Meat Production Characteristics of Black Bengal Goat

S. A. Chowdhury* and S. Faruque
Bangladesh Livestock Research Institute, Savar, Dhaka 1341, Bangladesh

ABSTRACT : Black Bengal goat is primarily reared for meat, skin comes here as a by-product. The present trial describes the effect of age on different carcass characteristics of Black Bengal goats of either sex. A total of 61 Black Bengal goats of different age and sex groups were slaughtered. They were reared under semi-intensive management on milk alone or with concentrates (of 10.14 MJ ME and 10.48 g M/kg DM) and freshly cut Napier grass (2 MJ ME and 25 g CP/kg of fresh matter) that provides the estimated NRC (1981) requirement. The four age groups were: pre-weaned kids (0-90 day), post-weaned kids (91-180 days), growing (181-365 days) and adult (>365 days). Goats were slaughtered according to 'Halal' method by severing the major vessels of the throat by a transverse cut. Different slaughter parameters of Black Bengal goat can be best predicted from the equations as follows: live weight (kg)=0.801 (shoulder height (cm))-24.32, (r^2=0.94); carcass weight (kg)=0.364 (height at hind legs (cm))-11.54, (r^2=0.91); edible weight (kg)=0.623 (shoulder height (cm))-19.94, (r^2=0.91) and saleable weight (kg)=0.701 (shoulder height (cm))-21.99, (r^2=0.92). Live weight, carcass weight, edible weight and saleable weight of castrated goat at one-year onward ranges from 20-22, 9.4-10.5, 14-16 and 16.6-18.8 kg, respectively, which are about 80% higher than most of the reported observations on Black Bengal goat of same age and sex. Slaughter weight, warm carcass weight, edible weight and saleable weight increased curvilinearly with age of slaughter but not affected ($p>0.05$) by sex. However, linearity of the response curve of affect of age on mentioned parameters ends at around 9 months. Visceral fat as per cent of live weight increased curvilinearly with age and attain its maximum (about 6%) at about 500 days. However, linear part of the quadratic model ends at about 300 days when visceral fat content is about 4.8% of body weight. Blood and skin yield for one-year old male goat was 797 g and 1.61 kg, respectively. Absolute yield of blood and skin increased curvilinealry and attained maximum level at about 400 days (13.3 months). Average proportion of different carcass cut were - round 27%, rump 7%, loin 10%, ribs (6-12th) 14%, shoulder 21%, Neck 7%, chest 14%. Thigh and shoulder constituted about 48.3% of the cold carcass weight. Overall crude protein content of meat samples of different carcass cuts progressively decreased with age starting from 57 at 0-90 days to 58, 47 and 33 per cent, respectively at 91-180, 181-365 and >365 days, respectively. Overall meat fat content increased almost linearly from 11.1% during 91-180 days to 22.9 and 39.5% during 181-365 and >365days, respectively. Results from this trial suggest that both carcass yield and carcass composition changes with age; and sex have little or no effect on carcass yield and carcass composition. However, caution should be made in using second conclusion as there were few female animals slaughtered relative to the male. Optimum slaughter age for Black Bengal goat reared under semi-intensive management with adequate feeding and management would be about 9 months when their live weight, warm carcass weight, edible and saleable weight of carcass can be about 16.74, 7.28, 12.05 and 13.81 kg, respectively.
(Asian-Aust. J. Anim. Sci. 2004. Vol 17, No. 6 : 848-856)

Key Words : Black Bengal Goat, Carcass, Composition

INTRODUCTION

Meat production is the most important function of goats in the tropics (Devendra, 1991). Devendra and Burn (1983) reviewed the meat production characteristics of different meat type goat breeds in the tropics. These studies assessed the growth and development of kids from birth to slaughter, carcass characteristics, and meat quality in relation to breed, age, sex and nutritional regime. Black Bengal goat is primarily a meat type breed, although it is also valued for its skin. Relatively fewer studies conducted on meat production characteristics of Black Bengal goat. Singh and Sengar (1979) compared the meat production characteristics of male Black Bengal or its crosses to that of the Jamnapari, Beetal, Barbari or their crosses. They showed that the dressing percentage and percentage of total edible meat was the lowest in Black Bengal goat (44.62 and 74.15%, respectively) and the highest in Barbari (49 and 80%, respectively). Black Bengal goat found to attain optimum slaughter weight at the shortest period (8.9 months) than the Jamnapari (23.48 months), Beetal (19.46 months) and Barbari (13.46 months). However, this was not a direct measurement rather was an estimation: slaughter weight= (Birth weight×7)-(Birth weight-2). This estimation was based on the assumption that postnatal growth is the function of living cells delivered at birth as the birth weight (Singh and Sengar, 1979). However, these measurements have not been validated on the Black Bengal goats. Shajalal et al. (2000) studied the effect of dietary protein concentration and feeding level on the growth and carcass characteristics of 8 months old castrated Black Bengal goat. They showed that goat having *ad libitum* feeding with high protein (20.3%) concentrate have better growth rate and carcass characteristics than those raised on restricted feeding of low protein (16.9%) diet. Moniruzzaman et al. (2002) studied the effect of stall-feeding, tethering, restricted grazing or free grazing on the carcass

* Corresponding Author: S. A. Chowdhury. Tel: +88-2-7708320, Fax: +88-2-7708325, E-mail: aprdblri@accesstel.net
Received July 13, 2003; Accepted January 7, 2004

Table 1. Number of goats slaughtered at different age and sex groups

Age of goats	Male	Female
0-90 days (Pre-weaned)	8	4
91-180 days (Post-weaned)	9	1
181-365 days (Growing)	10	-
>365 days (Adult)	28	1

characteristics of 1 year old Black Bengal does. They showed that stall-fed does had better meat production than the other systems. Quality and quantity of meat produced is generally a function of age, sex, genotype and management (feeding in particular). To our knowledge, effect of age groups on yield and carcass characteristics of Black Bengal goat of either sex has not been studied. The present research programme has therefore been designed to determine the effect of age on different carcass characteristics of Black Bengal goats of either sex.

MATERIALS AND METHODS

Experimental animals and their management

The experiment was conducted in the Goat Farm of Bangladesh Livestock Research Institute, Savar, Dhaka. A total of 61 Black Bengal goats of different age and sex groups were slaughtered (Table 1). Animals were reared under semi-intensive management. All male animals were castrated during 3rd to 4th week of their life. Pre-weaned kids (0-90 day) were absolutely on milk alone. Post-weaned kids (91-180 days) were given concentrate mixture (of 10.14 MJ meatbolizable energy (ME) and 10.48 g metabolizable protein (MP)/kg DM; Table 2) and freshly cut Napier grass (of 2 MJ ME and 25 g CP/kg of fresh matter) to meet the estimated nutrient requirement of NRC (1981). Depending on the body weight, growing and adult animals were given 350-600 g concentrate mixture (10.31 MJ ME and 11.7 g MP/kg DM; Table 2) daily in addition to 6 hours grazing in a mixed natural pasture.

Slaughter procedure and measurements

Prior to slaughter, goats were weighed by a hanging digital balance. Different body measurements including shoulder (wither) height, height at hind legs, chest depth (half of the circumference of chest girth) and body length (point of elbow to point of hip) were then recorded. Goats were slaughtered according to 'Halal' method by severing the major vessels of the throat by a transverse cut. Blood was collected and weighed in a pre-weighed bucket. Before flaying, a 20 cm steel-rod was inserted through left fetlock under the skin towards thigh. Air was then blown into the body through the perforation until the carcass was swelled with air under the skin. This was done to facilitate easy removal of skin. Skin was removed by conventional flaying method. The carcass was hoisted from its hock at a convenient height. Head was removed at the oxipito-atlantal joint and feet below the carpals (knee bones) in the fore legs and tarsals in the hind legs. Entire digestive tract was weighed before and after removing the contents. Data were recorded in terms of live weight, warm carcass weight, dressing percentage, weight of blood, visceral organs (liver, lung, kidney, heart, spleen), head, gut and caul fat, peri-nephric and channel fat, weight of digestive tract, total edible (carcass, viscera, visceral fat) and total saleable (edible plus skin) weight. Carcass was then chilled at -25°C. Chilled carcass was divided into different cuts (shoulder, loin, ribs, thigh) according to Warris (2000). About 250 g of meat sample from each cut was taken for their chemical analysis.

Table 2. Composition of kid starter used for feeding pre weaned and weaned kids

Ingredient	Amount in %	
	For kids	Growing and adults
Maize crush	30	35
Lathyrus Sativa crush	16	16
Wheat bran	25	25
Soyabean meal	20	20
Fish meal	-	1.5
Soyabean oil	1	-
Molasses	5	-
Dicalcium phosphate	1	1.4
Salt	1.5	1
Vitamin mineral pre-mix*	0.5	0.1
Total crude protein	17.40	18.81
UDP (g/kg DM)[a]	5.21	60
RDP (g/kg DM)[b]	12.19	12.81
Metabolizable protein (g/kg DM)	106	114
Metabolizable energy (MJ/kg DM)	10.14	10.31
Metabolizable protein g/J ME	10.48	11.07

* Vit A: 10,000,000 IU, Vit D_3: 1,000,000, Vit E: 10 g, Iodine: 2.5 g, Co: 800 mg, Cu: 6 g, Mn: 50 g, Mg: 100 g, Fe: 80 g, Zn: 45 g, Se 100 mg, per kg mixture.

[a] UDP = Rumen undegradable dietary protein.

[b] RDP = Rumen degradable dietary protein.

Chemical analysis

Meat samples from different cuts were analyzed for dry matter, ash, crude protein and ether extract according to the AOAC (1984). Concentrate mixture was also analyzed using the same procedure.

Statistical analysis

The data were analyzed using the statistical package of SPSS 9.05 for Windows (SPSS Ltd., 1998). In the analysis of variance appropriate for 4×2 factorial experiment the results presented for main effects and interactions as follows: A=age effect (0-90, 91-180, 181-365 and >365 days); S=sex (male (M) and female (F)) and A×S= interaction between the age and sex. The effect of age and

Table 3. Effect of age and sex on body measurements of Black Bengal goat under semi-intensive management

Parameter	0-90 days		91-181 days		181-365 days		>365 days		Significance		
	M	F	M	F	M	F	M	F	Age	Sex	A×S
Live weight (kg)	5.30	5.95	6.22	5.50	20.34	-	22.28	11.35	***	NS	***
	(1.071)	(1.383)	(1.071)	(2.396)	(0.906)		(0.470)	(2.396)			
Shoulder height (cm)	36	39	37	39	57	-	57	48	***	NS	***
	(1.63)	(1.63)	(0.94)	(2.83)	(0.94)		(0.58)	(2.83)			
Height at hind legs (cm)	38	41	37	40	58	-	59	50	***	NS	***
	(1.74)	(1.74)	(1.00)	(3.00)	(1.00)		(0.61)	(3.00)			
Chest depth (cm)	17	21	17	10	25	-	30	28	*	NS	NS
	(3.92)	(3.92)	(2.26)	(6.79)	(2.26)		(1.38)	(6.79)			
Body length (cm)	37	41	43	40	58	-	58	67	***	NS	NS
	(2.87)	(2.88)	(1.66)	(4.98)	(1.66)		(1.01)	(4.98)			

Values in the parenthesis indicate standard error of the mean. *, *** and NS indicate significance ($p<0.05$), ($p<0.001$) and ($p>0.05$), respectively.

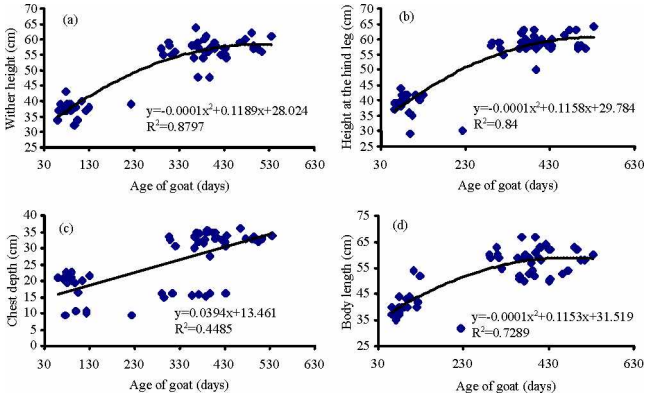

Figure 1. Relationship between age and wither height (a), or height at the hind legs (b) chest depth (c) or body length (d) of Black Bengal goat. Each point represents record of individual goat.

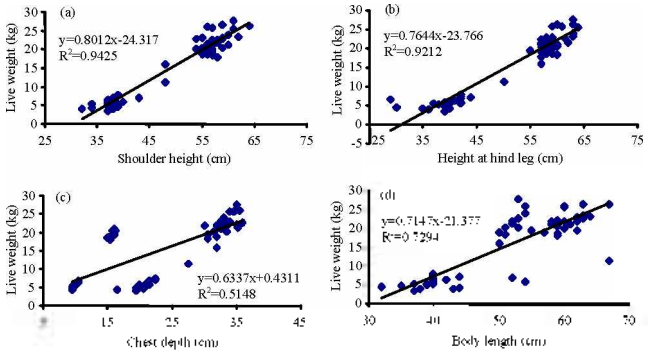

Figure 2. Relationships between live weight with height at shoulder (a), hind legs (b), chest depth (c) and body length (d) of Black Bengal goats at different ages and sex groups.

sex of goat and their interaction on slaughter weight, body measurement, yield of different carcass and non-carcass components and carcass composition, were determined by using the following linear model:

$$Y_{ij}=\mu+\alpha_i+\beta_j+\alpha\beta_{ij}+e_{ij}$$

where, Y_{ij} is the effect of i^{th} age at j^{th} sex on parameter in question, μ is the general mean, α_i is the effect of i^{th} (i=0-90, 91-180, 181-365 and >365 days) age group of goat, β_j is the effect of j^{th} (j=male (M) and female (F)) sex, $\alpha\beta_{ij}$ is the interaction effect of i^{th} age at j^{th} sex and e_{ij} is the random error. However, for chemical composition of meat, effect of sex was not included in the model. Besides, linear, exponential or quadratic model was used to express the relationship between to related variables using Microsoft Excel programme (Microsoft Office 2000).

RESULTS AND DICSCUSSIN

Pre-slaughter body parameters

Effect of age and sex on body weight and body parameters are shown in Table 3. All the body measurements were significantly ($p<0.001$) affected by the age but not by the sex. Across the age groups, male had higher body weight and size (measurements) than the female. Effect of age on body measurements is shown in Figure 1. Shoulder height (Figure 1a), height at hind legs (Figure 1b) and body length (Figure 1d) increased curvilinearly up to 450 days. However, chest increased linearly with age ($r^2=0.45$). Up to one-year, average shoulder height, height at hind legs, chest depth and body length were 57 (±0.94) cm, 58 (±1.00) cm, 25 (±2.26) cm and 58 (±1.66) cm, respectively. These values are much higher than that Monirzzaman et al. (2002), who, showed that wither (shoulder) height, chest depth and body length of one-year-old Black Bengal goat reared under stall fed condition were 48, 25 and 50 cm, respectively. Body measurement parameters in this trail are also higher than that observed by Husain (1993) in Black Bengal goat. Relationship of live weight, carcass weight, edible weight and saleable weight of Black Bengal goat with different body parameters is shown in Figure 2, 3, 4 and 5, respectively. Live weight (kg), carcass weight (kg), edible weight (kg) and saleable weight (kg) of Black Bengal goat can be best predicted from the following equations:

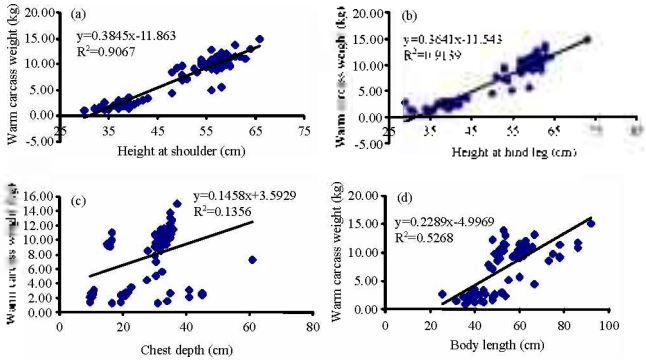

Figure 3. Relationship of warm carcass weight with body height at shoulder (a), hind legs (b), chest depth (c) and body length (d) of Black Bengal goat at different ages and sex group.

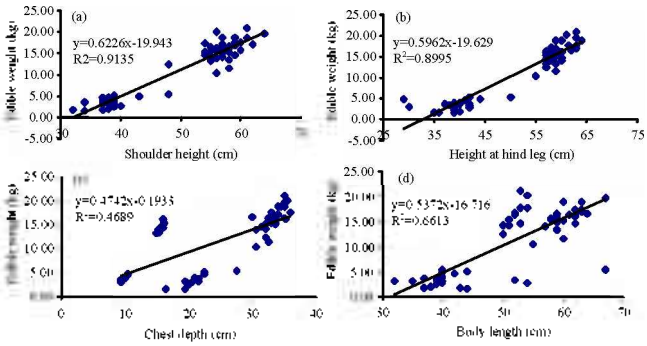

Figure 4. Relationships of edible weight with body height at shoulder (a), hind legs (b), chest depth (c) and body length (d) of Black Bengal goat at different ages and sex groups.

Live weight (kg)=0.801 (shoulder height (cm))-24.32; (r^2 = 0.94; Figure 2a)

Carcass weight (kg)=0.364 (height at hind legs (cm)) -11.54; (r^2 = 0.91; Figure 3b)

Edible weight (kg)=0.623 (shoulder height (cm))-19.94; (r^2 = 0.91; Figure 4a)

Saleable weight (kg)=0.701 (shoulder height (cm)) -21.99; (r^2 = 0.92; Figure 5a)

Slaughter weight and carcass yield

Effect of age and sex on slaughter weight and carcass yield characteristics of Black Bengal goat is shown in Table 4. Slaughter weight was significantly ($p<0.001$) affected by the age but not by the sex. Live weight at slaughter of goat increased curvilinearly (r^2=0.86) up to 520 days (17.3 months; estimated from the equation Figure 6a) but the linearity of the curve ends at about 270 days (9 months; estimated from the equation Figure 6a). This means that meat production efficiency of Black Bengal goat would be the highest at about 9 months, which is similar to the suggested (theoretical estimation) optimum slaughter age of 8.9 months for Black Bengal goat (Singh and Sengar, 1979).

Live weight of castrated male goat at one-year onward ranges from 20-22 kg, which, is about 78% higher than that

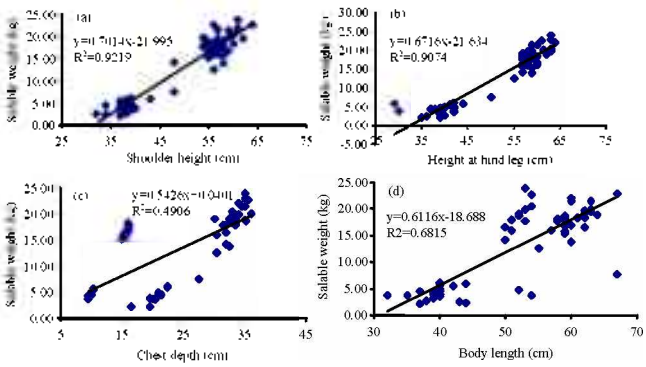

Figure 5. Relationships of saleable weight with body height at shoulder (a), hind legs (b), chest depth (c) and body length (d) of Black Bengal goat at different ages and sex groups.

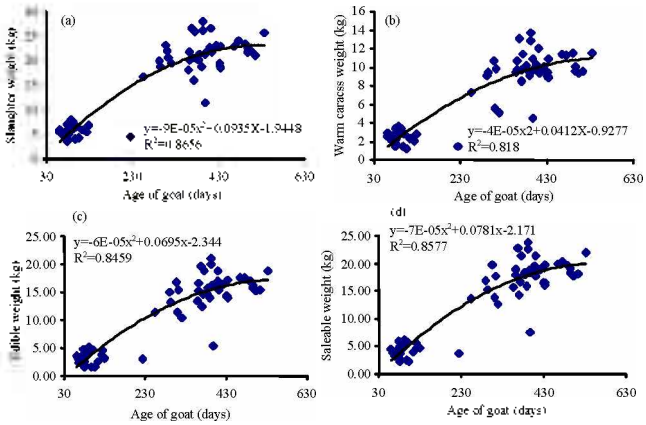

Figure 6. Effect of age on slaughter weight (a), warm carcass weight (b), edible weight (c) and saleable weight (d) of Black Bengal goat reared under semi-intensive management.

reported live weight of 13 kg (Guha et al., 1968), 11.6 kg (Singh and Sengar, 1979), 10.3 kg (Shajalal et al., 2000) and 12.3 kg (Monirzzaman et al., 2002) for the Black Bengal goat at one year. One possible reason is that goat under the present trail were given NRC (1983) recommended nutrient right from their *in-utero* life. While most of the trials (except Singh and Sengar, 1979) referred here are based on short-term observation of 3-5 months feeding under different types of management. Ryan (1990) showed that lambs and calves subjected to nutritional restriction during their *in-utero* life or soon after birth, may suffer permanent stunting of growth. This is probably due to the fact that pregnant dam can induce life long change in gene expression of many metabolic systems e.g. insulin/ glucose axis, growth hormone/IGF_1 axis and other key metabolic regulator of homeorhsis (Makkar, 2002). Result of this trial probably shows the real potentiality Black Bengal goat as meat animal.

Unlike live weight, carcass weight was significantly affected both by age ($p<0.001$), sex ($p<0.05$) and also by their interaction ($p<0.001$). Carcass weight of goat also increased curvilinearly (r^2=0.86) up to 525 days (17.3

Table 4. Effect of age and sex on slaughter weight and dressing percentage Black Bengal goat

Parameter	0-90 days		91-181 days		181-365 days		>365 days		Significance		
	M	F	M	F	M	F	M	F	Age	Sex	A×S
Live weight at slaughter (kg)	5.30	5.95	6.22	5.50	20.34	-	22.28	11.35	***	NS	***
	(1.071)	(1.383)	(1.071)	(2.396)	(0.906)		(0.470)	(2.396)			
Warm carcass weight (kg)	2.46	2.88	2.59	2.05	9.44	-	10.54	4.45	***	*	***
	(0.532)	(0.687)	(0.532)	(1.190)	(0.450)		(0.233)	(0.014)			
Dressing percentage	46.2	48.3	40.8	37.0	46.4	-	47.5	39.0	***	NS	*
	(1.40)	(1.90)	(1.40)	(3.20)	(1.20)		(0.60)	(3.20)			
Total edible (kg)	3.42	3.98	3.43	3.77	14.17	-	16.30	5.38	***	***	***
	(1.099)	(1.099)	(0.635)	(1.904)	(0.635)		(0.389)	(1.904)			
Edible as % of live weight	67.13	66.72	57.86	68.58	69.78	-	74.46	47.40	NS	NS	NS
	(4.482)	(4.482)	(2.588)	(7.764)	(2.588)		(1.585)	(7.764)			
Total saleable (kg)	4.24	4.85	4.37	4.61	16.531	-	18.809	7.61	***	***	***
	(1.210)	(2.211)	(0.699)	(2.097)	(0.699)		(0.428)	(2.097)			
Salable as % of live weight	83.07	81.41	74.41	83.78	81.38	-	85.93	67.05	NS	NS	NS
	(3.96)	(3.960)	(2.286)	(6.859)	(2.286)		(1.400)	(6.859)			

Values in the parenthesis indicate standard error of the mean. *, *** and NS indicate significance ($p<0.05$), ($p<0.001$) and ($p>0.05$), respectively.

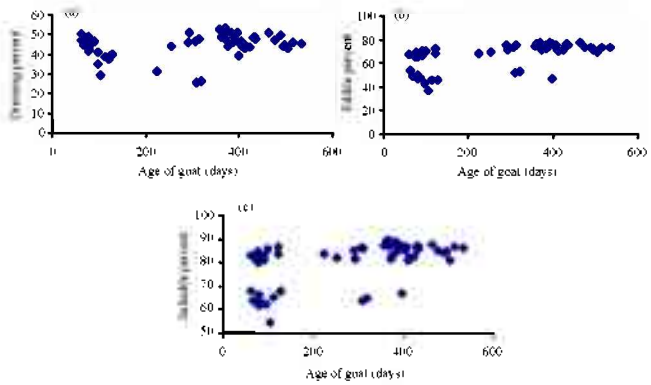

Figure 7. Relationship between slaughter age with dressing per cent (a), edible per cent (b) and saleable per cent (c) of Black Bengal goat reared under semi-intensive management.

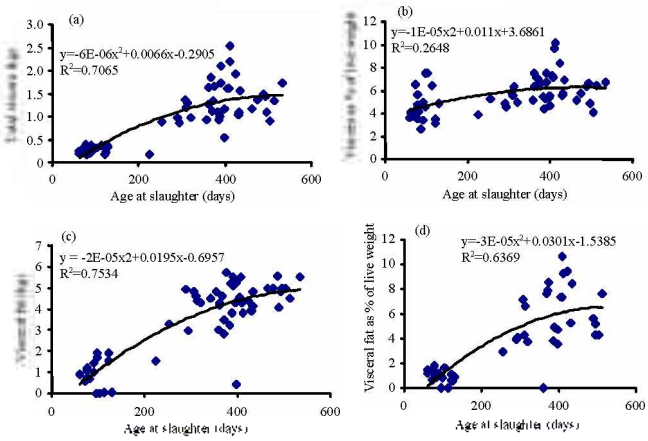

Figure 8. Effect of age on total viscera (a), viscera as % of live weight (b), total visceral fat (c) and visceral fat as % of live weight (d) of Black Bengal goat.

months). However, linearity of the curve ends at about 260 days (8.67 months; estimated from the equation Figure 6b), which, is slightly higher than the estimated (using an equation mentioned earlier) optimum slaughter age of 248 days (8.26 months) for Black Bengal goat (Singh and Sengar, 1979). In the present trial, carcass weight, at one year on-ward 9.4-10.5 kg, which, is about two times higher than that reported carcass weight of 5.17 kg (Singh and Sengar, 1979), 4.65 kg (Shajalal et al., 2000) and 5.17 kg (Moniruzzaman et al., 2002) for one year old male Black Bengal goat.

There is no apparent relationship between age and dressing percent (Figure 7a). However, dressing percent was significantly ($p<0.001$) lower (37.9±2.92%) during 91-180 days, although there is no obvious reason for that. Overall dressing percent (42.8±1.36%) in this trial was lower than that of 44.6% (Singh and Sengar, 1979) but slightly higher than 39-40% (Shajalal et al., 2000) or 34-42% (Moniruzzaman et al., 2002).

Total edible and saleable quantity of carcass was significantly ($p<0.001$) affected by the age and sex of goat and also by their interaction. However, age or sex had no significant ($p>0.05$) affect on edible or saleable part of carcass as per cent of live weight. With increase live weight, the edible (Figure 6c) and saleable (Figure 6d) quantity of carcass increased curvilinearly ($r^2=0.84$ and 0.86, respectively). Edible and saleable quantity increased up to 585 days (19.5 months; estimated from the equation Figure 6c) and 560 days (18.7 months; estimated from the equation Figure 6d), respectively but the linearity of increase, in both cases, ends at about 260 days (8.7 months; estimated from the equation Figures 6b and 6c). However, there is no apparent relationship between ages and edible (Figure 7b) or saleable (Figure 7c) as per cent of live weight. This is different from the observation that showed that percent of saleable bio-mass of East African female goats increased from 45.9% at birth to 61.8% at 4.1 kg weight which then decreased to 60.8, 57.5, 55.5 per cent at 7.3 kg, 11.3 kg and

Table 5. Effect of age and sex on edible product and by-products of Black Bengal goat

Parameter	0-90 days		91-181 days		181-365 days		>365 days		Significance		
	M	F	M	F	M	F	M	F	Age	Sex	A×S
Dressed carcass (kg)	2.46	2.88	2.59	2.05	9.44	-	10.54	4.45	***	*	***
	(0.532)	(0.687)	(0.532)	(1.190)	(0.450)		(0.233)	(0.014)			
Liver (g)	131	161	148	148	279	-	266	256	***	NS	NS
	(33.8)	(33.8)	(19.5)	(19.58)	(19.5)		(11.9)	(19.5)			
Lung (g)	27	35	64	62	63	-	60	130	***	NS	***
	(11.6)	(11.6)	(6.72)	(6.72)	(6.72)		(4.11)	(20.15)			
Kidney (g)	35	53	33	28	76	-	81	40	***	NS	***
	(7.97)	(7.97)	(4.60)	(13.81)	(4.60)		(2.82)	(13.81)			
Heart (g)	19	18	24	12	52	-	53	70	***	NS	NS
	(5.59)	(5.59)	(3.22)	(9.68)	(3.22)		(1.97)	(9.68)			
Spleen (g)	24	17	21	20	696	-	886	36	***	NS	*
	(145.3)	(145.3)	(83.9)	(251.6)	(83.9)		(51.4)	(252.7)			
Viscera (kg)	0.236	0.284	0.290	0270	1.166	-	1.34	0.530	***	NS	*
	(0.158)	(0.158)	(0.091)	(0.018)	(0.091)		(0.056)	(0.273)			
Viscera as % of live weight	4.07	4.70	5.19	3.13	5.66	-	6.44	4.69	NS	NS	NS
	(0.445)	(0.643)	(0.429)	(1.268)	(0.407)		(0.243)	(1.286)			
Visceral fat (g)	63	73	62	35	1063	-	1497	398	***	NS	NS
	(205.1)	(264.8)	(205.1)	(458.6)	(173.3)		(89.9)	(458.6)			
Visceral fat as % of live weight	1.18	1.22	0.97	0.64	5.10	-	6.61	3.51	***	NS	*
	(0.723)	(0.934)	(0.723)	(1.618)	(0.611)		(0.317)	(1.618)			

Values in the parenthesis indicate standard error of the mean. *, **, *** and NS indicate significant at ($p<0.05$), ($p<0.01$), ($p<0.001$) and ($p>0.05$), respectively.

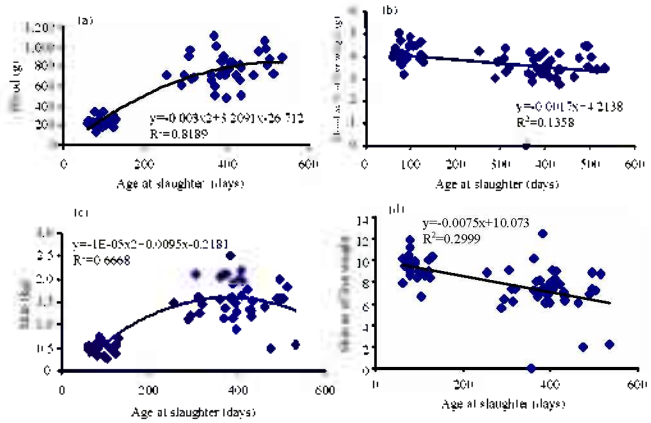

Figure 9. Effect of age on blood (a), blood as per cent of live weight (b), skin (c) and skin as per cent of live weight (d) of Black Bengal goat.

at maturity, respectively (Wilson, 1958). Overall edible (64.5±1.90) and saleable (79.6±1.67) per cent in this trial were similar to 61.2 and 81.5%, respectively for the Katjang goat of Malaysia (Devendra and Burns, 1983).

Edible by-products

Effect of age and sex on edible by-product yield of Black Bengal goat is shown in Table 5. Weight of dressed carcass, lung, liver, kidney, spleen, total viscera, visceral fat and visceral fat as per cent of live weight increased significantly ($p<0.001$) with age. However, sex had no significant ($p>0.05$) affect on edible carcass by-products. Although total visceral content increased curvilinearly with age ($r^2=0.71$; Figure 8a) but age of goat had little affect ($r^2=0.26$; Figure 8b) on visceral content as per cent of live weight.

However, both total visceral fat ($r^2=0.75$; Figure 8c) and visceral fat as per cent of live weight ($r^2=0.64$; Figure 8d) increased curvilinearly with age. Using the equation in Figure 8d ($Y=-0.00003X^2+0.0301X-1.5385$), it can estimate that maximum visceral fat as per cent of live weight (about 6%) can be achieved at about 500 days. However, linear part of the quadratic model ends at about 300 days when visceral fat content is about 4.8% of body weight. Up to 6 months visceral fat content was about 1.2% of live weight that increased to about 5% during 180-365 days and to 6% for animals over one year old. This trial shows that in Black Bengal goat, viscera as proportion of body weight do not changes but the proportion of visceral fat increases with age. As per as fat deposition is concern, optimum slaughter age will be around 300 days (10 months).

Non-edible by-products

Effect of non-edible age and sex on non-edible by products is shown in Table 6. Both absolute quantity and the proportions of different non-edible by products (except proportion of head) were affected by the age but not by the sex or by their interaction. Absolute yield of blood (Figure 9a) and skin (Figure 9c) increased curvilinealry and attained maximum level at about 400 days (13.3 months). However, age had little or no effect on blood (Figure 9b) or skin (Figure 9d) as proportion of live weight. Blood yield for one-year old male goat was 797 g in the present trial, while

Table 6. Effect of age and sex on non-edible carcass components of Black Bengal goats

Parameter	0-90 days		91-181 days		181-365 days		>365 days		Significance		
	M	F	M	F	M	F	M	F	Age	Sex	A×S
Blood (g)	218	245	270	216	741	-	797	475	***	NS	NS
	(55.4)	(71.6)	(55.4)	(123.9)	(46.9)		(24.31)	(123.9)			
Blood as % of live weight	4.14	4.05	4.32	3.93	3.64	-	3.57	4.19	**	NS	NS
	(0.205)	(0.265)	(0.205)	(0.459)	(0.173)		(0.090)	(0.459)			
Head (kg)	0.52	0.54	0.49	0.55	1.53	-	1.63	1.00	***	NS	NS
	(0.178)	(0.178)	(0.103)	(0.308)	(0.103)		(0.063)	(0.308)			
Head as % of live weight	10.2	9.3	8.5	10.0	7.6	-	7.4	8.8	NS	NS	NS
	(0.727)	(0.727)	(0.420)	(1.26)	(0.420)		(0.255)	(1.26)			
Feet (g)	136	157	161	150	401	-	402	330	***	NS	NS
	(28.3)	(28.3)	(16.3)	(49.1)	(16.4)		(10.0)	(49.0)			
Feet as % of live weight	2.68	2.63	2.82	2.73	1.97	-	1.84	2.91	***	NS	***
	(0.159)	(0.159)	(0.092)	(0.275)	(0.092)		(0.056)	(0.275)			
Skin (g)	526	548	576	554	1,614	-	1,582	900	***	NS	NS
	(176.2)	(227.4)	(176.2)	(394.2)	(149.3)		(77.3)	(394.4)			
Skin as % of live weight	9.96	9.26	9.21	10.07	7.95	-	7.14	7.93	**	NS	NS
	(0.775)	(1.00)	(0.775)	(1.732)	(0.655)		(0.34)	(1.732)			
Gastro-intestinal (GI) tract (kg)	0.45	0.38	1.09	0.86	2.37	-	2.78	3.20	***	NS	NS
	(0.301)	(0.301)	(0.174)	(0.521)	(0.106)		(0.106)	(0.521)			
GI tract as % of live weight	8.92	6.32	20.33	15.67	11.63	-	12.71	28.19	***	NS	***
	(2.772	(2.772)	(1.600)	(4.800)	(1.600)		(0.980)	4.800)			

Values in the parenthesis indicate standard error of the mean. *, **, *** and NS indicate significant at ($p<0.05$), ($p<0.01$), ($p<0.001$) and ($p>0.05$), respectively.

Table 7. Effect of age and sex on carcass cuts of Black Bengal goats

Parameter	0-90 days		91-181 days		181-365 days		>365 days		Significance		
	M	F	M	F	M	F	M	F	Age	Sex	A×S
Cold carcass weight (kg)	2.55	2.97	2.64	2.08	9.57	-	10.50	4.40	***	NS	***
	(0.518)	(0.669)	(0.518)	(1.159)	(0.438)		(4.40)	(1.159)			
Thigh (kg)	0.692	0.797	0.792	0.592	2.469	-	2.669	1.000	***	*	***
	(0.136)	(0.175)	(0.136)	(0.304)	(0.115)		(0.060)	(0.304)			
Thigh as % of cold carcass	27.4	26.8	31.4	28.5	25.8	-	25.5	22.7	***	NS	NS
	(1.2)	(1.5)	(1.2)	(2.6)	(1.0)		(0.5)	(2.6)			
Loin (kg)	0.252	0.291	0.268	0.192	0.997	-	1.031	0.500	***	NS	NS
	(0.084)	(0.108)	(0.084)	(0.187)	(0.071)		(0.037)	(0.187)			
Loin as % of cold carcass	10.2	9.75	10.7	9.23	10.3	-	9.82	10.3	NS	NS	NS
	(0.80)	(1.00)	(0.80)	(1.80)	(7.0)		(0.3)	(0.70)			
6-12th Ribs (kg)	0.289	0.364	0.367	0.268	1.350	-	1.580	0.700	***	NS	*
	(0.125)	(0.161)	(0.125)	(0.279)	(0.103)		(0.055)	(0.279)			
6-12th Ribs as % of cold carcass	11.5	12.3	14.6	12.9	14.0	-	15.0	15.9	**	NS	NS
	(0.90)	(1.20)	(0.90)	(2.00)	(0.80)		(0.40)	(2.02)			
Shoulder (kg)	0.533	0.600	0.572	0.424	1.824	-	2.065	1.500	***	NS	NS
	(0.142)	(0.183)	(0.142)	(0.317)	(0.120)		(0.062)	(0.317)			
Shoulder as % of cold carcass	21.4	20.3	22.7	20.4	19.1	-	19.7	34.1	NS	NS	*
	(1.40)	(1.90)	(1.40)	(3.20)	(1.20)		(0.60)	(3.20)			
Neck (kg)	0.187	-	0.174	-	0.581	-	0.667	-	***	-	-
	(0.049)		(0.054)		(0.055)		(0.037)				
Rump (kg)	0.149	-	124	-	650	-	716	-	***	-	-
	(0.072)		(0.089)		(0.092)		(0.062)				

Values in the parenthesis indicate standard error of the mean. *, *** and NS indicate significance ($p<0.05$), ($p<0.001$) and ($p>0.05$), respectively.

it was about 500 g in Black Bengal goats of same age and sex (Monirzzaman et al., 2002). However, when expressed as per cent of live weight, blood yield was higher in the later (5.05%) than the former (3.57%). Similarly, for one-year old male goat, yield of skin both absolute quantity (1.61 kg) and as proportion of live weight (7.95%) were higher in the present trial than those of 0.75 kg and 7.5%, respectively observed by Moniruzzaman et al. (2002).

Carcass cuts

Effect of age and sex on carcass cuts of Black Bengal goats is shown in Table 7. Quantity of thigh, loin, ribs,

Table 8. Chemical composition of dressed meat of some carcass cuts of Black Bengal goats slaughtered at different ages

Parameters	0-90 days	91-181 days	181-365 days	>365 days	Overall mean	Significance
Hind legs						
DM%	28.22^{bc}	22.72^{c}	29.90^{ab}	33.91^{a}	28.68	p<0.01
	(2.39)	(2.67)	(2.39)	(1.09)		
Ash%	4.83^{a}	5.06^{a}	3.55^{b}	3.31^{b}	4.18	p<0.05
	(0.421)	(0.471)	(0.471)	(0.211)		
CP%	65.37^{a}	56.51^{ab}	63.95^{a}	48.73^{b}	58.64	p<0.01
	(4.580)	(5.12)	(4.58)	(2.09)		
EE%	-	8.74^{c}	15.06^{b}	29.78^{a}	17.86	p<0.01
		(5.69)	(6.98)	(2.74)		
Shoulder						
DM%	32.30^{ab}	22.29^{b}	41.26^{a}	36.15^{a}	33.25	p<0.058
	(4.71)	(5.27)	(4.71)	(2.11)		
Ash%	3.72^{ab}	4.91^{a}	3.52^{ab}	3.04^{b}	3.80	p<0.05
	(0.759)	(0.658)	(0.658)	(0.302)		
CP%	53.55	57.67	44.21	45.98	50.35	NS
	(6.83)	(7.64)	(6.83)	(3.05)		
EE%	-	11.04^{b}	24.92^{ab}	33.38^{a}	23.11	p<0.05
		(8.69)	(12.29)	(5.02)		
Eye muscle						
DM%	29.93^{ab}	23.61^{b}	36.55^{a}	33.04^{a}	30.78	p<0.01
	(2.49)	(2.78)	(2.78)	(1.35)		
Ash%	3.77^{ab}	4.52^{a}	2.28^{c}	3.03^{bc}	3.40	p<0.01
	(0.516)	(0.447)	(0.516)	(0.205)		
CP%	69.41^{a}	58.79^{ab}	46.92^{b}	55.28^{b}	57.60	p<0.05
	(5.78)	(6.46)	(6.46)	(2.63)		
EE%	-	13.44^{b}	20.36^{ab}	33.39^{a}	22.39	p<0.06
		(8.42)	(11.90)	(4.67)		
Chest						
DM%	40.37	-	48.75	43.84	44.32	NS
	(4.29)		(5.55)	(2.05)		
Ash%	2.76	-	2.64	2.27	2.56	NS
	(0.514)		(0.727)	(0.249)		
CP%	41.63^{a}	-	34.09^{ab}	30.28^{b}	35.33	p<0.05
	(4.70)		(6.07)	(2.42)		
EE%	-	-	27.19	61.45	44.37	p<0.01
			(19.04)	(5.74)		

Values in the parenthesis indicate standard error of the mean. NS indicate not significant at (p<0.05).

shoulder, neck and rump were significantly (p<0.001) affected by the age but not by sex. Average proportion of different carcass cut were - round 27%, rump 7%, loin 10%, ribs (6-12th) 14%, shoulder 21%, Neck 7%, chest 14%. Thigh and shoulder constituted about 48.3% of the cold carcass weight. This is slightly higher than 44.7% observed by Singh and Sengar (1979). United State Department of Agriculture adapted 4 primal cuts in goat are leg, loin rack and shoulder (http://www.inform.umd.edu/EdRes/Topic /AgrEnv/ndd/goat/CHEVON_MEAT_C.. 2002) for goat. Leg and shoulder constitute 50% of the cold carcass. Loin is the most valuable carcass cut, they are about 10% of the carcass in the present trial, while, and this is only 4% according to USA standard.

Chemical composition

Effect of age on chemical composition of dressed meat from some carcass cuts is given in Table 8. Dry matter content of hind leg (p<0.01), shoulder (p<0.06), eye muscle and chest (p>0.05) increased with age. Overall increase in carcass DM content followed a sigmoid trend with relatively lower values at 91-180 days and at >365 days (Figure 10). Ash content was the highest during 91-180 days but decreased with progress in age. Overall crude protein content, on the other hand, progressively decreased with age starting from 57 at 0-90 days to 58, 47 and 33 per cent, respectively at 91-180, 181-365 and >365 days, respectively (Figure 10). The highest overall protein content was observed in the eye muscle (53%) and the lowest (35%) in chest cut (Table 8). Overall protein content of 33-58% of meat was much higher in this trial than 21-22.8% (Shahjalal et al., 2000) or 20.8-22.4% (Moniruzzaman et al., 2002), but it was lower than 61% (Singh and Sengar, 1979) observed in Black Bengal goat.

Unfortunately we do not have the data on carcass fat content during 0-90 days. Overall meat fat content

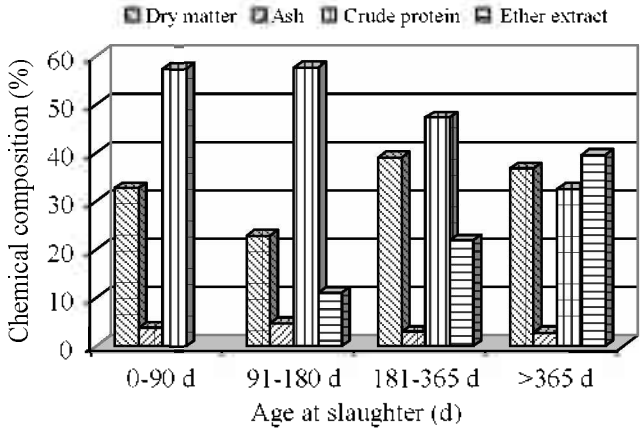

Figure 10. Overall chemical composition of Black Bengal goat carcass at different ages.

increased almost linearly from 11.1% during 91-180 days to 22.9 and 39.5% during 181-365 and >365 days, respectively (Figure 10). Overall fat content was the highest in the chest cut (44%) and the lowest in the eye muscle (22%). Overall fat content of 11-40% of meat was much higher in this trial than 6-6.9% (Shahjalal et al., 2000) or 4.9-9.2% (Moniruzzaman et al., 2002) or 7.77% (Singh and Sengar, 1979) observed in Black Bengal goat. Relatively higher fat content in this trial was probably due to higher body weight of goats in this trial of 20-22 kg than those of 9.63-11.4 (Shahjalal et al., 2000), 9-12.3 kg (Moniruzzaman et al., 2002) and 11.6 kg of (Singh and Sengar, 1979).

CONCLUSION

Results from this trial suggest mainly two things

i) both carcass yield and carcass composition changes with age; ii) sex have little or no effect on carcass yield and carcass composition. However, caution should be made in using second conclusion as there were few female animals slaughtered relative to the male. Optimum slaughter age for Black Bengal goat reared semi-intensive management with adequate feeding and management would be about 9 months when their live weight, warm carcass weight, edible and saleable weight of carcass can be about 16.74, 7.28, 12.05 and 13.81, respectively.

REFERENCES

AOAC. 1984. Official Methods of Analysis. Centennial Edition. Association of Official Analytical Chemist. Washington DC. USA.

Devendra, C. 1991. Breed Differences in Productivity in goats. In: Genetic Resources of Pig, Sheep and Goat. World Animal Science, B8 (Ed. K. Maijala). Agricultural Research Center, Department of Animal Production, 31600, Finland. Elsevier Science Publishers, B.V. Amsterdam. pp. 429-440.

Devendra, C. and M. Burns. 1983. Goat Production in the Tropics. Commonwealth Agricultural Bureaux, Franham House, Franham Royal, Slough SL2 3BN. UK.

Guha, H., S. Gupta, A. K. Mukharjee, S. K. Moulick and S. Bhattacharia. 1968. Some causes of variation in growth rates of Black Bengal goats. Indian Journal of Veterinary Science and Animal Husbandry 38:269-278.

Hussain, S. S. 1993. A study on the productive performance and genetic potentials of Black Bengal goats. Ph.D. Dessertation. Animal Breeding and Genetics. Bangladesh Agricultural University, Mymensingh.

Makkar, H. 2002. Improvement of animal productivity in developing countries by manipulation of nutrition *in utero* to alter gene expression. Animal Production and Health News Letter. Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture and FAO/IAEA Agriculture and Biotechnology Laboratory, Seibersdorf. International Atomic Energt Agency, Viena. 36:26-27.

Moniruzzaman, M., M. A. Hashem, S. Akther and M. M. Hossain. 2002. Effect of different feeding system on carcass and non-carcass parameters of Black Bengal goat. Asian-Aust. J. Anim. Sci. 15(1):61-65.

NRC. 1981. Nutrient Requirements of goats: Angora, Dairy, and meat goats in the Temperate and Tropical Countries. National Academy Press, Washing, DC.

Ryan, W. J. 1990. Compensatory gain in cattle and sheep. Nutrition Abstracts and Reviews-Series B. 60:653-664.

Shahjalal, M., M. A. A. Bishwas, A. M. M. Tareque and H. Dohi. 2000. Growth characteristics of goats given diets of varying protein concentration and feeding level. 13(5):613-618.

Singh, S. N. and O. P. S. Sengar. 1979. Studies on the combining ability of desirable characteristics of important goat breeds for milk and meat separately and in combination. A report of the PL-480 project on Goats. Raja Balwant Singh College, Department of Animal Husbandry & Dairying, Bichpuri-283105 (Agra), U.P., India.

SPSS. 1998. SPSS 9.05 for Windows.

Chevon-Meat cuts. In: National Goat Handbook. 2002 http://www.inform.umd.edu/EdRes/Topic/AgrEnv/ndd/goat/CHEVON_MEAT_C

Warriss, P. D. 2000. The slaughter of animals. In: Meat Science-An Introductory Text. CABI Publishing, 10 E 40th Street, Suite 3203, New York, NY 10016 USA. pp. 68-92.