Nutrient Utilization and Compensatory Growth in Crossbred (*Bos indicus*×*Bos taurus*) Calves

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ABSTRACT : A feeding trial was carried out over 238 days to determine the effect of compensatory growth in crossbred calves having 166 kg body weight. Fifteen crossbred calves were divided into two groups of five calves (G1 group) and ten calves (G2 group) as per randomized block design. Growth study was conducted on the feeding of wheat straw based diet containing 60 and 30 percent concentrate supplying equal amount of protein in group G1 and G2 respectively for 119 days (phase - I). At the end of phase-I, calves of G2 group were subdivided in to two groups (G3 and G4). One sub group (G4) received 60% concentrate in their diet (during 120 to 238 days of experiment) while other subgroup G3 received 30% concentrate in their diet (phase-II). The calves of G1 group continued to receive the same diet as during phase-I experiment. Mean DM intake was significantly higher in calves fed high level of concentrate (in G1 and G4 groups), which resulted in significantly higher digestibility of all nutrients except NDF. Nitrogen balance was positive in all the groups and showed significant differences in phase-II (higher nitrogen retention in G4 group than G1 group). ME intake was significantly affected by the level of dietary concentrate, being higher in high concentrate fed group (G1 and G4 than G2 and G3 group). Higher daily body weight gain in the calves of G4 group during phase-II than in G1 and G3 groups was due to compensatory growth on shifting animals from low concentrate to high concentrate based ration. Average daily body weight gain was higher in phase-I than in the phase-II. Protein and energy intake per unit body weight gain were significantly lower in calves fed high concentrate diet. (*Asian-Aus. J. Anim. Sci. 1999. Vol. 12, No. 8 : 1285-1291*)

Key Words : Crossbred Calves, Compensatory Growth, Wheat Straw, Energy Balance

INTRODUCTION

Compensatory growth is a phenomenon of rapid growth exhibited by mammals and birds after a period of growth restriction (Wilson and Osbourn, 1960). The capacity of compensatory growth manifested in the growing animals reared on restricted feeding or on the diets of low nutrient content may be advantageously utilized in livestock farming under the situation compelling to feed the animals at low plane of nutrition in the growing phase. Compensatory growth in domestic livestock has been reported by many workers (Hopkins and Tulloh, 1985; Ryan, 1990; Ryan et al., 1993 and Horton et al., 1994). In cattle, factors associated with compensatory growth include greater feed intake (Baker et al., 1992), higher efficiency of feed utilization and increase in gut fill weight (Carstens et al., 1989). Compensatory growth is better expressed when feed restriction occurs at a relatively later stage of life (Berge et al., 1991). In some countries of the world due to recurrent and short term seasonal variations in feed supply, animals are generally subjected to variable period of different levels of undernutrition as a result of failure of crops and inadequate herbage or pasture due to drought or flood. A knowledge of the effect of feed deprivation on livestock is of economic importance during times of feed scarcity as the producers wish to keep their animals alive at the lowest possible cost. This is commonly achieved by allowing animals to utilize their own energy conservation mechanisms, namely the accretion of body tissue during periods of feed surplus and the subsequent depletion of these reserves during the period of scarcity. Keeping in view the above facts, the aim of the present study was to observe the compensatory changes in the animals on adequate concentrate feeding after a period of restricted concentrate feeding.

MATERIALS AND METHODS

Experimental animals

Fifteen growing male crossbred (*Bos indicus*×*Bos taurus*) calves of nine months of age and 166±3.47 kg mean body weight were used for growth studies. The animals were dewormed with Nilverm® and vaccinated against Foot and mouth diseases before starting the experiment. The animals were housed in a well ventilated shed having cemented floor with individual feeding and watering facilities.

Phase-I

Fifteen calves were randomly divided on the basis of body weight into two groups of five calves (G1 group) and ten calves (G2 group) as per randomized block design in such a way that mean body weight

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Received November 17, 1998; Accepted February 20, 1999

Table 1. Composition of experimental diets

Attributes	Concentrate mixture		Wheat straw
	C1	C2	
Physical composition (%)			
Crushed maize	39	26	
Wheat bran	40	7	
Groundnut cake	18	64	
Mineral mixture[a]	2	2	
Salt	1	1	
Vitamin supplement[b]			
Chemical composition[c]			
Organic matter	89.88	90.22	93.06
Ash	10.12	9.78	6.94
Crude protein	16.10	31.85	3.09
Ether extract	3.20	4.13	1.48
Total carbohydrate	70.58	54.24	88.49
Neutral detergent fibre	37.43	37.92	81.75
Acid detergent fibre	10.40	11.70	51.07
Hemicellulose	27.03	26.22	30.68
Lignin	3.94	3.65	10.97
Gross energy (kcal/g)	4.34	4.28	4.13

[a] Mineral mixture contained calcium 28.0%, phosphorus 6.2%, common salt 35.8%, iron 0.4%, iodine 250 ppm, manganese 740 ppm, copper 280 ppm and sulphur 0.15%.

[b] Vitamin supplement (Rovimixe)® was added 20 g per 100 kg of concentrate mixture. Rovimixe® contained 40,000 IU vitamin A, 20 mg vitamin B_2 and 5,000 IU vitamin D_3 per g.

[c] On percentage dry matter basis.

[d] Total carbohydrate : Organic matter - (crude protein + ether extract).

were similar in both groups. Two concentrate mixtures (table 1) were prepared which contained 16.1 and 31.9% CP and iso-calorie in such a way that 30% concentrate (C2) in the diet of the calves in G2 group supplies same amount of CP as supplied by 60% concentrate (C1) in the diet of G1 group. The calves were fed according to NRC standards (1989) to achieve a live weight gain of 500 g/d. Wheat straw was used as basal roughage. A weighed quantity of wheat straw was offered to the animals after one hour of concentrate mixture was offered, during which the animals consumed the concentrate mixture. Calves in group G1 received 60% concentrate (C1) and 40% wheat straw in their diet, while the ratio of concentrate (C2) to wheat straw was received 30:70 in G2 group. All calves were individually fed at 9.00 am and weight of feed offered and refusals were recorded daily. Clean drinking water was offered *ad libitum* twice daily at about 0830 and 1500 hrs. All calves were weighed fortnightly immediately prior to feeding. Energy and nitrogen balance studies were conducted in metabolic cages after 60 days of experimental feeding in all animals with a collection period of eight days. During this period, daily feed offered, feed refused, faeces and urine voided by individual calves were recorded. 24 hr faecal output of each animal was quantified and 25% of the voided faecal sample was dried in forced draught hot air oven at 60℃. Dried faeces from individual animals covering eight days collection period was bulked, sampled and ground in a hammer mill to passed through 2 mm sieve. The ground samples were stored in air tight bottles until required for chemical analysis. Urine voided by individual animal in 24 hr during the eight days collection period was also quantified and 4% voided urine/day was pooled in a kjeldahl flask containing 20 ml concentrated H_2SO_4 for later chemical analysis to assess nitrogen balance. Another 4% voided urine/day during eight days collection period was pooled in a air tight bottle and stored in a refrigerator at 4℃ for energy estimation. Growth study was continued for 119 days.

Phase-II

At the end of phase-I, calves of G2 group were divided into two subgroups (G3 and G4) in such a way that two subgroups had similar mean body weights. The calves in G4 group were shifted from low concentrate diet to high concentrate diet. The ratio of concentrate and wheat straw in the diet of experimental calves of group G1, G3 and G4 were 60:40, 30:70 and 60:40 respectively. Concentrate C1 was offered in the diets of G1 and G4 whereas concentrate C2 was offered in the diet of G3 so that diets of all the groups were isonitrogenous. Calves were fed according to NRC standard (1989) to acheive a live weight gain of 500 g/d for a further 119 days. Fortnightly body weights were taken of all calves. Metabolic balances were carried out after 60 days of experimental feeding to measure the energy and nitrogen utilization by the experimental calves.

Chemical analysis

The chemical composition of biological samples (feed, faeces and urine) was determined by the methods described by Association of Official Analytical Chemists (AOAC, 1990) and the fibre fractions, netural detergrent fibre (NDF), acid detergrant fibre (ADF) and lignin as per Van Soest et al., (1991). The gross energy (GE) of feed, faeces and urine was estimated with the help of ballastic bomb calorimater (Gallen Kamp). Methane production was determined using the method of Bratzler and Forbes (1940) for cattle.

Statictical analysis

All statistical analysis were carried out according to Steel and Torrie (1980). The difference between the treatments mean was tested using the Duncan's multiple range test (Duncan, 1955).

RESULTS

Nutrients digestibility

The digestibility of nutrients and nutritive value of rations in phase - I and phase - II are presented in table 2. The digestibility of OM, CP and GE were higher ($p<0.01$) in G1 than in G2 group (phase - II) and in G1, G4 than G3 group (phase - II). But NDF digestibility was higher ($p<0.01$) in G2 and G3 group. DCP% in the ration of all groups was similar. Digestible energy content per 100 kg feed was higher ($p<0.01$) in G1 than G2 (phase-I) and G1 and G4

Table 2. Nutrient digestibility and nutritive value of ration

Attributes	Phase-I		±SEM	Significance	Phase-II			±SEM	Significance
	G1	G2			G1	G3	G4		
Digestibility (%)									
OM	60.27	55.05	0.54	**	57.75^A	54.19^B	58.54^A	0.32	**
CP	69.44	64.99	0.25	**	68.11^A	65.60^B	68.78^A	0.48	**
NDF	48.20	51.35	0.23	**	45.98^B	50.10^A	46.61^B	0.37	**
ADF	42.38	43.13	0.27	NS	39.54	40.46	40.27	0.64	NS
Energy	59.56	52.92	0.51	**	56.78^A	52.61^B	57.62^A	0.49	**
Nutritive value of ration (% DM)									
CP	10.88	11.80	0.18	*	10.43^b	11.31^a	10.54^b	0.22	*
DCP	7.55	7.68	0.07	NS	7.11	7.42	7.24	0.09	*
DE (Mcal)	254.1	221.8	3.75	**	247.5^A	221.5^B	251.5^A	2.47	*

Mean value bearing different superscript in a row differ significantly. * $p<0.05$, ** $p<0.01$.

Table 3. Balance of nitrogen in experimental calves

Attributes	Phase-I		±SEM	Significance	Phase-II			±SEM	Significance
	G1	G2			G1	G3	G4		
N intake									
g/kg $W^{0.75}$/d	1.68	1.76	0.05	NS	1.54	1.48	1.65	0.08	NS
N-excreted in faeces									
g/kg $W^{0.75}$/d	0.51	0.62	0.02	*	0.49	0.51	0.52	0.03	NS
% of N intake	30.56	35.01	0.24	**	31.89^B	34.54^A	31.29^B	0.21	**
N-excreted in urine									
g/kg $W^{0.75}$/d	0.56	0.46	0.02	**	0.55^a	0.45^b	0.53^a	0.01	*
% of N intake	33.46	26.35	0.51	**	35.88^A	30.32^C	32.04^B	0.39	**
% of N absorb	48.19	40.57	1.55	**	52.69^A	46.23^B	46.63^B	0.53	**
N retained									
g/kg $W^{0.75}$/d	0.61	0.67	0.04	NS	0.49^b	0.52^b	0.60^a	0.02	*
% of N intake	35.98	38.61	1.11	*	32.22^b	35.26^a	36.60^a	0.48	*
% of N absorb	51.81	59.42	1.55	**	47.31^B	53.36^A	53.76^A	0.56	**

Mean value bearing different superscript in a row differ significantly. * $p<0.05$, ** $p<0.01$.

than G3 group (phase-II).

Nitrogen balance

Nitrogen intake per kgW$^{0.75}$/d was not statistically differed between groups during both phase of experiment (table 3). Excretion of nitrogen in faeces as percentage of nitrogen intake was higher (p<0.01) in group G2 (phase-I) and G3 (phase-II) whereas through urine it was highest in group G1. Nitrogen retention in group G2 (phase-I) and G3 and G4 (phase-II) was highest than in group G1.

Energy distribution

Daily gross energy intake per kgW$^{0.75}$ was highest (p<0.01) in G1 (phase-I) and G1 and G4 (phase-II) group (table 4). Losses of energy (as percent of GE intake) through faeces and urine was significantly higher in G2 and G3 groups whereas energy loss as

Table 4. Energy distribution in experimental calves

Attributes	Phase-I		±SEM	Significance	Phase-II			±SEM	Significance
	G1	G2			G1	G3	G4		
Gross energy intake									
g/kg W$^{0.75}$/d	428^{A}	390^{B}	10.58	**	398^{A}	344^{B}	420^{A}	9.47	**
Faecal energy									
g/kg W$^{0.75}$/d	169	184	7.28	NS	172	163	178	5.12	NS
% of GE intake	40.41	47.08	0.79	**	43.38^{B}	47.15^{A}	42.51^{B}	0.67	**
Urinary energy									
g/kg W$^{0.75}$/d	5	6	0.27	NS	5.60	5.92	5.71	0.16	NS
% of GE intake	1.25	1.51	0.04	*	1.41^{b}	1.64^{a}	1.37^{b}	0.02	*
Methane energy									
g/kg W$^{0.75}$/d	28	25	0.68	*	25^{A}	22^{B}	27^{A}	0.59	**
% of GE intake	6.78	6.48	0.07	*	6.64^{a}	6.25^{b}	6.38^{a}	0.03	*
Metabolisable energy									
g/kg W$^{0.75}$/d	224	175	6.08	**	194^{A}	154^{B}	209^{A}	4.64	**
% of GE intake	52.08	44.83	0.62	**	48.87^{A}	44.95^{B}	49.84^{A}	0.55	**

Mean value bearing different superscript in a row differ significantly. *p<0.05, **p<0.01.

Table 5. Growth response and nutrient utilization by experimental calves

Attributes	Phase-I		±SEM	Significance	Phase-II			±SEM	Significance
	G1	G2			G1	G3	G4		
Number of experimental animals	5	10	-	-	5	5	5	-	-
Duration of experiment	119	119	-	-	119	119	119	-	-
Body weight (kg)									
Initial	166.10	165.90	3.58	NS	240.40^{A}	216.01^{B}	214.20^{B}	8.32	**
Final	240.40	215.10	6.20	**	300.60^{A}	260.13^{B}	287.80^{A}	9.31	**
Gain (g/d)	629.31	413.42	28.55	**	505.88^{B}	369.75^{C}	618.48^{A}	14.28	**
Dry matter intake									
g/kg W$^{0.75}$/d	93.48	83.31	1.17	**	91.59^{B}	82.19^{C}	97.33^{A}	1.53	**
Nutrient intake per kg gain									
DM (kg)	8.23	10.60	0.43	**	12.09^{b}	13.24^{a}	10.01^{c}	0.33	*
CP (kg)	0.90	1.25	0.04	*	1.21^{b}	1.54^{a}	1.05^{c}	0.08	*
DCP (kg)	0.62	0.81	0.03	**	0.87^{b}	1.01^{a}	0.73^{b}	0.05	*
DE (Mcal)	20.96	23.64	0.09	**	30.66^{B}	31.97^{A}	24.77^{C}	0.07	**
ME (Mcal)	18.21	19.91	0.05	**	26.01^{b}	26.64^{a}	21.39^{c}	0.03	*

Mean value bearing different superscript in a row differ significantly. * p<0.05, ** p<0.01.

methane was lower ($p<0.05$) in groups G2 and G3 during first and second phase of experiment respectively. Daily intake of metabolisable energy per kg $W^{0.75}$ was higher ($p<0.01$) in G1 than G2 (phase-I) and G1 and G4 than G3 group (phase-II).

Growth response and nutrient utilization

Average daily live weight gain was higher ($p<0.01$) in the calves of G1 group during first phase of experiment whereas during second phase of experiment daily live weight gain was highest ($p<0.01$) in group G4 followed by group G1 and G3. Total dry matter intake per kg $W^{0.75}$/d was significantly higher ($p<0.01$) in G4 group followed by G1 and G3 group. Calves of G1 group consumed less amount of CP, DCP, DE and ME for each kg body weight gain than G2 group (phase-I). DM, CP, DCP and ME intake for each kg body weight gain during second phase of experiment were highest in group G3 followed by G1 and G4 group.

DISCUSSION

The digestibility of nutrients depends on the nature and proportion of roughage in the animal diet (Colucci et al., 1989; Slabbert et al., 1992; Murphy et al., 1994). This is also evident from the results of present experiment that increasing level of wheat straw in the diet of experimental calves decreased digestibility of nutrients (OM, CP, and energy). The digestibility of NDF increased with higher level of wheat straw (Eun, 1990; Poore et al., 1990; Kennedy and Bunting, 1992). The depression in ruminal fibre digestibility observed on adding grain or concentrate to forage diet has been attributed to a lower pH leading to a delay in the onset of fibre digestion in the rumen (Mertens and Loften, 1980; Hoover, 1986). The shifting of calves from low concentrate diet to high concentrate diet resulted in similar reduction in digestibility.

The concentration of CP in the diet of the low dietary concentrate fed group (G2) was significantly higher than the high dietary concentrate fed group (G1) but difference was not significant for DCP of the two diets due to a lower digestibility of CP in high fibre diet in the former group. Higher ratio of wheat straw in the diet was conspicuous by significantly lower energy value in the diet of group G2 in first experiment. The density of both protein and energy in the diet was much less than the diet recommended in NRC standards (1989). Such effects has been frequently been observed with the feeding of high wheat straw diet to ruminants (Baruah et al., 1988). Since there was no change in the concentrate:roughage ratio during the second experiment there was also no change in the nutritive value of the diet except a marginal reduction in digestible energy value. The digestible energy level of the diet was significantly higher for high concentrate diet (G1 and G4) than low concentrate diet (G3). But the DCP concentration was not significantly differed between the diets of three groups.

Nitrogen retention were positive in the calves of two groups during first phase of experiment. As expected there was no difference in mean nitrogen intake between the two groups during first phase of experiment due to composition of the rations. The nitrogen voided in faeces was higher in the calves of low concentrate fed group (G2) in comparison to high concentrate fed group (G1) due to higher contribution of lignin and ADF bound nitrogen in wheat straw which formed much greater proportion of diet in the former group (Orskov, 1982). Mean retention of nitrogen was higher in low concentrate fed group in comparison to high concentrate fed group (Lebengarts, 1986) but the values were more than the requirement in both the groups. During second phase of experiment the calves of G4 group grow at a faster rate on shifting from low concentrate diet to high concentrate diet which resulted in increased daily nitrogen intake. Urinary loss in nitrogen was low in calves of G4 group in comparison to G1 group due to utilization of more nitrogen for compensatory growth. This resulted in higher nitrogen retention in G4 group than G1 group (Fox et al., 1972).

Daily gross energy intake per $KgW^{0.75}$ by calves was higher in high concentrate fed group (G1 and G4) due to lower fibre content in their diet in comparison to calves in low concentrate fed group (G2 and G3) which resulted in lower energy excretion in the faeces of the former groups. Although the loss of energy through urine was small but significantly higher ($p<0.05$) in low concentrate fed group. However, energy loss in methane was significantly higher in high concentrate fed group due to higher intake of digestible carbohydrates in these groups (Raven, 1972). High proportion of wheat straw in the diet resulted in a significant depression in the metabolisable energy values for the calves on low concentrate fed groups (G2 and G3) (Nachtomi et al., 1991; Johnson and Comb, 1992).

Mean daily dry matter intake in group G1 in first phase of experiment was higher due to higher content of concentrate in the diet in comparison to G2. This difference was reflected in higher daily body weight gain and better utilization of nutrients in group G1. The reduction in nutrient utilization for body weight gain was the associative effect of low energy diet and lower body weight gain due to which higher percentage of nutrients consumed was utilized for the maintenance of body functions. A positive relationship between live weight gain and dietary concentrate intakes has also been reported by many workers

(Matthes, 1991; Nachtomi et al., 1991; Murphy et al., 1994). Due to less fibre content of diet and better utilization of energy, the intake of nutrients (DM, CP, DCP, DE and ME) for each kg body weight gain was lower in the calves of high concentrate fed group (Johnson and Comb, 1992; Murphy et al., 1994). The calves of G4 group showed significantly higher daily dry matter intake and body weight gain due to compensatory growth for the compensation of lower growth during the first phase of experiment (Graham and Price, 1982; Ryan et al., 1993, Horton et al., 1994; Yambayamba et al., 1996). This resulted in better feed conversion efficiency and nutrient utilization in G4 group (Fox et al., 1974; Baker et al., 1985; Abdalla et al., 1988). Higher intake of dry matter and nutrients per unit body weight gain during second phase of experiment in comparison to first experiment was a normal phenomenon as fat content of body weight gain increases with increasing age leading to a higher requirement for energy per unit gain in body weight (Pathak and Ranjhan, 1990).

Although lower energy density through lower proportion of concentrate in wheat straw based diet suppressed growth rates but this can be compensated by increasing the density of dietary energy of the ration.

ACKNOWLEDGMENT

The fellowship awarded to senior author by the Director, IVRI, is gratefully acknowledged.

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