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Effect of Concentrate to Roughage Ratio on Cost Effective Growth Performance of Brahman Crossbred Calves

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Abstract: An experiment was conducted to evaluate the growth performance and cost per gain of Brahman × local crossbred bull calves receiving three diets with varying concentrate to roughage ratio (C:R) of 75:25, 65:35 and 55:45 on dry matter (DM) basis. Twelve bull calves (aging 11.5 ± 1.2 months and 170.8 ± 13.0 kg live weight) divided into three equal groups were fed on three diets. The diets were balanced to 14.5% crude protein (CP) level and 10.5 MJ metabolizable energy (ME) per kg DM, formulating different concentrate mixtures. German grass (*Echinoclora grousgali*) and paddy straw were offered at 2:1 ratio on DM basis as roughages. The results revealed that C:R ratio did not affect ($P > 0.05$) the intake of feed and nutrients, feed efficiency (7.04, 6.94 and 6.76) and average daily gain (981, 958 and 976 g). Digestibility of nutrients was not affected ($P > 0.05$) by C:R. Animals fed diet with C:R = 55:45 had the lowest feed cost (Bangladeshi Taka 136.8 BDT/kg live weight gain), which was increased (147.5 BDT and 153.8 BDT) non-significantly ($P > 0.05$) with the increasing level of concentrate. The diet consisting of 55% concentrate mixture showed similar results with the diet consisting of 75% concentrate mixture, but was comparatively economic. Therefore, considering the growth performance and cost per kg gain of Brahman crossbred growing calves, it may be concluded that the diet consisting of 55:45 C:R may be used for economic beef production.

Key words: Brahman crossbred, concentrate to roughage ratio, growth, iso-nitrogenous.

1. Introduction

Under traditional feeding, the growth rate of young indigenous cattle was found to be 100 g/d to 200 g/d, and on improved feeding it was improved to 300 g/d to 800 g/d [1, 2]. A crossbreeding program between Brahman sire and indigenous non-descript native cows was undertaken in order to meet the growing demand of meat in different parts of Bangladesh. The advantage of Brahman sire with faster growth rates can not be sufficiently exploited unless adequate nutrition in both quantity and quality are available in feedlot. A feedlot ration should be designed to give maximum weight gain and fattening rate at the lowest cost with minimum digestive upset. Modern beef feeding requires the manipulation of concentrate to roughage ratio (C:R) which affects gain and efficiency of gain. Over time, there has been a trend towards higher grain feeding levels in most feedlot diets. Generally, a feedlot ration containing of C:R = 75:25 gives satisfactory weight gain at minimum risk, although it can vary from 50:50 to 90:10 [3]. As forage concentration increased, dry matter (DM) intake increased, but average daily gain (ADG) remained unchanged, thereby resulting in lower feed efficiency [4]. Feeding high-forage at concentrations greater than 55% may reduce gain and feed conversion [5], and feeding concentrate at concentration of 60% showed better performance when comparing four iso-nitrogenous diets containing

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of 20%, 40%, 60% and 80% concentrate, respectively [6]. Diets containing a high proportion of grass silage (100% or 72%) have sustained lower growth rates and resulted in a lower proportion of fat and protein in the gain than that of diet containing 44% silage, when similar quantities of energy and protein have been given in the form of high-concentrate diets [7]. However, a trend towards higher gain costs was observed as grain level increased. In a trial of four iso-nitrogenous diets, cost estimates were greater (1 kg of gain) for cattle fed with the high grain or concentrate diet, and as grain levels increased, cost of gain estimates also increased [8]. Therefore, it is quite necessary to evaluate a range of C:R ratio in iso-nitrogenous and iso-caloric diets for feedlot cattle. However, literature regarding feeding effect on growth performance of Brahman × local crossbred bull calves under feedlot is scanty in Bangladesh. Thus, the present study was conducted to evaluate three iso-nitrogenous and iso-caloric diets with varying C:R ratio on growth performance, digestibility of diets and cost per kg gain in Brahman crossbred growing bull calves and to determine the appropriate C:R ratio for economic beef production.

2. Materials and Methods

2.1 Experimental Site, Animals and Housing

The experiment was conducted in the Central Cattle Breeding and Dairy Farm, Savar, Dhaka under the Department of Livestock Services for a period of 124 d from June 18 to October 19, 2012. Twelve Brahman × local crossbred bull calves of 11.5 ± 1.2 months and 170.8 ± 13.0 kg average live weight were selected, kept in individual stall (10 feet × 5 feet) with separate feeding and watering systems under a tin shed, adjusted to experimental diets for 10 d, and de-wormed with anthelmintics immediately before the start of feeding experimental diets. Each animal was tied up by a rope, so that animals could easily take feed and lay down for rest on the stanchion barn. All the animals were kept under strict hygienic measures and uniform management throughout the experimental period.

2.2 Experimental Diets

The animals were divided into three treatment groups, each group with four animals had similar average live weight and were fed three diets with varying C:R ratio. Concentrates were formulated based on wheat bran, ground corn, crushed khesari (*Lathyrus sativus*), soybean meal, dicalcium phosphate and salt. The rations were formulated according to the nutritional requirements described in Refs. [3, 9] expecting of daily gains 1.0 kg/animal. The chemical compositions of the feed ingredients, the dietary combination and the experimental diets are shown in Tables 1 and 2, respectively. Three diets were formulated with concentrate mixtures and roughages (German grass and paddy straw). In these experimental diets, C:R ratios were 75:25, 65:35 and 55:45 on DM basis, which were designated as diet A, B and C, respectively. Three concentrate mixtures were formulated for three diet groups to make the diets iso-nitrogenous with 145 g crude protein (CP)/kg DM and iso-caloric with 10.5 MJ metabolizable energy (ME)/kg DM (Table 3). German grass (*Echinoclora grousgali*) and paddy straw were offered at 2:1 ratio on DM basis as roughage, while German grass was provided *ad libitum*. Grass and straw were chopped into small pieces before offering to the experimental animals. All concentrate feed ingredients for the experiment was collected at the same time to avoid variations in feed composition.

The ME value of each ingredient was estimated by Eq. (1) [10]:

$$\text{ME (MJ/kg DM)} = 13.50 + 0.263 \times \text{EE\%} - 0.133 \times \text{ash\%} - 0.136 \times \text{ADF\%} \quad (1)$$

where, EE = ether extract, ADF = acid detergent fiber.

The ME value of concentrate mixture was calculated by the estimated ME value of the ingredients. The ME for German grass was estimated by Eqs. (2) and (3) [10]:

$$\text{ME (MJ/kg DM)} = 0.15 \times \text{DODM\%} \quad (2)$$

$$\text{DODM} = 75.73 - (0.269 \times \text{ADF\%}) \quad (3)$$

Table 1 Chemical composition of feed ingredients.

Ingredient	DM (%)	Composition (% in DM)			
		OM	CP	Ash	ADF
Wheat bran	87.04	92.80	15.22	7.20	13.53
Ground corn	86.41	98.51	9.00	1.49	6.81
Crushed khesari	89.08	94.84	30.70	5.16	14.99
Soybean meal	88.57	91.75	43.56	8.25	7.04
Paddy straw	91.57	82.98	3.84	17.02	46.85
German grass	16.00	89.84	10.53	10.16	41.21

DM = dry matter, OM = organic matter, CP = crude protein, ADF = acid detergent fiber.

Table 2 Formulation and chemical composition of the diets (on DM basis).

Parameters	Diets		
	A	B	C
Dietary composition			
Concentrate mixture (%)	75.00	65.00	55.00
Roughage (%)	25.00	35.00	45.00
Total	100	100	100
Nutrient composition (% of DM)			
Organic matter	92.33	92.26	92.13
Crude protein	14.52	14.51	14.51
Acid detergent fiber	19.97	21.83	23.94
Ash	7.67	7.74	7.87
Calcium	0.63	0.65	0.66
Estimated ME (MJ/kg DM)	10.52	10.56	10.53

Diet A with C:R = 75:25, diet B with C:R = 65:35, diet C with C:R = 55:45.

Table 3 Formulation of three concentrate mixture for three diets (kg DM).

Ingredients	Diets		
	A	B	C
Wheat bran	71.05	46.03	14.65
Ground corn	12.15	29.61	49.79
Crushed khesari	11.13	8.69	8.94
Soybean meal	2.63	12.17	22.49
Di-calcium phosphate	2.43	2.81	3.32
Salt	0.60	0.69	0.81
Total	100	100	100
Chemical composition			
Crude protein (%)	16.48	17.67	19.30
Estimated ME (MJ/kg DM)	11.16	11.60	12.08

Diet A with C:R = 75:25, diet B with C:R = 65:35, diet C with C:R = 55:45.

The ME value of paddy straw was assumed to 6.2 MJ ME/kg DM [11].

2.3 Feeding

The animals were provided with DM of 2.8% of the body weight according to Refs. [3, 12]. Total amount of concentrate mixtures and straw allocated for each animal were weighed out daily, divided into two halves and supplied to the animal at 07:00 and 15:30. Green grass was provided at 11:00 am *ad libitum* after complete consumption of morning's allocated straw. It was ensured that offered amount of

concentrate and straw were fed. The leftover of grass in the feed trough was weighed at the following morning. Clean and fresh water was offered twice a day to all animals.

2.4 Feed Intake, Digestibility and Live Weight Gain (LWG)

Daily feed offered to and refused by an individual animal were recorded. The daily DM intake (DMI) of each animal was determined by Eq. (4):

Daily DMI = the amount of DM supplied on the earlier day – the amount of DM left over in the next morning (4)

Initial live weight of each animal was measured before feeding at the beginning day of experiment and final live weight was measured at the end of the feeding period. Animals were weighed at 10 d interval, except for the last 14 d, before morning fed with a platform weighing balance to observe the total LWG during experiment. The total LWG were measured by Eq. (5):

Total LWG = final live weight – initial live weight (5)

The daily LWG of an individual bull calf was calculated with Eq. (6):

Daily LWG = total LWG/total days of the experiment (6)

A conventional digestibility trial was conducted for a period of 7 d collection period towards the end of the growth trial to determine the digestibility of DM, organic matter (OM), CP, ash and ADF. During the digestibility trial period, in addition to weighing of feeds and refusals, feces of the individual animal was collected and weighed. Representative samples of feed, refusals and feces were collected and used for chemical analysis. The DM and CP of feed, refusal and feces were analyzed during the collection period. A part of well-mixed fresh feces sample, collected every day from individual animal, was stored at -20 °C. At the end of collection period, the stored feces were composite together and then used for the determination of DM, CP, ash and ADF contents.

2.5 Chemical Analysis

The representative samples of feed ingredients, feces and left over of grass were used for chemical (DM, CP, EE and ash) analysis in the laboratory of Bangladesh Livestock Research Institute following the methods in Ref. [13], and the ADF and NDF were analyzed following the method in Ref. [14]. German grass was sampled every two weeks and analyzed for DM and CP. All the samples were analyzed in duplicate and mean values were recorded. The digestibility of nutrients was calculated according to Ref. [15].

2.6 Economic Analysis

Economic analyses were done considering feed cost only. The costs of concentrate mixtures for diet A, B and C were calculated as Bangladeshi Taka (BDT) 28.65, 30.20 and 32.45 BDT/kg DM, respectively, and costs of straw and grass were calculated as 3.28 BDT/kg DM and 6.25 BDT/kg DM, respectively. Thus, the cost of diet was calculated: 21.84 BDT/kg DM of diet A; 21.24 BDT/kg DM of diet B and 20.22 BDT/kg DM of diet C. The gain cost was calculated according to Eq. (7):

Gain cost (BDT/kg gain) = [total DMI (kg) × cost/kg of diet DM]/total LWG (kg) (7)

2.7 Calculation of Methane Production

Emission of methane from animals fed experimental diets was calculated by Eq. (8) [16]:

Emission of methane (g/d) = 0.034 × DMI + 3.439 (8)

2.8 Statistical Analysis

The data were analyzed in an ANOVA of a completely randomized design using general linear models procedure with SAS software [17] and the significant differences in the response of the diets were determined by Duncan's multiple-range test for different parameters at 5% level of probability [18].

3. Results

3.1 Feed Intake and Digestibility

The intakes of DM, CP and ME by the bull calves were not affected ($P > 0.05$) by C:R ratios (75:25, 65:35 and 55:45) in diets (Table 4). There were no differences ($P > 0.05$) in the digestibility coefficient of DM and other nutrients among the diets (Table 4). The highest digestibility coefficient of DM, OM and CP was observed in diet B, followed by diet C and diet A, whereas, ash and ADF digestibility decreased, but non-significantly, with the increase of concentrate level in the diet. No differences were observed in different digestible nutrients in the diet except ADF. A higher ADF (23.94%) content and digestibility of diet C than that of other two diets (19.97% in diet A and 21.83% in diet B) resulted in a significantly ($P < 0.01$) increased amount of digestible ADF (17.0 g/100 g dietary DM; Table 4).

3.2 LWG and Feed Conversion Efficiency

Total LWG of 121.6, 118.0 and 121.0 kg, respectively for diet A, B and C, were not significantly different ($P > 0.05$). Similar to the total LWG, the C:R ratio had no influence ($P > 0.05$) on ADG of 981, 958 and 976 g in the same respective order (Table 5). No significant differences were found among the diets for feed conversion efficiency ($P > 0.05$). Similarly, CP and ME conversion ratio did not diverge ($P > 0.05$) among the diets. The non-significance for feed conversion efficiency among diets may have been a result of similar digestibility of nutrients in the diets.

3.3 Calculated Methane Production

The calculated emission of methane from animals fed experimental diets is presented in Table 5. The C:R ratio had no influence on methane production ($P > 0.05$). The daily methane production for all diets varied from 225.7 g/d to 236.9 g/d or equal to 34.51 g/kg DMI to 34.53 g/kg DMI.

3.4 Economic Efficiency

Daily feed cost was found the highest ($P < 0.05$) in

Table 4 Feed intake, digestibility and nutritive value of different diets.

Parameters	Diets			SEM	*P*
	A	B	C		
Feed and nutrient intake					
DMI from roughage (kg/d)	2.01[c]	2.38[b]	2.94[a]	0.117	< 0.0001
DMI from concentrate (kg/d)	4.85[a]	4.24[b]	3.60[c]	0.165	< 0.0001
Total DMI (kg/d)	6.87	6.63	6.54	0.091	0.33
CP intake (kg/d)	0.98	0.95	0.94	0.013	0.52
Estimated ME intake (MJ/d)	71.90	69.90	68.70	0.943	0.41
Digestibility (%)					
DM	69.90	73.30	72.80	0.75	0.13
OM	74.10	77.40	76.40	0.67	0.10
CP	74.70	76.60	75.00	0.70	0.53
Ash	19.90	22.50	29.60	2.33	0.23
ADF	65.00	69.90	71.10	1.30	0.12
Digestible nutrients (g/100 g DM)					
Digestible OM	68.40	71.40	70.40	0.61	0.10
Digestible CP	10.80	11.10	10.90	0.10	0.54
Digestible Ash	1.53	1.74	2.33	0.18	0.19
Digestible ADF	13.00[c]	15.30[b]	17.00[a]	0.54	0.0003

[a, b, c]Values having different superscripts in the same row differ significantly at $P < 0.05$.

Diet A with C:R = 75:25, diet B with C:R = 65:35, diet C with C:R = 55:45; DMI = dry matter intake; DM = dry matter; OM = organic matter; CP = crude protein; ADF = acid detergent fiber; SEM = standard error of means.

Table 5 Growth performance, feed efficiency and methane production of Brahman crossbred bull calves fed different diets.

Parameters	Diets			SEM	*P*
	A	B	C		
Growth performance					
Initial live weight (kg)	176.60	176.00	177.00	3.78	0.99
Final live weight (kg)	298.30	294.80	298.00	2.73	0.86
Total LWG (kg)	121.60	118.80	121.00	2.45	0.90
Average daily gain (g)	981.00	958.00	976.00	0.020	0.90
Feed utilization					
Feed conversion efficiency (kg DMI/kg LWG)	7.04	6.94	6.76	0.207	0.87
CP conversion efficiency (kg CPI/ kg LWG)	1.00	1.00	0.97	0.03	0.92
ME conversion efficiency (MJ MEI/kg LWG)	73.80	73.20	71.10	2.18	0.89
Calculated methane production					
Methane production (g/d)	236.90	228.80	225.70	3.08	0.33
Methane production (g/kg DMI)	34.50	34.50	34.50	0.007	0.44

DMI = dry matter intake, CPI = crude protein intake, MEI = metabolizable energy intake, LWG = live weight gain, SEM = standard error of means; Diet A with C:R = 75:25, diet B with C:R = 65:35, diet C with C:R = 55:45.

Table 6 Feed cost of different diets.

Parameters	Diets			SEM	*P*
	A	B	C		
Feed cost (BDT/d)	145.00[a]	140.80[ab]	132.20[b]	2.88	0.02
Feed cost (BDT/kg LWG)	153.80	147.50	136.80	4.92	0.40

[a,b]Values having different superscripts in the same row differ significantly at $P < 0.05$.

SEM = standard error of means; Diet A with C:R = 75:25, diet B with C:R = 65:35, diet C with C:R = 55:45.

diet A and the lowest ($P < 0.05$) in diet C, and this was intermediate for diet B, which did not differ either with diet A or C (Table 6). The feed costs required for 1 kg LWG were 153.8, 147.5 and 136.8 BDT for the experimental diet A, B and C, respectively, and these were not differed significantly, but apparently showed a decrease in cost with the decrease in concentrate level in diet.

4. Discussion

4.1 Feed Intake and Digestibility

The numerically slight higher DMI by the animals fed with 75% concentrate diet may be explained by the results of Owens and Goetsch [19] who found that the volume of rumen digesta was the highest, when concentrate level was 50%-80% in diet in comparison to < 20% and 20%-50% concentrate, and the volume of rumen digesta decreased when concentrate level was above 80%. Similar intake of CP and ME by animals fed with three diets could be due to the fact that DMI was not different among the diets and that the diets were iso-nitrogenous and iso-caloric (Table 2). The daily feed and protein intake was not affected by concentrate level ranging 20% to 80% in iso-nitrogenous diets in different breeds [20], steers [21] and heifers [22], which were in accordance with the present results. Feeding four iso-protein diets of different concentrate proportion to Holstein × Brahman crossbred calves [23] found the higher intake of DM, OM and CP in 60% concentrate diet compared to 80% concentrate diet, whereas the DM and CP intake was found to be similar between 40% and 80% concentrate diet.

In the present experiment, the digestibility of DM and other nutrients was not influenced by C:R ratio of diets, which agrees with the results of DM and CP digestibility between two iso-nitrogenous diets [22], among three concentrate levels in diets [23] and

among concentrate level from 0.5% to 1.5% of live weight in diets [24]. Unlike to the present results, as reported by Carvalho et al. [25], DM digestibility was increased with increased concentrate supplementation in diet, when steers were fed with diets based on sugarcane bagasse. Similarly, the increased apparent digestibility of DM and OM of silage based diet due to the increasing concentrate level has been well documented [26, 27]. Paulino et al. [28] found that the animals received concentrate at the rate of 1.2% of live weight showed higher apparent digestibility of diets in relation to those who received concentrate at the rate of 0.6% of live weight.

The reduction in fiber digestibility due to the increased concentrate level, partially comparable to present results, has been reported previously [26, 27, 29]. The negative associative effect is attributed to a depression in fiber digestibility in the rumen and in the total digestive tract from inclusion of rapidly fermentable carbohydrate, such as concentrate [30, 31] in grass silage based diet, and depression rate increased sharply after 60% concentrate level [30].

4.2 LWG and Feed Conversion Efficiency

The concentrate proportion in experimental diets did not affect ADG of Brahman crossbred calves, which are consistent with the results reported by McEwen [21, 32] in beef steers fed on iso-nitrogenous diets of 40%-100% concentrate or McEwen and Mandell [8] in Angus steers between 70% and 35% corn level in diet. Helal et al. [33] reported similar ADG (941-1,017 g) in buffalo calves fed with diets of varied concentrate levels (70%, 85% and 100%). Ribeiro et al. [23] conducted a study to evaluate four iso-nitrogenous diets containing 20%, 40%, 60% and 80% concentrate, respectively, and suggested to keep C:R ratio at 60:40 in the diet of growing calves. The present results are disagreed with Norris et al. [20] who reported a higher ($P < 0.05$) daily gain in animals with C:R = 60:40 than animals with feed C:R = 45:55 and C:R = 35:65 diets containing of iso-nitrogenous. Similarly, Marino et al. [34] found no influence on growth rate by concentrate levels (70% and 30%) in Podolian young bulls. Nellore heifers fed with 45% concentrate diet had greater ADG (0.90 kg) than that (0.74 kg) of those fed with 22.5% concentrate diet, although DM intake, CP intake or feed efficiency between concentrate levels did not vary [22].

The non-significance ADG among the diets in the present experiment was probably due to similar intake of DM, CP and ME, and nearly similar digestibility of DM, OM and CP. Daily weight gain was not affected either by protein level due to similar intake of CP and ME by heifers [35], which corresponds well with the present findings. The above results indicate that total amount of CP and ME intake and CP digestibility regulates weight gain to a great extent.

In the present experiment, C:R ratio in diets did not affect feed conversion efficiency, which are in line with the findings in Refs. [21, 22, 32] that evaluated iso-nitrogenous diets of varied concentrate levels. Feed efficiency was differed neither between 94% and 81.8% concentrate level [36] nor between 70% and 35% corn in diet for steers [8]. In a feeding trial of buffalo calves, Helal et al. [33] found better feed efficiency for 70% concentrate diet than 85% and 100% concentrate diet. Crossbred males fed with high concentrate diet had better ($P < 0.05$) feed conversion rate than that of those fed with medium and low concentrate diets containing of iso-protein [20], which are not supported by the present study, although feed conversion rate (FCR) (7.0) of 60% concentrate diet is similar to the authors' study. Loerch and Fluharty [4] reported that during finishing phase, feed efficiency was the highest ($P < 0.05$) for steers continually fed with 100% concentrate and the lowest ($P < 0.05$) for steers continually fed with 85% concentrate.

4.3 Calculated Methane Production

The overall average methane emission for three diets was found to be 34.52 g/kg DMI, which is closely in agreement with Purnomoadi [16], who

described that the real measured values of methane production were 32.3 g/kg DMI and 36.3 g/kg DMI for Ongole grade cattle and Limousine crossbred cattle, respectively, fed with fermented straw (*ad libitum*) and concentrate (1.5% of live weight). Similarly, Purnomoadi et al. [37] revealed that methane production was 31.9 g/kg DMI for buffaloes fed with commercial concentrate 1% of live weight, while 70% concentrate in diet produced 32.5 g methane/kg DMI.

4.4 Economic Efficiency

Table 6 shows that feed cost/kg LWG increased to 7.8% in diet B and 12.4% in diet A compared to that of diet C. Thus from economical point of view, calves fed with diet C were economically efficient, although not significantly efficient than that of those on diet A and B. The feed cost required for 1 kg LWG increased with the increase of concentrate level in diet. This is in line with McEwen [21] and Helal et al. [33], who demonstrated that feed cost for 1 kg weight gain increased with the increase in concentrate level (15% to 100%) in buffalo and steers, respectively.

5. Conclusions

The diet consisting of 55% concentrate performed more economically compared to the diet consisting of 75% concentrate. Thus, the diet consisting of C:R ratio 55:45 may be used for growing Brahman × local crossbred calves in feedlot.

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