Growth and Carcass Characteristics of Goats Given Diets Varying Protein Concentration and Feeding Level

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ABSTRACT : Twelve castrated male Black Bengal goats with an average live weight of 10.3 kg (8 months old) were used in a 2x2 factorial arrangement to study the effects of dietary crude protein concentration [20.3% (HP) and 16.9% (LP)] and feeding level [*ad libitum* and 85% of *ad libitum* (restricted)] on growth and carcass characteristics. *Ad libitum* feeding, on average, significantly ($p<0.05$ to $p<0.01$) increased daily live weight (6.27 vs -5.86 g), dry mater intake (409 vs 351 g/d), estimated gain in carcass (0.195 vs -0.200 kg) and empty body weight (0.385 vs -0.350 kg), chemically extracted fat in meat sample (6.89 vs 6.48%), depth of *M. longissimus dorsi* (22.1 vs 18.3 mm) and gut and caul fat (170 vs 130 g) compared with restricted feeding regime. The greater intake of dietary protein from the HP diet resulted in significantly ($p<0.05$ to $p<0.01$) greater values for depth (20.9 vs 19.5 mm) and width (32.4 vs 27.9 mm) of *M. longissimus dorsi*, gut and caul fat (190 vs 110 g) and also perirenal and retroperitoneal fat (85 vs 50 g) than those of the goats that received the LP diet. Similarly, the HP diet had significantly ($p<0.05$ to $p<0.01$) higher values for CP digestibility and DCP concentration than those of the LP diet. The results indicated that growth rate and carcass gain were highest in goats fed the HP diet *ad libitum* and therefore, diet containing 20.3% CP may be suggested for feeding growing goats. (*Asian-Aus. J. Anim. Sci. 2000. Vol. 13, No. 5 : 613-618*)

Key Words : Goats, Digestibility, Growth, Carcass, Protein Concentration, Feeding Level

INTRODUCTION

Bangladesh has 34 million goats (FAO, 1997) of which 98% is distributed in the rural area of the country (BBS, 1986). Among domestic animals, goats play a dominant role in small farm animal production systems and in the lives of landless peasantry. They are traditionally raised by poverty-stricken village people in a sedentary system of grazing on harvested or fallow land, along roads and canal sides. They are also maintained by feeding tree leaves and by-products of human food. This system of feeding can not satisfy their nutrient requirement for maintaining proper growth and productivity, resulting in severe economic losses. Therefore priority has to be given to optimize the productivity of goats utilizing available feed resources in the country. Dietary nutrients, especially energy and protein, are major environmental factors affecting meat production in goats (Ash and Norton, 1987a; Devendra, 1988; Shahjalal et al., 1992). Reports on the nutrient requirements of Bangladeshi Black Bengal goats are scanty and little information is available particularly on the contribution of dietary energy and protein to the quality and quantity of meat produced by these animals under Bangladesh condition. The work reported here was therefore undertaken to investigate the effects of dietary protein concentration and feeding level on the growth and carcass characteristics of Black Bengal goats.

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MATERIALS AND METHODS

Location

The experiment was conducted at the Bangladesh Agricultural University Animal Nutrition Field Laboratory, Mymensingh for a period of 77 days.

Animals, diets and experimental design

Twelve castrated male Black Bengal goats of approximately 8 months of age and weighing, on average, 10.3 kg were purchased from the local market for this experiment. The goats were kept in individual pens in an animal house subjected to natural light and ventilation and allowed 15 days to adapt to the experimental conditions and feeds prior to the commencement of the study. During this period all the goats were dewormed with an anthelmentic drug (Nilzan, Hochest, BD Ltd.). The animals were blocked into four groups according to live weight and the blocked groups were assigned at random to four dietary treatments. Each treatment consisted of either low or high level of protein (LP or HP) and at either *ad libitum* or restricted feeding regime. Two iso-energetic loose mix diets (9.65 MJ ME/kg DM) differing in protein concentration of 20.3% (HP) or 16.9% (LP) were formulated with green grass, *Sesbania* leaves, wheat bran, soybean meal and sesame oil cake (table 1). Two diets were offered at two feeding levels in a 2×2 factorial experiment with

three goats per treatment. The two feeding levels were achieved by offering the diets either *ad libitum* or 85% of *ad libitum* (restricted). The total quantity of the diet offered daily was divided into two equal halves and fed at 08:00 and 16:00 h and refusals were collected on the next day before morning feeding. Roughage and concentrate fractions of the diets were fed separately. Water was made available at all times. Daily food intake and weekly change in live weight for individual animals were recorded. A digestibility trial was conducted towards the end of growth trial to assess the utilization of dietary nutrients by the animals. Feeds, faeces and refusals were analysed for proximate components (AOAC, 1980).

Table 1. Ingredient and chemical composition of the experimental diets

Ingredients (g/kg)	Diets	
	High protein (HP)	Low protein (LP)
Wheat bran	62	134
Sesame oil cake	31	8
Soybean meal	31	17
Green grass	627	740
Sesbania leaves	249	101
Composition:		
DM (%)	26.5	29.3
CP (%)	20.3	16.9
ME (MJ/kg DM)[#]	9.7	9.6

[#] Estimated from ME concentration of ingredients (Ranjhan, 1980).

Carcass characteristics

Two goats from each dietary group were slaughtered unfasted at 77 days after commencing the experiment and the method and procedures for slaughter and the subsequent measurements made on carcass were similar to those described by Shahjalal et al. (1997). About 250 g of meat sample was taken from shoulder, thigh, best end, loin and flank regions of each carcass. These were chopped, mixed and minced and then analysed for DM, CP, EE and ash.

Statistical analysis

The data were analysed using the MSTAT statistical program to compute analysis of variance (ANOVA). In the ANOVA, appropriate for a 2×2 factorial experiment, the treatment sum of squares was partitioned into three components each with one degree of freedom and the results presented for main effects and interactions are as follows:

P=main effect of dietary protein level (LP vs HP); E=main effect of feeding level (*ad libitum* vs restricted); I=interaction between the dietary protein and feeding level.

RESULTS AND DISCUSSION

Growth performance

The average growth performance of goats fed different diets is shown in table 2. *Ad libitum* feeding of goats significantly ($p<0.01$) increased average daily DM (409 vs 351 g), estimated ME (4.0 vs 3.4 MJ) and CP (64.0 vs 54.9 g) intakes compared to those of restricted feeding regime (85% of *ad libitum*). The higher intake of energy and protein by the animals given *ad libitum* diet resulted, on average, significantly ($p<0.05$) superior values for daily live weight change (6.27 vs -5.86 g) and feed conversion efficiency (0.015 vs -0.018 g LWG/g DMI) than those received

Table 2. Effects of protein concentration and feeding level on the growth performance of goats

Parameter	*Ad libitum*		Restricted (85% of *ad libitum*)		SEM	Significance of contrast[#]		
	HP	LP	HP	LP		P	E	I
Initial live weight (kg)	10.27	10.30	10.33	10.13	0.52	NS	NS	NS
Final live weight (kg)	11.40	10.13	9.67	9.90	0.86	NS	NS	NS
Live weight gain (g/d)	14.71	-2.17	-8.67	-3.04	5.32	NS	*	*
Dry matter intake (g/d)	409.7	407.8	352.3	349.0	11.68	NS	**	NS
Feed conversion efficiency (LWG/DMI)	0.035	-0.006	-0.025	-0.011	0.02	NS	**	NS
Crude protein intake (g/d)	73.34	54.64	63.06	46.76	1.88	**	**	NS
Protein conversion efficiency (CPI/LWG)	6.23	0.84	-9.28	5.02	2.81	NS	NS	**
ME intake (MJ/d)	3.97	3.92	3.42	3.35	0.11	NS	**	NS
Energetic efficiency (MEI/LWG)	0.340	0.064	-0.500	0.363	0.18	NS	NS	**
CPI: MEI (g/MJ)	23.75	16.87	23.52	16.88	0.21	**	NS	NS

[#] Contrast P=(*ad libitum*-HP+restricted-HP) vs (*ad libitum*-LP+restricted-LP); E=(*ad libitum*-HP+*ad libitum*-LP) vs (restricted-HP +restricted-LP); I=interactions between main effects.

restricted diet. However, growth rate recorded in the present experiment was much lower than that described in the previous studies with Australian Cashmere goats (Ash and Norton, 1987b). They have reported that growing goats received *ad libitum* diet gained 85.8 g while goats on restricted diet gained 57.8 g daily. The lower live weight gains recorded in this study may be attributed to poor genetic potentiality of Black Bengal goats for converting dietary nutrients (energy and protein) into body tissues and growth compared with Cashmere goats cited above.

The daily energy requirement for maintenance of the experimental animals (10.3 kg LW) were estimated as 2.44 MJ ME (NRC, 1981) which showed 1.62 and 1.39 times more energy intake in goats from diets fed *ad libitum* and at restricted level, respectively. The results of the current study, therefore, indicated that either dietary energy was not utilized properly for maintaining growth rate or goats of this particular breed may have required more energy for their maintenance than that recommended for different breeds of goats by the NRC (1981). Moreover, energy requirement for activity was not considered in this study although goats were seen to expend energy in exercising and jumping which may have reduced the availability of energy for growth.

Goats fed the HP diet significantly ($p<0.01$) increased CP intake (68.1 vs 50.7 g/d) but not of ME (3.70 vs 3.64 MJ/d) or DM (381.0 vs 378.1 g/d) intake compared with the LP diet. The higher amount of protein intake from the HP diet did neither significantly ($p>0.05$) improve growth rate (3.02 vs -2.61 g/d) nor feed conversion efficiency (0.005 vs -0.009 g LWG/g DMI). However, there are evidence that DM intake and growth rate in Alpine and Nubian goats increased linearly as the level of protein concentration in the diet increased (Lu and Potchoiba, 1990). Lack of significant effect on growth rate due to high protein treatment in the present investigation may be attributed to the similar amount of protein available from both protein levels at the small intestine although there were great differences in CP intakes between the HP and LP diets. The major proportion of the dietary protein in goats fed the HP diet was probably degraded in the rumen with the production of ammonia and may have resulted in greater urinary losses of nitrogen. This may be the reason for obtaining similar growth rate in goats fed the HP and LP diets. Previous studies with Australian Cashmere goats given the HP diet (20.9% CP) indicated that 28% of the dietary nitrogen was apparently lost across the stomach (Ash and Norton, 1987b).

The growth rate of the goats fed the HP diet *ad libitum* was 14.71 g/day. This group only gained live weight but goats on other dietary groups lost their live weights. This lower growth rate recorded in this study can be explained by the fact that Black Bengal goats are mainly habituated to pasturing/grazing and not accustomed to stall feeding. Immediately after the end of the experiment, this was observed by allowing four remaining goats (one from each treatment group after slaughtering) to 6.0 hours daily grazing for one month and during this period all the goats gained an average live weight of 20 g per day. Furthermore, intake of protein as a ratio of energy in the HP and LP diets used in the present study were 23.6 and 16.9 (g CP/MJ ME), respectively. However, protein to energy ratio for optimum growth of goats was recommended as 9.38 g CP per MJ ME (NRC, 1981). Therefore, excess protein was wasted and excreted from the body as proposed above and resulted in poor growth rate in goats.

Significant ($p<0.05$ to $p<0.01$) interactions between protein and feeding levels were recorded for live weight gain and efficiency of conversion of protein and energy into live weight. These results suggested that the effects of increasing feeding level for goats on the HP diet was greater than that for goats on the LP diet and that of increasing protein level for the *ad libitum* feeding group was greater than for the restricted feeding group.

Digestibility and nutritive value

The apparent digestibilities of dietary CP (75.86 vs 77.20%), CF (63.24 vs 67.90%), EE (61.43 vs 56.96%), NFE (64.50 vs 72.23%) and OM (68.50 vs 71.62%) were not significantly ($p>0.05$) different between the *ad libitum* and restricted fed animals (table 3). Here, the results indicated that the level of feeding had no much effect on nutrient digestibility. Ash and Norton (1987b) also reported that the digestibility of OM or N was not altered in Australian Cashmere goats due to change of feeding level from restricted to *ad libitum*. Similar to nutrient digestibility, D value (61.51 vs 66.11%), DCP (14.66 vs 14.87%) and TDN (65.44 vs 69.89%) concentrations were almost similar in both the feeding regimes although higher values tended to be recorded for these parameters in goats fed on restricted diet.

Goats received the HP diet had significantly ($p<0.05$ to $p<0.01$) higher values for the digestibility of CP (78.92 vs 74.15%) and EE (69.87 vs 48.52%) compared to those received the LP diet. Ash and Norton (1987b) also reported that the feeding of HP diet to goats significantly improved nitrogen digestibility compared with the LP diet (77.7 vs 67.3%). In contrast, feeding the LP diet significantly ($p<0.05$) increased NFE digestibility (75.89 vs 64.84%) than that of feeding the HP diet. However, dietary protein concentration had no effect on the digestibility of CF (63.2 vs 67.9%) or OM (68.9 vs 71.2%). The

Table 3. Effects of feeding level and dietary protein concentration on the digestibility and nutritive value of diets fed to goats

Parameter	*Ad libitum*		Restricted (85% of *ad libitum*)		SEM	Significance of contrast[#]		
	HP	LP	HP	LP		P	E	I
Apparent digestibility (g/100 g):								
CP	79.04	72.68	78.79	75.61	2.09	NS	NS	NS
CF	58.35	68.13	68.14	67.65	2.81	NS	NS	NS
EE	68.37	54.49	71.37	42.55	5.68	**	NS	NS
NFE	61.35	71.64	68.32	80.14	3.84	**	NS	NS
OM	67.31	69.69	70.55	72.68	2.51	NS	NS	NS
Nutritive value (g/100 g DM):								
DCP	17.11	12.20	17.06	12.57	0.39	**	NS	NS
DCF	9.92	11.60	11.56	11.52	0.48	NS	NS	NS
DEE	4.05	2.24	4.23	1.76	0.28	**	NS	NS
DNFE	27.42	38.44	30.54	42.94	1.81	**	NS	NS
TDN	63.57	67.30	68.68	71.04	2.30	NS	NS	NS
DOM (D value)	58.50	64.51	63.38	68.84	2.22	*	NS	NS

[#] Contrast P=(*ad libitum*-HP+restricted-HP) vs (*ad libitum*-LP+restricted-LP); E=(*ad libitum*-HP+*ad libitum*-LP) vs (restricted-HP +restricted-LP); I= interactions between main effects.

Table 4. Selected carcass characteristics of goats given diets differing in protein concentration and feeding level

Parameter	*Ad libitum*		Restricted (85% of *ad libitum*)		SEM	Significance of contrast[#]		
	HP	LP	HP	LP		P	E	I
Slaughter weight (SW, kg)	11.40	10.13	9.63	9.87	0.86	NS	NS	NS
Warm carcass weight (WCW, kg)	4.65	3.98	3.90	4.01	0.37	NS	NS	NS
Estimated carcass gain (kg)	0.46	-0.07	-0.28	-0.12	0.17	NS	*	NS
Gut fill (kg)	2.33	2.26	1.94	2.00	0.20	NS	NS	NS
Empty body weight (EBW, kg)	9.07	7.87	7.70	7.87	0.70	NS	NS	NS
Estimated EBW gain (kg)	0.90	-0.13	-0.55	-0.15	0.34	NS	*	*
Gut and caul fat (kg)	0.25	0.09	0.13	0.13	0.02	**	*	**
Perirenal and retroperitoneal fat (kg)	0.09	0.05	0.08	0.05	0.01	**	NS	NS
Killing out proportion:								
WCW/SW	0.40	0.39	0.40	0.40	0.01	NS	NS	NS
WCW/EBW	0.51	0.51	0.51	0.51	0.01	NS	NS	NS
M. longissimus dorsi:								
Area (cm^2)	3.44	2.53	3.22	2.03	0.40	NS	NS	NS
Depth (mm)	23.60	20.50	18.10	18.47	0.63	**	**	**
Width (mm)	32.40	29.50	32.43	26.23	1.01	**	NS	NS

[#] Contrast P=(*ad libitum*-HP+restricted-HP) vs (*ad libitum*-LP+restricted-LP); E=(*ad libitum*-HP+*ad libitum*-LP) vs (restricted-HP +restricted-LP); I= interactions between main effects.

HP diet had significantly higher ($p<0.01$) DCP concentration (17.1 vs 12.4%) and lower ($p<0.05$) D value (60.9 vs 66.7%) compared with the LP diet.

Carcass characteristics

Feeding level (*ad libitum* vs restricted), on average, had no significant ($p>0.05$) effect on slaughter weight (SW, 10.77 vs 9.75 kg), empty body weight (EBW, 8.47 vs 7.79 kg), warm carcass weight (WCW, 4.32 vs 3.96 kg) and killing out proportion expressed either as WCW/SW (0.395 vs 0.400) or WCW/EBW (0.510 vs 0.510) although higher values for SW and EBW were recorded in goats given diet *ad libitum* (table 4). Goats fed on *ad libitum* diet had significantly ($p<0.05$) higher values for estimated gain in carcass (0.195 vs -0.200 kg), EBW (0.385 vs -0.350 kg) and gut and

Table 5. Chemical composition of meat sample of goats given diets differing in protein concentration and feeding level

Parameter	*Ad libitum*		Restricted (85% of *ad libitum*)		SEM	Significance of contrast[#]		
	HP	LP	HP	LP		P	E	I
Chemical composition (g/100g sample):								
Dry matter	32.60	28.20	28.27	33.58	1.11	NS	NS	NS
Crude protein	21.93	21.00	22.84	22.48	0.60	NS	NS	NS
Ether extract	6.89	6.92	6.87	6.09	0.17	NS	*	*
Ash	0.49	0.45	0.46	0.45	0.25	NS	NS	NS

[#] Contrast P=(*ad libitum*-HP+restricted-HP) vs (*ad libitum*-LP+restricted-LP); E=(*ad libitum*-HP+*ad libitum*-LP) vs (restricted-HP +restricted-LP); I= interactions between main effects.

caul fat (170 vs 130 g) compared to those on restricted feeding regime. These parameters ran in parallel to live weight gain of goats given diet *ad libitum*. High level of feeding (*ad libitum*) significantly ($p<0.01$) increased depth (22.05 vs 18.29 mm) of *M. longissimus dorsi* than those of low level of feeding (restricted). But there was no difference in width (30.95 vs 29.33 mm) or cross sectional area (2.49 vs 2.63 cm^2) of *M. longissimus dorsi* between the levels of feeding (*ad libitum* vs restricted).

The HP diet significantly ($p<0.01$) increased depth (20.9 vs 19.5 mm) and width (32.4 vs 27.9 mm) of *M. longissimus dorsi* and also gut and caul fat (190 vs 110 g) and perirenal and retroperitoneal fat (85 vs 50 g) compared with the LP diet. However, concentration of dietary protein, on average, had no effect on SW (10.52 vs 10.00 kg), WCW (4.28 vs 4.00 kg), estimated carcass gain (0.090 vs -0.095 kg), EBW gain (0.175 vs -0.140 kg), killing out proportion (0.400 vs 0.395 or 0.51 vs 0.51) and cross sectional area of *M. longissimus dorsi* (3.33 vs 2.28 cm^2). The lack of significant effect on carcass characteristics due to protein treatments indicated that the availability of protein at the tissue level was considered to be similar despite large differences in dietary protein intake. Feeding levels and dietary protein concentrations had no effect on the weight of gut fill. The average weight of gut fill recorded as 21.4 and 20.2% of live weight of goats fed *ad libitum* and restricted diets, respectively. Fehr et al. (1976) observed that gut fill varied from 12% of live weight in milk fed kids (57 days old) to 25% of live weight in weaned kids (133 days old). In the present experiment, the average gut fill ranged from 20.1 to 22.3% of live weight in different dietary groups which correspond to the above findings.

Goats fed *ad libitum* contained significantly ($p<0.05$) higher amount of ether extract (EE, 6.89 vs 6.48%) in their meat sample compared with the restricted fed goats (table 5). The results are in accordance with those reported by Ash and Norton (1987a) for Australian Cashmere goats raised on *ad libitum* feeding. They reported that *ad libitum* feeding resulted in more fat in the body compared with the restricted feeding regime. Level of feeding had no effect on DM, CP or ash content of meat sample. Likewise, HP diet did not significantly ($p>0.05$) increase the content of DM, EE, CP and ash in the meat sample of goats compared with that on the LP diet. Ash and Norton (1987b) also reported that the dietary protein concentration had no effect on the composition of the EBW of goats.

Significant interactions ($p<0.05$ to $p<0.01$) between feeding level and protein concentration were recorded for estimated EBW gain, depth of *M. longissimus dorsi*, gut and caul fat and also for ether extract content of meat sample. These results indicated that increasing feeding level generally produced positive effect on the above parameters with the HP diet (except for ether extract which was higher with the LP diet) and negative effect with the LP diet. Similarly, increasing dietary protein level resulted in positive effect on the *ad libitum* fed goats and negative effect on the restricted fed group.

CONCLUSION

The results showed that growing goats given the HP diet *ad libitum* gained live weight, however, lost live weight on the LP diet under the same feeding regime. Therefore, the HP diet containing 20.3% CP may be suggested for feeding *ad libitum* basis to growing Black Bengal goats.

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