest FCR.

At the first stage, the MECR was significantly more for the high energy diet as well as low energy level ($P < 0.05$), whereas the lowest amount was obtained for the diet with the standard level of ME (Table 2). The highest and lowest amounts of MECR were found when the animals received treatments E3 and E2 respectively ($P < 0.05$) during the second stage of the experiment.

Regarding the crude protein conversion ratio (CPCR), diet E2 had the lowest amount ($P < 0.05$), but the diet E1 showed the highest amount of CPCR during the first and second stages of the experiment (Tables 2). As a whole, the energy levels affected FCR, MECR, and CPCR ($P < 0.05$).

Slaughtering characteristics: Results of the carcass characteristics are presented in Table 3. It was found that there were no significant differences between treatments for the carcass traits with the exception of abdominal fat, which was significantly affected by the energy levels ($P < 0.05$).

Table 3. Effect of treatments on the slaughtering traits.

Parameters	Treatments			SEM
	E1	E2	E3	
Live weight (kg)	336.7 b	378.7 a	335.7 b	12.24
Warm carcass weight (kg)	168.8	190.8	167.7	10.98
Cool carcass weight (kg)	164.8	186.2	163.3	11.27
Dressing percentage				
1	50.13	52.83	49.96	2.93
2	48.94	52.21	48.63	3.12
3	54.73	54.53	53.56	2.17
Abdominal fat %	13.1 b	15.4 a	13.2b	1.65b
Meat %	67.5	65.8	67.3	1.75
Bone %	18.4	17.4	18.2	1.84

E1=Low energy. E2=NRC recommended energy. E3=High energy
Means with the different superscripts within a row are significantly ($P < 0.05$) different.
SEM= Standard error of mean
1- Based on: (warm carcass weight /body weight before slaughtering) ×100
2- Based on: (cool carcass weight/ body weight before slaughtering) ×100
3- Based on: (cool carcass weight /empty body weight before slaughtering) ×100

Discussion

Economic forces dictate that livestock producers choose the shortest way of production by optimizing feed efficiency and a major step towards a feasible production is energy manipulation along with changing level of nutrients intake, which could provide drastic variation in metabolic processes in ruminant animals. Works done earlier reported that the body weight of buffalo calves was 350-400 kg when they were slaughtered at 16-20 months of ages (17). It also has been reported that, in a short fattening period of about 4 months, river buffalo male calves may reach 350 kg of body weight with an initial weight of 200 kg (1).

In the present study, final body weight was 336.7, 378.7, and 335.7 kg for the E1, E2, and E3 treatments, respectively, when the animals were 18 month old. These results are in accordance with the above-mentioned reports. However, the live weight of buffalo male calves may be affected by the type and breed of the animal, environmental factors, and feeding management (18-20).

The results obtained from daily body weight gain (Table 2) showed that the energy levels of the diets significantly affected the daily body weight gain ($P < 0.05$). The highest amount of daily gain was obtained in calves that received diets containing NRC recommended energy (standard level), whereas the animals that received high or low energy diets had lower average daily gain. The same trend was observed for the final body weight at the end of each stage of the experiment. The results of this experiment in stage one are different from those reported by Baruah et al. (10), when they conducted an experiment on buffalo male calves, from 80-90 kg to 300-kg live weight fed low-, standard-, or high-energy diets that contained 90%, 100%, and 110% of NRC (11), suggested for beef cattle requirements. They found that the average daily gain was 516, 559, and 607 g, respectively, which was significantly influenced by the energy levels. Although in the first stage we found higher amounts of daily gains in all treatments, in the second stage our results were not far from the findings of the above work. Similar data were reported by Yunus et al. (6), where they found a daily weight gain of 980 g for yearling buffalo calves where it is not far from the results of the first stage in this experiment. The average daily gain could also be affected by genetic resources, initial body weight, age, and nutritional management (21,22). Such results indicating that manipulation of energy level in the diet could exert a profound effect on the weight gain of these animals at this age.

There was also significant variation among treatments for dry matter intake ($P < 0.05$), which was between 5.56 and 5.81 kg per animal per day at the first stage and between 4.7 and 6.52 kg during the second stage of this experiment (Table 2). Variation between the treatments was also significant ($P < 0.05$), when the dry matter intake was calculated based on the metabolic body weight ($BW^{0.75}$). It seemed that the diet formulated to provide the standard energy level (11) encouraged the animals to consume more dry matter during the both stages of the experiment.

We concluded that, beside the physical and chemical characteristics of the ration, the feed intake is mostly affected by the energy concentration in the diet (10). In our opinion the feeding behavior of buffaloes may put a limit on concentrate consumption and cause an inhibitory effect on its intake. The results of DMI in this study are similar to those reported by Udeybir et al. (8), and Barque et al. (23), where they found that DMI was 2.1% and 2.4% of body weight or 89 to 94 g per kg of metabolic body weight for growing buffaloes weighing between 200 and 320 kg. Similar studies were performed to estimate the dry matter requirement of growing Indian buffalo calves fed concentrate and wheat straw to supply 2 levels (75% and 100%) of protein and 3 levels (90%, 100%, and 110%) of energy as the NRC beef cattle (11), for 500 g daily gain (5,24), and they found that DMI is dependent on the body weight, daily gain, and energy levels of the diet. Singh et al. (4), who studied nutrient utilization and growth rate of buffalo calves, reported that the average daily dry matter intake, based on the kg/100 kg body weight, was 2.47, in accordance with the low energy diet used in our experiment (2.38 kg).

The results of feed efficiency (estimated based on the dry matter intake), metabolizable energy intake, and crude protein intake per kg of live weight gain were significantly affected by the treatments in both stages of the experiment (Table 2).

The results from stage one (5.41-5.8 FCR) are not far from the findings published by Yunus et al. (6), who reported an FCR of 5.2 with 980 g/day of live weight gain in buffalo calves, when the animals received standard energy diet. However, the FCR was less than that reported by Boujarpoor (25), who studied the fattening performance of buffalo male calves in the same area of Iran. Our findings from the second stage are in accordance with this report. In general, various results of daily gain and FCR reported for buffalo male calves are due to variation in breed, age, feeding systems, and management (1,26). However, estimation of feed efficiency based on the energy and protein consumption per unit of live weight gain may give comparable results for growing animals, including buffalo calves.

At the first stage, the MECR was significantly more for the high energy diet as well as low energy level ($P < 0.05$), whereas the lowest amount was obtained for the diet with the standard level of ME (Table 2). The highest and lowest amounts of MECR were found where the animals received treatments E3 and E2 respectively ($P < 0.05$) during the second stage of the experiment. Similar results indicated that metabolizable energy and crude protein intake increased with increasing level of metabolizable energy and crude protein contents in the diet of Nili-Ravi buffalo calves (13).

In spite of the CP content, the protein degradability and bioavailability also can affect feed and nutrient efficiency in buffalo calves. It has also been reported that the digestibility of CP and nitrogen balance were higher in buffaloes when compared with cross-bred cattle calves (4). For the levels of energy, it has been shown that the standard level (10.12 MJ ME/kg DM) resulted in the lowest FCR (5.41), which was lower than the other reports (7), which found 10.46 to 11.10 for buffalo calves fed urea ammoniated wheat straw based rations, supplemented with concentrate mixtures with roughage to concentrate ratio of 58:42. Feed efficiency is also affected by the age, breed, body weight, fattening period, and nutrient concentration of the diet. As found in this experiment, feeding diets with the NRC recommended energy level resulted in better efficiency in yearling buffalo calves. As for the crude protein conversion ratio (CPCR), diet E2 had the lowest amount ($P < 0.05$)

while diet E1 showed the highest CPCR during both stages of the experiment (Table 2).

Little information has been reported for the carcass characteristics of buffalo calves; however, the results of this study are in agreement with Sengar et al. (27), who found that there were no significant differences in carcass quality of male buffalo calves fed diets containing different protein levels and slaughtered at 24 months of age. Marcos et al. (28) reported that hot and cold dressing percentages were from 50.3 to 51.2 and from 48.8 to 49.5 respectively for buffalo calves fed different roughage:concentrate diets and slaughtered when they were around 500 kg of live weight, in accordance with our results. The percentage of meat to carcass weight in this study was between 64.4% and 68.1%, which was higher than those (59% to 61%) reported by Marcos et al. (28), but the bone percentage was from 16.9% to 19.7%, which was similar to those (16.0% to 17.3%) reported by the above authors. According to the data from Guangxi Buffalo Research Institute, China, triple crossbred buffalo calves at 18 months of age had a dressing percentage of 59.9%, net meat of 42.1%, and bone to meat ratio of 1.4:4.0 (29). Carcass characteristics also could be affected by the breed, nutritional management, age, and live weight of buffalo calves.

The results of this study indicated that favorable growth performance of male yearling buffalo calves may be obtained by providing 10.13 MJ/kg of dietary metabolizable energy with 11.2% crude protein from 12 to 15 months age, but for 15 to 18 months around 10.42 MJ/kg of dietary metabolizable energy and about 10.22% of crude protein are required. However, further research is needed for the validation of nutrient requirements for different physiological stages of buffalo calves. A system to monitor the nutritional status of buffaloes would be beneficial to reduce losses and maximize efficiency of nutrient utilization.

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