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Growth, carcass characteristics and organ development of goat kids fed different levels of cow milk

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Abstract

This study was conducted to determine the effect of feeding different levels of cow milk on growth, hematological parameters, carcass characteristics, rumen and testicular development of goat kids. Eighteen Black Bengal kids were randomly allocated to three groups on the basis of milk feeding levels, 10% (n = 6), 15% (n = 6), and 20% (n = 6) of liveweight. The average liveweight of each group was 2.40 kg. The milk was fed at regular intervals daily up to 13 weeks of age when they were weaned. Blood samples were collected at 8 weeks of age to determine different blood components. At 16 weeks of age kids were sacrificed to examine carcass characteristics, rumen and testes development. Increasing levels of milk improved liveweight gain of kids. Kids fed 20% milk were heavier (7.78 ± 0.37 kg) at slaughter than others. Numbers of red blood cells were significantly higher in the 15% milk fed group than 20% milk fed group. Carcass weight and dressing percentage of meat did not differ significantly among the groups. Histological examination revealed that rumen papillae length (707.00 ± 37.07 µm) and width (430.23 ± 29.86 µm) were significantly higher in 20% milk fed kids than others. The sizes of right testicles were significantly wider in 20% milk fed kids than that of 10% groups of kids. In conclusion, cow milk could be fed to kids at the rate of 20% of their liveweight for maximum growth and organ development.

Introduction

In tropical and sub-tropical regions, high rates of kid mortality affect goat production. The major cause for higher kid mortality is insufficient milk production of dam (Husain, 1993). Artificial feeding is required to prevent kid mortality. Artificial feeding involves feeding of young kids from a bottle with a rubber nipple on the end as a substitute or supplement to natural suckling. The success of artificial rearing depends on many factors such as breed, milk quality, access to feed and pasture, environment and the system of milk feeding (Havrevoll *et al.*, 1991). Quantity of milk to be fed to kids is an important factor that influences performances of kids. Conventionally, milk supplied to kids, lambs and calves at the rate of 10% of their live weight (Jasper and Weary, 2002). Recent studies have reported higher weight gains under higher rates of feeding (Khan *et al.*, 2011). Some studies have examined feeding rates of 15% (Conneely *et al.*, 2014), 20% (Khan *et al.*, 2007a) and 12%, 15% and 18% (Khouri and Pickering, 1968) to calves of their live weight. In these studies, higher feeding rates increased calf growth and other measures of performance. The amount of milk fed to dairy calves during the pre-weaning period influences dry feed consumption, growth, and health (Appleby *et al.*, 2001), gut development (Anderson *et al.*, 1982), mammary growth and capacity for milk production (Bar-Peled *et al.* 1997).

Neonatal kids are functionally monogastric like pigs and humans. At this stage, all four compartments of ruminant stomach except abomasum are non-functional, undeveloped, and small in size and disproportionate to the adult digestive system (Tamate *et al.*, 1962). The rumen of the neonatal occupies about 25% volume of the whole stomach (Sato *et al.*, 2010). The rumen only starts to grow at two to three weeks of age and growth will continue until about 2 months of age. Faster rumen development is desirable as it has synergistic effects on growth (Quigley *et al.*, 2006). When the young goat starts to eat solid foods, these feeds stay in the rumen and lead to development of the microbial population. However, *ad-libitum* milk consumption during pre-weaning can reduce or delay the solid feed consumption

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(Appleby *et al*., 2001; Hammon *et al*., 2002) and is associated with poor post-weaning performance, probably because of delayed ruminal development (Baldwin *et al*., 2004).

The actual requirement of milk for artificially fed goat kids is not precisely known. Therefore, the present study was aimed at determining the amount of cow milk required for optimum productivity of artificially reared kids. In the present study, milk was fed at the rate of 10%, 15% and 20% of liveweight and the effects of three levels of milk on growth, carcass characteristics, blood components and development of rumen and testes examined in Black Bengal kids.

Materials and Methods

Kids and Management

Eighteen male Black Bengal kids of 3 weeks old were separated from their dams and divided into three groups (Groups A, B and C) that were equal for initial weight. Each group contained 6 kids. They were housed in 3 separate pens. The floor space per kid was 13.33 sq. ft. The house was well ventilated. Every day the floor, feeder and water trough were cleaned using phenyl as antiseptic. A separate feeder was used for roughage and concentrate feeding and no records were kept. After five weeks small amount of concentrate mixture and roughage were supplied to the kids. The three groups of kids were fed cow milk individually on different milk treatments: A -10%, B -15%, C - 20% of live weight per day in whole cow's milk. Kids fed three times daily from 4 to 6 weeks old, twice daily from 7 to 10 weeks old, and once daily from 11 to 13 weeks old. Thereafter, gradual weaning began at 9 weeks old and ended at 13 weeks old. The amount of milk fed to the kids was gradually reduced to zero by the end of week 13, using week 7 intakes as a base 2%, 3% and 4% level in 10 %, 15% and 20% milk feeding groups, respectively. This careful weaning method was employed to reduce the within treatment variation in weight gains. After five weeks small amount of concentrate mixture (24% crude protein) were supplied to the kids. Then after 6 weeks concentrate feeds were increased gradually up to the end of experiment. This study was approved as ethically sound by Bangladesh Agricultural University Research System (BAURES).

Liveweight

Each kid was weighed weekly at 8.00 am using a digital balance. The kids were kept off feed overnight (17 hours) before weighing.

Collection and processing of blood

Blood samples were collected at 8 weeks of experimental period at 9.00 am via jugular vein puncture into evacuated tubes containing EDTA (Ethylene diamino tetraacetate) for determination of blood parameters including red blood cell (RBC), white blood cell (WBC), haemoglobin (Hb), Erythrocyte sedimentation rate (ESR) and packed cell volume (PCV). Collection and examination of blood were performed following the procedure described by Sarker *et al*. (2015). In brief, the area from where blood is to be collected was shaved by blade. The needle was inserted into the raised vein and then removed from syringe for discharging the blood into vial containing anticoagulant gentle. For haematological test, blood was stored in EDTA tube.

Carcass and non-carcass variates

Kids were sacrificed at 16 weeks of age. Liveweight, length of body, heart girth, circumference and length of neck, and height at withers of each kid were recorded prior to sacrifice. Kids were fasted overnight (17h) and sacrificed using the approved “Halal” method. By this method, goats were bled by cutting the throat and then slaughtered by severing the head at its articulation on the occipito-atlantal space. At the time of sacrifice, blood was collected in a pail and weights were recorded. The head was removed along with the pelt and feet and each weighed individually. The digestive tract was removed and weighed at full and empty conditions to obtain the weight of the “gut fill”. Liver, kidney, spleen, lung with trachea, heart, caul fat and renal fat were separated from attached tissue and weighed separately. Warm carcass weights were recorded immediately after completing dressing and evisceration. Testicles were removed and collected into phosphate buffered saline (PBS).

Rumen development

After sacrifice, reticulo-rumens were emptied, and rinsed with cold water, then transported immediately to the laboratory. Rumen tissues were sampled from nine different positions: right side of cranial ventral sac (RD), left side of cranial ventral sac (LD), right side of cranial dorsal sac (RC), right side of caudal dorsal sac (RB), right side ventral portion of caudal ventral blind sac (RE), left side ventral portion of caudal ventral blind sac (LE), left side of cranial dorsal sac (LC), left side of caudal dorsal sac (LB), caudal portion of the caudal ventral blind sac (A) following the procedure described by Sarker *et al*.(2015). The thickness of the rumen was measured at each of these sites. To determine papilla density, the number of papillae per microscopic field was assessed at 5×10x, and visual observations were taken using a Stereo Zoom microscope (CZM6: Labo America Inc., California, USA) at the nine different sites.

Histology

After collection adipose tissues surrounding the testes were removed carefully. Length and width of each testis were measured with Slide Callipers and their weights were also recorded. Tissue from testes and rumen were fixed in Bouin's solution for subsequent measurement of testicular development and rumen papilla length and width respectively. After dehydration in graded alcohol and cleaning in xylene, tissues were infiltrated and embedded in melted paraffin. Five cm thick sections were prepared by using a rotatory microtome (Thermo Fisher Scientific) and placed upon glass slide and air dried in room temperature. The sections were then stained with haematoxylin and eosin. Finally, the stained sections were permanently mounted with a cover slip using DPX (Sigma-Aldrich) mounting reagent.

Microscopy

For the rumen samples, the length and width of papillae were measured using an ocular micrometer attached with the Stereo Zoom microscope (Olympus, USA) at nine different position (5 × 10*x*) using thirty microscopic fields. Every fifth serial section was observed with a Differential Interference Contrast (DIC) microscope (Olympus, USA).

Statistical analysis

Data were represented as the mean ± SE (standard error). All data were subjected to one-way ANOVA, and the significance of difference among means was determined using Tukey's HSD test. All analyses were conducted in "SAS/STAT version 9.1.3" for Windows Service Pack 4, 2004 SAS Institute, Cary NC USA for Windows. Differences at $p<0.05$ were considered statistically significant.

Results and Discussion

Liveweight gain of kids

Figure 1 showed the liveweights of the kids on three treatments over the course of the experiment. Final liveweight of 10%, 15% and 20% milk fed groups were 5.59 ± 0.29, 6.54 ± 0.65, and 7.78 ± 0.37 kg, respectively (Table 3). Total liveweight gain from 3weeks to slaughter was significantly higher ($p<0.05$) in 20% (5.37 ± 0.40 kg) milk fed kids than 10% (3.23 ± 0.25kg) milk feeding group. The weekly and daily liveweight gain was also significantly higher ($p<0.05$) in 20% (0.41 ± 0.03kg/week, 0.05 ± 0.00 kg/day) milk fed kids than 10% (0.24 ± 0.02 kg/week, 0.03 ± 0.00 kg/day) treatment groups. Increasing the supply of nutrients through feeding a greater volume of milk based on liveweight resulted in an increase in growth in the 20% milk feeding group of kids. This result was consistent with the earlier studies reviewed by Khan *et al*. (2011). They reported that allotting approximately 20% liveweight per day resulted in improved growth, greater BW gain, improved feed efficiency, reduced incidence of disease, and greater opportunity to express natural behaviors, which in combination suggest improved welfare. Previously, Khan *et al*. (2007b) reported that higher milk consumption resulted in higher liveweight gain in male calves. It has been reported that presence of several growth factors and hormones, both colostrum and milk enhance the growth and maturation of the gastrointestinal tract of calves (Blum and Baumrucker, 2002). Greater nutrient supply through increased amount of milk appears to improve immune function and long-term performance of kids. It has been reported that milk feeding levels influence feed intake and growth of dairy calves (Appleby *et al*., 2001; Jasper and Weary, 2002; Khan *et al*., 2011). Here, we observed that milk feeding levels positively influenced post-weaning (13 to 16 weeks period) growth. Calves fed milk at 10% liveweight were lighter at five weeks of age than those fed 15% (Conneely *et al*., 2014). Restricted nutrient supply early in life had a long-term negative effect on metabolism of the calves (Bach, 2012). Jasper and Weary (2002) concluded that calves fed more milk remained healthy and gained weight much more rapidly before weaning. These calves consumed less solid food before weaning, but not after weaning. Weight gains and concentrate intakes after weaning were similar in kids fed conventionally and *ad-libitum*, but the weight advantage of the *ad-libitum* fed calves persisted for at least several weeks after weaning. Jensen *et al*. (2015) reported that calves fed the standard milk allowance were likely to be much hungrier and thus highly motivated to consume any feed accessible regardless of social stimulation.

Changes in blood components

Numbers of red blood cell (RBC) were higher ($p<0.05$) in 15% milk fed group than 20% group (Table 1). No specific reason were found for higher RBC. The values for WBC, Hb and PCV percentage were similar in all treatments ($p>0.05$). Several factors are known to be involved in the blood parameters of farm animals. Dukes (1955) posited that haematological values of farm animals are influenced by age, sex, breed, climate, season, nutritional status, health status and husbandry practices of animals. However, the present study showed that different levels of milk intake do not influence the blood parameters of goat kids.

Body measurements

Body length and wither height at the time of slaughter differ significantly ($p<0.05$) between 10% and 20% treated group. Heart girth (cm), circumference of neck at the position of apex, middle and base and length of neck (cm) did not differ significantly among three treatment groups (Table 2). Khan *et al.* (2007b) reported that greater live weight gain, body length, wither height, heart girth, and neck length during the post-weaning period could be attributed to higher feed consumption and greater absorption of nutrients from a metabolically functional and developed rumen in kids on 20% feeding compared with those on conventional feeding. Previous experiments showed increased skeletal growth and body condition in calves fed higher amounts of whole milk (Shamay *et al*., 2005). In contrast, Morrison *et al*. (2012) observed no effect of increasing milk intake on withers height at any stage of development, despite faster live weight gains at both pre- and post-weaning stages.

Carcass and non-carcass variates

Although there were no significant differences among the treatment groups, the trend in carcass weight for the kids was consistent with the higher live weight observed in 20% milk fed group (Table 3). Weights of shoulder, rack and loin were insignificantly higher (p>0.05) in 20% milk fed kids than others (Table 4). Weights of hind legs and neck were significantly higher (p<0.05) in 20% milk fed kids than the 10% feeding group. Table 5 showed that blood weight, skin weight, skin length, skin width, gut weight and gut fill did not differ significantly among the treatments for the kids at slaughter.

Organ development of kids

The weight of head, heart, liver, kidney, lung with trachea and pluck among the treatment groups did not differ significantly among the kids. Weight of spleen was significantly higher in 20% milk fed kids than 10% group (Table 6). Higher consumption of milk caused the higher growth of organs although most of them did not differ significantly among the treatment groups.

Rumen development

The weights of the rumen were significantly (p<0.05) higher in 20% milk feeding kids than 10% groups. Weights of reticulum, omasum, abomasum and large intestine did not differ significantly among the kids fed different levels of milk. (Table 7). The weight of small intestine was significantly higher (p<0.05) in 20% milk fed kids than 10% feeding group. Average rumen wall thicknesses at nine different sites were insignificantly higher in 20% milk feeding kids than 10% group (Table 8). Feeding increased amount of milk resulted increased papillae density (Table 9, Figure 2). The length and width of the papillae differed significantly in 20% milk feeding group than 10% and 15% milk treated group (Table 9, Figure 3). It has been reported that rumen papillae length and width, rumen wall thickness, and papillae density is influenced by dietary factors (Brownlee, 1956; Harrison *et al*., 1960; Tamate *et al*., 1962). Khan *et al*. (2007a) reported that greater consumption of concentrate resulted in higher rumen wall thickness, papillae length and width, and weight of the fore-stomach in 20% milk fed kids compared with those fed conventionally (10%). Also calves fed higher volumes of milk had a greater rumen capacity at weaning (Khan *et al*., 2007a).

Testicular development

The testicular width was higher in 20% milk fed kids than the 10% milk fed group but all other measured testicular variates did not differ significantly among the treatments (Table 10). Higher amount of nutrients supplied from higher levels of milk consumption might enhance testicular development comparing low milk feeding kids. It has been reported that nutrition has a positive influence on growth of testicular growth in ruminants (Martin *et al*., 2010; Cameron *et al*., 1988).

Table 1. Blood components of kids fed different levels of milk as a percentage of live weight (mean ± SE)

Blood variates		Feeding Different Levels of Milk to Kids		
		10% of liveweight	15% of liveweight	20% of liveweight
RBC (m/mm^3)		9.72^{ab} ± 0.26	10.04^{a} ± 0.11	9.24^{b} ± 0.56
WBC (th./mm^3)		8.70 ± 0.35	8.76 ± 0.60	7.30 ± 0.17
Hb (g)		7.22 ± 0.31	7.37 ± 0.09	7.13 ± 0.20
PCV (%)		28.2 ± 0.47	29.33 ± 0.33	28.0 ± 0.74
Differential Leukocytes Count (%)	Neutrophil (%)	33.66 ± 1.14	33.33 ± 0.84	32.5 ± 0.56
	Eosinophil (%)	2.66 ± 0. 42	3.67 ± 0.49	2.67 ± 0.33
	Basophil (%)	0	0	0
	Lymphocyte (%)	60.17 ± 1.13	61.83 ± 1.19	62.0 ± 0.86
	Monocyte (%)	1.83 ± 0.54	2.33 ± 0.33	2.0 ±0.25

Within a row, means with different superscripts are significantly different (p < 0.05); m/mm^3 = million per cubic millimeter, th./mm^3 =thousands per cubic millimeter

Table 2. Body measurements of kids fed different levels of milk as a percentage of liveweight (mean ± SE)

Variates	Feeding Different Levels of Milk to Kids		
	10% of liveweight	15% of liveweight	20% of liveweight
Body length (cm)	$38.33^{b} \pm 1.05$	$39.08^{ab} \pm 1.08$	$42.41^{a} \pm 0.80$
Wither height (cm)	$38.0^{b} \pm 0.81$	$39.33^{ab} \pm 1.17$	$42.00^{a} \pm 0.90$
Heart girth (cm)	39.17± 1.07	40.83 ± 1.70	43.00 ± 0.68
Circumference of neck (cm)			
Apex	19.17 ± 1.04	19.67 ± 1.33	19.58 ± 0.80
Middle	19.0 ± 1.31	20.50 ± 1.62	21.17 ± 1.01
Base	20.83 ± 1.35	23.67± 1.54	23.50 ± 0.95
Neck length (cm)	13.87 ± 0.95	14.17 ± 0.47	15.83 ± 0.47

Within a row, means with different superscripts are significantly different ($p<0.05$)

Table 3. Carcass characteristics of kids fed different levels of milk as a percentage of liveweight (mean ± SE)

Varieties	Feeding Different Levels of Milk to Kids		
	10% of Liveweight	15% of Liveweight	20% of Liveweight
Live weight (kg)			
13 weeks	$4.37^{b} \pm 0.32$	$5.43^{ab} \pm 0.47$	$6.12^{a} \pm 0.36$
14 weeks	$4.87^{b} \pm 0.35$	$5.80^{ab} \pm 0.54$	$6.70^{a} \pm 0.37$
15 weeks	$5.18^{b} \pm 0.33$	$6.05^{ab} \pm 0.65$	$7.13^{a} \pm 0.40$
16 weeks	$5.59^{b} \pm 0.29$	$6.54^{ab} \pm 0.65$	$7.78^{a} \pm 0.37$
Total live weight gain (kg)	$3.23^{b} \pm 0.25$	$4.03^{ab} \pm 0.69$	$5.37^{a} \pm 0.40$
Consumption of milk (L)	$16.85^{b} \pm 0.59$	$18.10^{ab} \pm 1.13$	30.11a ± 0.82
Weekly live weight gain (kg)	$0.24^{b} \pm 0.02$	$0.31^{ab} \pm 0.05$	$0.41^{a} \pm 0.03$
Daily gain (kg)	$0.03^{b} \pm 0.00$	$0.04^{ab} \pm 0.00$	$0.05^{a} \pm 0.00$
Carcass weight (kg)	2.65 ± 0.29	3.16 ± 0.49	3.81 ± 0.19
Dressing percentages (%)	46.82 ± 3.25	47.33 ± 3.90	49.04 ± 1.17
Rib Eye Area (mm^2)	538.03 ± 62.50	466.42 ± 89.05	678.93 ± 39.96
Renal fat (g)	13.67 ± 1.58	18.83 ± 3.65	18.16 ± 2.10
Caul fat (g)	31.50 ± 4.74	33.50 ± 8.53	37.00 ± 9.86

Within a row, means with different superscripts are significantly different ($p < 0.05$)

Table 4. Measurements in the carcasses of male kids fed different levels of milk as a percentage of liveweight (mean ± SE)

Varieties	Feeding different levels of milk to kids		
	10% of liveweight	15% of liveweight	20% of liveweight
Shoulder (g)	220.83 ± 15.46	235.67 ± 25.64.80	332.33 ± 45.62
Rack (g)	168.00 ± 17.18	233.0 ± 41.53	245.56 ± 27.22
Loin (g)	276.67 ± 74.68	381.33 ± 90.34	366.66 ± 102.04
Hind leg weight (g)	$406.16^{b} \pm 43.82$	$487.83^{ab} \pm 69.36$	$610.33^{a} \pm 35.18$
Neck (g)	$284.5^{b} \pm 9.31$	$348.67^{a} \pm 20.40$	$379.33^{a} \pm 4.37$
Leg length-hind (cm)	27.00 ± 1.06	26.83 ± 1.01	29.66± 1.33
Leg width-hind (cm)	15.00 ± 1.82	14.0 ± 2.23	18.83 ± 2.77

Within a row, means with different superscripts are significantly different ($p < 0.05$)

Table 5. Effect of feeding different levels of milk as a percentage of live weight on non-edible by-products of kids (mean ± SE)

Varieties	Feeding Different Levels of Milk to Kids		
	10% of liveweight	15% of liveweight	20% of liveweight
Blood weight (g)	237.17 ± 11.06	266.67 ± 21.24	293.83± 22.97
Skin (g)	560.33± 51.89	619.67 ± 97.13	698.33± 36.60
Skin Length (cm)	50.62± 3.22	54.28 ± 3.76	55.57± 1.13
Skin width (cm)	16.49± 0.41	18.46 ± 0.53	18.36± 1.09
Skin thickness (at butt, mm)	1.12± 0.48	1.23± 0.71	1.41± 0.43
Gut (kg)	1.38± 0.07	1.77 ± 0.13	1.71± 0.23
Gut fill (kg)	0.61 ± 0.06	0.96 ± 0.13	0.80± 0.14

Non-significant ($p > 0.05$)

Table 6. Effect of feeding different levels of milk as a percentage of live weight on non-edible by-products of kids

Varieties	Feeding different levels of milk to kids		
	10% of Live weight	15% of Live weight	20% of Live weight
Head (g)	603.83 ± 41.85	639.0 ± 54.75	651.66 ± 37.29
Heart (g)	34.83 ± 7.07	31.0 ± 3.37	33.66 ± 2.12
Spleen (g)	13.33^{b}± 0.84	16.0^{ab}± 1.71	21.16^{a}± 2.63
Liver (g)	144.0 ± 11.12	189.33 ± 17.47	182.83 ± 19.14
Kidney (g)	31.0 ± 1.98	39.0 ± 3.75	42.33 ± 3.36
Lung + Trachea (g)	102.66 ± 11.47	111.50 ± 13.65	113.0 ± 25.44
Pluck (g)	325.83± 11.75	386.83 ± 34.77	400.33 ± 33.93

Within a row, means with different superscripts are significantly different ($p < 0.05$), value = mean ± SE

Table 7. Weight of rumen, reticulum, omasum, abomasum and intestines of kids (mean ± SE)

Varieties	Feeding Different Levels of Milk to Kids		
	10% of liveweight	15% of liveweight	20% of liveweight
Rumen (g)	170.33^{b} ± 4.66	203.42^{ab} ± 16.58	224.00^{a}± 16.68
Reticulum (g)	24.25 ± 1.77	27.72 ± 5.47	32.14 ± 3.09
Omasum (g)	22.11 ± 1.86	26.38 ± 2.41	28.6 ± 2.76
Abomasum (g)	48.97 ± 2.20	52.49 ± 4.75	60.57± 5.71
Small intestine (g)	317.33^{b}± 11.62	378.17^{ab} ± 29.36	436.50^{a}± 39.08
Large intestine (g)	71.50± 6.98	72.33 ± 6.06	70.83± 8.79

Within a row, means with different superscripts are significantly different ($p < 0.05$)

Table 8. Rumen wall thickness (mm) of kids fed different levels of milk as a percentage of liveweight

Location in rumen	Feeding Different Levels of Milk to Kids		
	10% of liveweight	15% of liveweight	20% of liveweight
Average across nine sites	1.59 ± 0.12	1.68 ± 0.23	1.67 ± 0.11

Non-significant ($p > 0.05$); Nine sites were right side of cranial ventral sac (RD), left side of cranial ventral sac (LD), Right side of cranial dorsal sac (RC), Right side of caudal dorsal sac (RB), Right side ventral portion of caudal ventral blind sac (RE), Left side ventral portion of caudal ventral blind sac (LE), Left side of cranial dorsal sac (LC), Left side of caudal dorsal sac (LB), Caudal portion of the caudal ventral blind sac (A).

Table 9. Rumen development of kids fed different levels of milk as a percentage of liveweight

Varieties	Feeding Different Levels of Milk to Kids		
	10% of liveweight	15% of liveweight	20% of liveweight
Papillae density (No/ob., 5×10x)	17.56 ± 1.08	17.26 ± 1.50	21.63 ± 3.63
Papillae length (µm, 5 × 10x)	358.33^{b} ± 18.69	456.67^{b} ± 34.41	707.00^{a} ± 37.07
Papillae width (µm, 5 × 10x)	128.33^{b} ± 8.33	182.83^{b} ± 37.65	430.23^{a} ± 29.86

Within a row, means with different superscripts are significantly different ($p < 0.05$), No. and observation of rumen papillae

Table 10. Testicular development of kids fed different levels of milk as a percentage of liveweight (mean ± SE)

Varieties	Feeding different levels of milk to kids		
	10% of live weight	15% of live weight	20% of live weight
Right testicular weight (g)	23.39± 4.45	29.69 ± 5.09	31.27 ± 3.49
Left testicular weight (g)	24.03 ± 11.78	29.39 ± 11.08	30.98 ± 8.78
Right testicular length (mm)	50.21 ± 4.33	52.80 ± 2.95	54.20 ± 3.85
Left testicular length (mm)	49.63 ± 9.63	51.84 ± 8.86	54.27 ± 9.49
Right testicular width (mm)	25.35^{b} ± 1.67	28.14^{ab} ± 1.62	31.59^{a} ± 0.69
Left testicular width (mm)	25.05 ± 4.35	26.65 ± 3.42	30.31 ± 1.98
Right testicular volume (ml^3)	21.50 ± 4.17	27.75 ± 3.14	28.50 ± 1.68
Scrotal length (cm)	8.16 ± 0.33	7.92 ± 0.62	10.83 ± 4.50
Scrotal circumference (cm)			
Base	8.16 ± 0.94	10.5 ± 1.25	9.16 ± 1.10
Middle	12.20 ± 1.38	14.83 ± 0.60	15.0 ± 1.58
Apex	8.33 ± 1.22	8.66 ± 1.17	9.66 ± 1.65

Within a row, means with different superscripts are significantly different ($p < 0.05$)

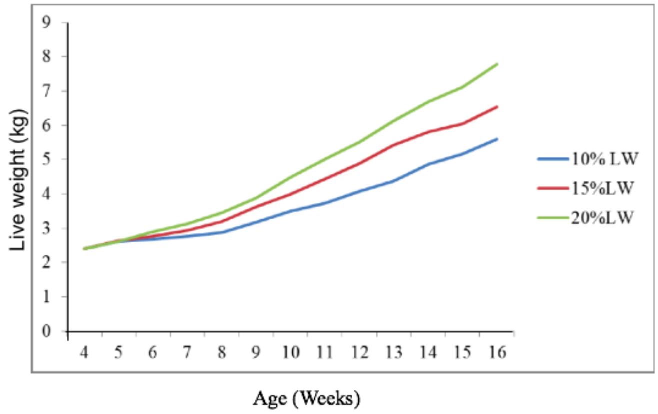

Fig. 1 Cumulative growth curve of kids feeding cow milk

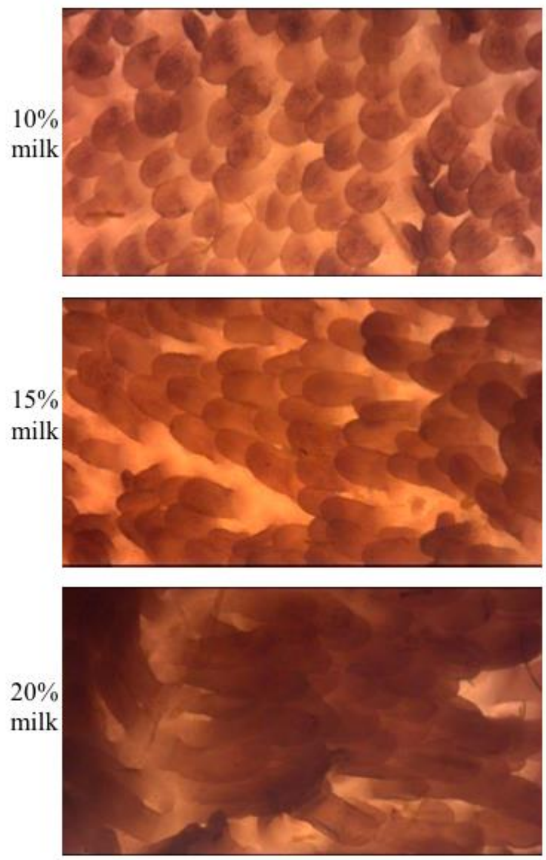

Fig. 2 Density of rumen papillae obtained from kids feeding different levels of milk, under Stereo Zoom microscope (1 ×10X)

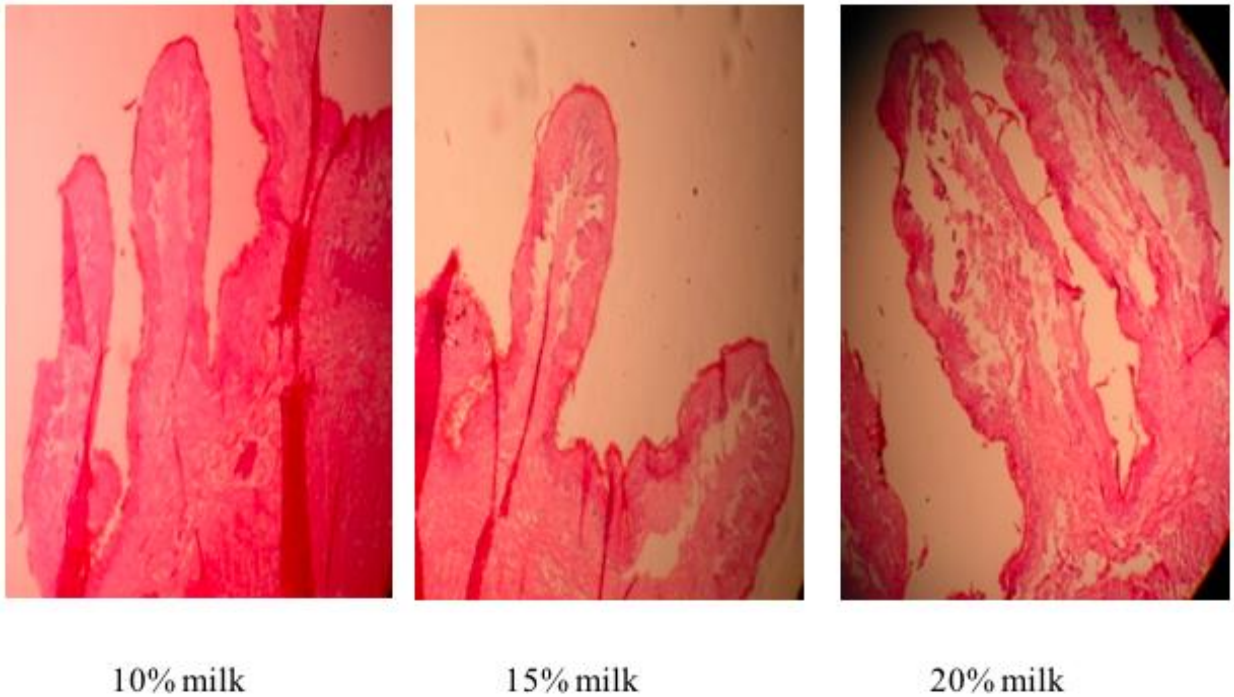

Fig. 3 Histological section of rumen papillae (at 10×10 X) obtained from kids fed different levels of milk. Rumen sample were fixed in Bouin's solution. The tissues were dehydrated ascending grades of alcohol. After cleaning and infiltration tissues were embedded with melted wax for preparation of paraffin blocks. Five µm thick sections were prepared by using rotatory microtome and placed upon glass slide and dried in the air. The sections were then stained with haematoxylin and eosin.

Conclusion

Neonatal goat kids should be reared artificially by feeding cow milk at the rate of 20% of their liveweight for maximum growth and organ development (rumen and testicle development) of Black Bengal kids.

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Conflict of interest

The authors declare that there is no conflict of interest that could be perceived as prejudicing the impartiality of the research reported.

References

Anderson, M. J., Khoyloo, M. and Walters, J. L. 1982. Effect of feeding whole cottonseed on intake, body weight and reticulo-rumen development of young Holstein calves. *Journal of Dairy Science*, (65): 764–772. https://doi.org/10.3168/jds.S0022-0302(82)82265-0

Appleby, M. C., Weary, D. M. and Chua, B. 2001. Performance and feeding behavior of calves on ad libitum milk from artificial teats. *Applied Animal Behaviroul Science* (74): 191–201. https://doi.org/10.1016/S0168-1591(01)00171-X

Bach, A. 2012. Ruminant Nutrition Symposium: Optimizing Performance of the Offspring: Nourishing and managing the dam and postnatal calf for optimal lactation, reproduction, and immunity. *Journal of Animal Science*, (90):1835–1845. https://doi.org/10.2527/jas.2011-4516

Baldwin, R. L., McLeod, V.I. K. R., Klotz J. L. and Heitmann, R. N. 2004. Rumen development, intestinal growth and hepatic metabolism in the pre- and post-weaning ruminant. *Journal of Dairy Science*, (87)(E Suppl.):E55–E65. https://doi.org/10.3168/jds.S0022-0302(04)70061-2

Bar-Peled, U., Robinzon, B., Maltz E., Tagari, H., Folman, Y., Bruckental, I., Voet H., Gacitua, H. and Lehrer, A. R. 1997. Increased weight gain and effects on production parameters of Holstein heifer calves that were allowed to suckle from birth to six weeks of age. *Journal of Dairy Science*, (80):2523–2528. https://doi.org/10.3168/jds.S0022-0302(97)76205-2

Blum, J. W. and Baumrucker, C. R., 2002. Colostral and milk insulin like growth factors and related substances: Mammary gland and neonatal (intestinal and systemic) targets. *Domestic Animal Endocrinology*, (23):101–110. https://doi.org/10.1016/S0739-7240(02)00149-2

Brownlee, A. 1956. The development of rumen papillae in cattle fed on different diets. *British Veterinary Journal*, (112): 369–375. https://doi.org/10.1016/S0007-1935(17)46456-6

Cameron, A.W.N., Murphy, P.M. and Oldham, C.M., 1988. Nutrition of rams and output of spermatozoa. *Proceedings of the Australian Society of Animal Production*, (17): 162–165.

Conneely, M., Berry, D.P., Murphy, J.P., Lorenz, I., Doherty, M.L.and Kennedy, E., 2014. Effects of milk feeding volume and frequency on body weight and health of dairy heifer calves. *Journal of Livestock Science*, (161): 90–94. https://doi.org/10.1016/j.livsci.2013.12.022

Dukes, H.H., 1955. *The physiology of domestic animals* (7th ed.) Baillers Tindall and Co. London.

Hammon, H. M., Schiessler, G., Nussbaum, A. and Blum, J. W., 2002. Feed intake patterns, growth performance, and metabolic and endocrine traits in calves fed unlimited amounts of colostrums and milk by automate, starting in the neonatal period. *Journal of Dairy Science*, (85): 3352–3362. https://doi.org/10.3168/jds.S0022-0302(02)74423-8

Harrison, H.N., Warner, R.G, Sander, E.G. and Loosli, K.J., 1960. Changes in the tissue and volume of the stomachs of calves following removal of dry feed or consumption of inert bulk. *Journal of Dairy Science*, (43): 1301–1312. https://doi.org/10.3168/jds.S0022-0302(60)90317-9

Havrevoll, O., Hadjipanayiotou, M., Sanz-Sampelayo, M.R., Nitsan, Z.and Schmidely, P. 1991. Milk feeding systems of young goats. In: P. Morand-Fehr (Editor), Goat Nutrition. EAAP Publication No. (46), 259–270.

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

Jasper, J. and Weary, D. M. 2002. Effects of ad libitum milk intake on dairy calves. *Journal of Dairy Science*, (85): 3054–3058. https://doi.org/10.3168/jds.S0022-0302(02)74391-9

Jensen, M. B., Duve, L.R. and Weary, D.M. 2015. Pair housing and enhanced milk allowance increase play behavior and improve performance in dairy calves. *Journal of Dairy Science*, (98): 2568–2575. https://doi.org/10.3168/jds.2014-8272

Khan, M. A., Lee, H. J., Lee, W. S., Kim, H.S., Kim, S.B.,Ki, K.S., Ha, J.K.,Lee, H.G. and Choi, Y.J. 2007a. Pre- and postweaning performance of Holstein female calves fed milk through step-down and conventional methods. *Journal of Dairy Science* (90): 876–885. https://doi.org/10.3168/jds.S0022-0302(07)71571-0

Khan, M. A., Lee, H.J., Lee, W.S., Kim, H.S., Ki, K.S., Hur, T.Y., Suh, G.H., Kang, S.J. and Choi, Y.J. 2007b. Structural growth, rumen development, and metabolic and immune responses of Holstein male calves fed milk through step-down and conventional methods. *Journal of Dairy Science*, (90): 3376–3387. https://doi.org/10.3168/jds.2007-0104

Khan, M.A., Weary, D.M. and von Keyserlingk, M.A.G. 2011. Invited review: Effects of milk ration on solid feed intake, weaning and performance in dairy heifers. *Journal of Dairy Science*, (94): 1071–1081. https://doi.org/10.3168/jds.2010-3733

Khouri, R.H. and Pickering, F.S., 1968. Performance of calves fed on different levels of whole milk relative to body weight. *New Zealand Journal of Agricultural Research*, (11): 227–236. https://doi.org/10.1080/00288233.1968.10431422

Martin, G.B., Blache, D., Miller, D.W.and Vercoe, P.E. 2010. Interactions between nutrition and reproduction in the management of the mature male ruminant. *Animal*, (4): 1214–1226. https://doi.org/10.1017/S1751731109991674

Morrison, S.J., Wicks, H.C.F., Carson, A.F., Fallon, R.J., Twigge, H., Kilpatrick, D.J. and Watson, S. 2012. The effect of calf nutrition on the performance of dairy herd replacements. *Animal*, (6): 909–919. https://doi.org/10.1017/S1751731111002163

Quigley, J.D., Wolfe, T.A. and Elsasser, T.H., 2006. Effects of additional milk replacer feeding on calf health, growth, and selected blood metabolites in calves. *Journal of Dairy Science*, (89): 207–216. https://doi.org/10.3168/jds.S0022-0302(06)72085-9

Sarker, M.B., Alam, M.H., Saha, B.K., Amin, M.R. and Moniruzzaman, M. 2015. Effects of soybean milk replacer on growth, meat quality, rumen and gonad development of goats. Small Ruminant Research, (130): 127–135. https://doi.org/10.1016/j.smallrumres.2015.07.018

SAS Institute Inc. 2004. Base SAS/STAT version 9.1.3 for windows service pack 4, SAS Institute, Cary NC, USA.

Sato, T., Hidaka, K., Mishima, T., Nibe, K., Kitahara, G., Hidaka, Y., Katamoto, H. and Kamimura, S. 2010. Effect of sugar supplementation onrumen protozoa profile and papillae development in retarded growth calves. *The Journal of Veterinary Medical Science*, (72): 1471–1474. https://doi.org/10.1292/jvms.09-0399

Shamay, A., Werner, D., Moallem, U., Barash, H. and Bruckental, I. 2005. Effect of nursing management and skeletal size at weaning on puberty, skeletal growth rate, and milk production during first lactation of dairy heifers. *Journal of Dairy Science*, (88): 1460–1469. https://doi.org/10.3168/jds.S0022-0302(05)72814-9

Tamate, H., McGilliard, A.D., Jacobson, N.L. and Getty, R. 1962. Effect of various dietaries on the anatomical development of the stomach in the calf *Journal of Dairy Science*, (45): 408–420. https://doi.org/10.3168/jds.S0022-0302(62)89406-5