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ORIGINAL ARTICLE

Effect of complete pellet feed on commercial goat production under the stall feeding system in Bangladesh

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ABSTRACT

Objective: This study aimed to identify the effect of complete pellet feed on animal performances in both on-station and on-farm trials conducted on growing goats.

Materials and Methods: A complete pellet feed was developed with 40% roughage (rice straw) and 60% concentrate [rice polish (50%), maize crush (16%), soybean meal (20%), molasses (10%), salt (2%), Dicalcium Phosphate (1%), vitamin–mineral premix (0.5%), and pellet binder (0.5%)] for commercial goat production and the research trial was carried out on the research station and on the farmers' validation level.

Results: The results of the experiment on the effect of the developed complete pellet feed on goat production under stall feeding condition demonstrated that feeding complete pellet feeds helped in increasing the daily body weight gain of goats (36.96 and 52.46 gm, respectively) compared to traditional semi-intensive feeding (17.76 gm) with significantly ($p < 0.05$) better body condition score of goats. Feed Conversion Ratio was considerably lower (5.7) in the pellet feeding group than in the other groups where no pellet feed was used (8.32 and 8.03). Significantly ($p < 0.05$) lower feed price per kg weight gain was also observed in the pellet feeding group (BDT 124.22) compared to other groups (BDT 203.85 and BDT 214.74, respectively).

Conclusion: The results suggest that complete pellet feed can be more economical for commercial goat production under the stall feeding condition, and farmers can be benefited by about 40% more compared to conventional grass, urea molasses straw, and concentrate-based feeding system.

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Introduction

Goat is the most popular and essential small ruminant species, widely distributed throughout the world [1,2]. In tropical and subtropical regions, it forms an integral component of the farming system to fulfill animal protein demand through meat production [3,4]. In Bangladesh, goats stands as second in number after cattle population [5,6], and are mainly used for meat production purposes. Their skin is also a valuable byproduct that earns appreciable foreign currencies [7,8]. About 25.7 million goat herds are distributed throughout the country [9], which are generally reared in a semi-intensive system [10]. However, Rashid et al. [11] reported that the Black Bengal goat contributes to more than 90% of the goat population in Bangladesh.

In Bangladesh's rural areas, small ruminant feeding mainly depends on the agricultural crop residues and byproducts, low-quality hay, tree leaves, and natural grasses [12]. Moreover, seasonal variations play a potential role in the nutrient composition of common grasses, as higher dry matter (DM) content in grasses is reported during the dry season than rainy season [11,13]. However, these available feed sources are characterized by high roughage content with low protein, energy, mineral, and

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vitamin contents, which definitely cannot meet the maintenance requirements of goats adequately [14]. Lower digestibility with a lack of feed intake finally results in poor performances [15]. Similarly, faster growth rates were found in stall feeding goats than feedlot goats, as it allows finishing at specific target weights [11]. Therefore, to enhance profitable goat production in Bangladesh, it is necessary to determine an alternative feeding approach to rear goats under intensive or stall-fed conditions. A feeding system based on complete pellet feed is one of the feed processing methods expected to establish a profitable goat production by better utilization of nutrients from agricultural crop residues.

Nevertheless, complete pellet feed prepared from total mixed ration ensures the balanced nutrition of goats by maintaining an adequate amount of roughage and concentrate mixture. It also provides uniform feed to reduce unnecessary feed waste by increasing digestibility and palatability [11,16]. Hence, the present experiment was designed to develop a roughage-based complete pellet feed and evaluate how it enhances commercial goat production under intensive or stall-fed conditions.

Materials and Methods

Ethical standard and statement

All experiments have been examined and approved by the Animal Experimentation Ethics Committee of Bangladesh Livestock Research Institute (BLRI), Savar, Dhaka, Bangladesh (Approval no. BLRI0010), and PIU-BARC, NATP-2 Project, Bangladesh Agricultural Research Council, Farmgate, Dhaka, Bangladesh.

Collection and processing of feedstuffs

Rice straw and agroindustry-based concentrate feed ingredients were purchased from the local sources. Rice straw was used as a roughage source with the agroindustry-based concentrate mixture to formulate the basal total mix ration for pelleting according to the goats' nutrient requirement. For the pelleting of feed, a small-scale pelleting machine was designed and fabricated locally. All the roughages were ground to 5 mm using a Hammer mill machine containing a 5-mm sieve.

Preparation of pellets

40% roughage (rice straw) and 60% concentrate [rice polish (50%), maize crush (16%), soybean meal (20%), molasses (10%), salt (2%), Dicalcium Phosphate (1%), vitamin–mineral premix (0.5%), pellet binder 0.5%) were used for the formulation of complete pellet feed [17]. Before transferring it to the pelleting machine, an adequate amount of water (about 50%) was added for better mixing. The prepared pellet was sun-dried and stored before goat feeding (Fig. 1).

Chemical composition of the experimental diet

Samples of the experimental diets were dried and ground in a grinding mill through a 2-mm sieve before analysis. Crude protein (CP) content of the experimental diet was determined using the automated Kjeldahl method [18]. DM content of the pellet was measured by overnight drying of the samples at 105°C in the oven. After that, the sample's ash content was measured by further burning in a muffle furnace at 500°C for 4 h. The neutral detergent fiber (NDF) and acid detergent fiber (ADF) composition were analyzed using the method described by Ahmed et al. [5]. The chemical composition (%) of the pellet feed is given in Table 1.

Selection and management of goats

On the research station

The experiment was conducted at BLRI, Savar, about 24 km northwest of Bangladesh's capital city. The site is located at 23°42′0″ N, 90°22′30″ E, at an altitude of 4 mm above sea level (Fig. 2). A total of 18 intact male Black Bengal goats of 4–5 months of age were selected. The goats were divided into three treatment groups (having six animals in each group) by stratified randomization based on their average body weight. The control groups were fed *ad libitum* oat grass (T_1), and *ad libitum* Urea molasses straw (UMS) (T_2) with concentrate supplementation (at 1.5% of body weight), and the treatment group (T_3) was fed *ad libitum* developed complete pellet feed. The goat house was

Figure 1. Preparation and sun drying of pellets. (A) Preparation of pellet, (B) Sun-drying of the pellets, and (C) Individual pellet.

Table 1. Chemical composition (%) of the experimental diets.

Ingredients/feed	DM	Ash	CP	ADF	NDF
Complete pellet feed	91.70	14.29	13.40	32.24	51.56
Oat grass	13.74	5.78	16.54	51.6	78.8
UMS	61.73	12.3	9.45	61.31	73.8
Concentrated mixture	88.55	5.93	18.65	9.98	35.81

UMS = Urea molasses straw; DM = Dry matter; CP = Crude protein; ADF = Acid detergent fiber; NDF = Neutral detergent fiber.

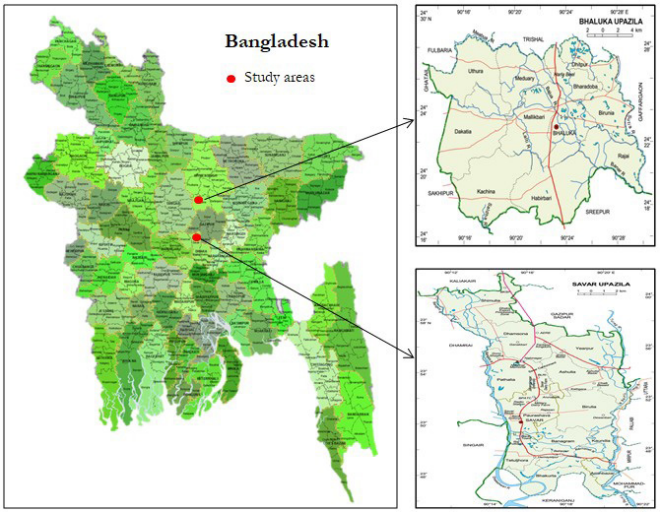

Figure 2. Map of Bangladesh showing the study areas.

decorated with individual pens on a plastic slated floor equipped with a separate feeder and waterer. They were dewormed at the onset of the experiment. The feed was supplied twice daily (9 am and 4 pm), and feed residues were collected before morning feeding to know the feed intake. Animals were weighed weekly before morning feeding. The duration of the experiments was 90 days.

On the farmers' level

The experiment was conducted at Bhaluka Upazila under the Mymensingh district of Bangladesh. This site is located at a latitude of 24° 22′ 30.00″ N and longitude of 90° 22′ 40.08″ E (Fig. 2). A total of 12 farmers were selected, having at least one castrated male goat that was 4–5 months of age. They were equally distributed into two treatment groups (T_0 and T_1), having six male goats in each group. In T_0, the goats were reared under the traditional semi-intensive system (allowed 8 h grazing in fallow land, no or minimal concentrate supplementation, and provided night shelter). In T_1, goats were reared under stall feeding conditions and fed complete pellet feed, allowing a 10-day adjustment period. Animals were weighed weekly before morning feeding. The experimental duration was 60 days. Data from the above two treatments were compared with the on-station pellet feeding data designated as T_2.

Metabolic trial

Three animals from each of the dietary groups were randomly selected immediately after the research station's growth trial to determine the feeds digestibility and nutrients using the total collection method. However, the animals were allowed for 3 days to adjust to the new management system of metabolic trial. The experimental diets of the growth trial were also continued for this metabolic trial. For proper and separate feces and urine collection for 7 days, metabolic trays were placed under the individual animal pens. Each animal feces was collected separately, then weighed, sampled (10%), and kept in a freezer (−20°C) for further analysis. To prevent ammonia loss, each of the animals' total urine was weighed and sampled (10%), then kept in the freezer in plastic containers containing 100 ml 6N H_2SO_4. The composite mixture of the samples for each animal was prepared by proper and thorough mixing of the feed and refusal samples of the total collection period and then taken to the laboratory to analyze the chemical components.

Economics of feeding experimental pellets

The cost per kg pellet preparation, per kg meat production cost, and the return were calculated to know the cost–benefit ratio (BCR) for pellet feeding. The cost of per kg pellet feed preparation was BDT 20.14 in Bangladeshi currency. To calculate the BCR selling price of per kg of meat was considered to be about BDT 600.00. The dressing percentage was assumed to be about 50%, i.e., 1 kg of live weight gain indicates 0.50 kg of meat and the price was BDT 300.00.

Experimental design and statistical analysis

The experiment was arranged in a completely randomized design, and the software International Business Machines Corporation Statistical Package for the Social Sciences 20 was used for the statistical analysis of the data. The DMRT tested the differences, and significant differences were declared when $p < 0.05$.

Results and Discussion

Growth performances of goats at the research station

Table 2 shows the effect of complete pellet feed on goat performances compared to conventional stall feeding. Although DM intake (DMI) did not differ significantly among the treatment groups (0.264, 0.245, and 0.272 kg/day for T_1, T_2, and T_3, respectively), a numerically higher amount of DMI was observed in the pellet-feeding group (T_3), which indicates that grinding and pelleting increased voluntary feed intake. Consequently, an average of 16 gm more daily weight gain was found in the pellet-feeding group (50.29 gm in T_3) than the other two conventional feeding groups (33.80 gm in T_1 and 34.78 gm in T_2) of goats. However, daily weight gain did not differ significantly. A similar observation was also found by Roy et al. [17] by feeding rice straw-based complete pellet feed to growing Black Bengal goats and Sarker [19] by supplying wheat straw-based-treated pellets in lambs. Rashid et al. [13] found a significantly higher DMI by feeding roughage and concentrate in a compound pellet form to Black Bengal goats.

Table 2. Performances of goats fed with pellet feed compared to conventional stall feeding.

Parameters	Treatments			SEM	Level of sig.
	T_1	T_2	T_3		
Initial weight (kg)	7.01	6.98	7.01	0.266	NS
Final weight (kg)	10.14	10.02	11.54	0.411	NS
DMI (kg/day)	0.264	0.245	0.272	0.009	NS
DMI (% body weight)	3.25	3.03	3.06	0.066	NS
Feed Conversion Ratio (FCR)	8.32	8.03	5.7	0.607	NS
Daily weight gain (gm)	33.80	34.78	50.29	3.866	NS
Feed cost/kg gain (BDT)	203.85[a]	214.74[a]	124.22[b]	17.297	*
Total cost/kg weight gain (BDT)	265.00	279.16	161.48	22.486	.052
Total benefit/kg weight gain (BDT)	300.00	300.00	300.00	0.00	NS
BCR	1.23	1.16	1.93	0.133	*

[ab] = Different superscripts in the same row differ significantly; T_1 = *Ad libitum* oat grass + concentrate mixture at 1.5% of body weight; T_2 = *Ad libitum* UMS + concentrate mixture at 1.5% of body weight; T_3 = *Ad libitum* developed complete pellet feed.

The Feed Conversion Ratio (FCR) did not differ significantly among the treatment groups, but a considerably low FCR was observed in the pellet-feeding group (5.7 in T_3) than in other groups (8.32 in T_1, and 8.03 in T_2). Rashid et al. [13] also observed the best FCR in the compound pellet-feeding group, although that did not differ significantly among the different treatment groups. The most critical parameter, the feed cost per kg weight gain, was significantly lower ($p < 0.05$) in the pellet-feeding group (BDT 124.22 in T_3) compared to the other groups (BDT 203.85 in T_1 and BDT 214.74 in T_2) due to better FCR and higher average daily gain. This result is in agreement with the findings of Rashid et al. [13], who reported the lowest feed cost (BDT 150.93) per kg weight gain by complete feed compared to conventional grass and concentrates-based feeding system (BDT 226.08). Nagalakshmi and Reddy [20] reported that due to a lower feed cost and better FCR, the cost of feed/100 kg and per kg weight gain was more deficient for 50% sorghum bagasse and 50% concentrate-based complete pellet diet goats. In Murrah buffaloes, they also reported the cost of feeding per kg milk production lower when a complete pellet diet containing sugarcane bagasse as a roughage source was used [20].

Similarly, Reddy et al. [21] reported that the cost of feed/kg gain was reduced in Ongole bull calves due to the expander extruder pelleted complete diet containing sugarcane bagasse. Processed diets also reported reducing feed cost per kg of weight gain in sheep and calves [21,22]. It might be due to the efficiency of feed that was enhanced by grinding and pelleting. Moreover, in weaned lambs, Patel et al. [23] reported lower feed cost, feed cost/kg gain, and feed cost/kg dressed weight due to cheaper non-conventional ingredients. The relatively better BCR ($p < 0.05$) was also observed in the pellet-feeding group (1.93 in T_3) compared to the other groups (1.23 in T_1 and 1.16 in T_2).

Results suggest that complete pellet feed would be more economical for commercial goat production under stall-fed condition, and farmers would be more benefited using complete pellet feed compared to conventional grass and concentrate or UMS and concentrate-based feeding system. Rashid et al. [13] also reported the highest net profit ($p < 0.05$) by using Napier grass and concentrate-based complete pellet feed compared to conventional Napier grass and concentrate mixture fed separately in growing Black Bengal goat under the stall-fed condition.

The digestibility of DM, Organic Matter (OM), CP, and NDF was significantly higher (78.74, 80.98, 85.24, and 77.23, respectively) in the T_1 group (feeding on common grass and concentrate feed separately) compared to T_2 (70.62, 73.12, 68.35, and 67.26, respectively) and T_3 (71.52, 71.87, 75.41 and 65.67, respectively) groups (Table 3). This may be due to high-quality green oat grass as a basal roughage source for T_1 group animals. But the average daily gain was numerically higher in the T_3 group, and better FCR also observed in the T_3 group, which indicated that grinding and pelleting to prepare complete pellet feed enhances the palatability and the efficiency of utilization of the diet [21]. Nevertheless, Rashid et al. [13] reported CP digestibility to be increased significantly ($p < 0.01$) for a compound pellet feed (50% ground Napier grass + 50% concentrate mixture) compared to its mash and conventional feeding (separate grass and concentrate feeding) fed to the growing Black Bengal goats.

No disease or clinical symptoms were observed during the experimental period. Using rice straw-based complete pellet feed indicates that pellet feeding did not alter the animals' normal rumen function and animal physiology.

Table 3. Nutrient digestibility (%) by the different treatment groups of goats fed different feeds.

Parameters	Treatment			SEM	Level of Sig.
	T_1	T_2	T_3		
DM digestibility	78.74[b]	70.62[a]	71.52[a]	1.553	*
OM digestibility	80.98[b]	73.12[a]	71.87[a]	1.677	*
CP digestibility	85.24[c]	68.35[a]	75.41[b]	2.598	**
ADF digestibility	70.30	68.34	62.34	1.683	NS
NDF digestibility	77.23[b]	67.26[a]	65.67[a]	2.043	*

[ab] = Different superscripts in the same row differ significantly; T_1 = *Ad libitum* oat grass + concentrate mixture at 1.5% of body weight; T_2 = *Ad libitum* UMS + concentrate mixture at 1.5% of body weight; T_3 = *Ad libitum* developed complete pellet feed.

Table 4. Performances of goat fed on complete pellet feed in the on-farm condition.

Parameters	Treatments			SEM	Level of sig.
	T_0	T_1	T_2		
Initial weight (kg)	9.51	9.48	7.51	0.397	NS
Final weight (kg)	10.76	12.98	9.51	0.493	*
Body weight change (kg)	1.24	3.50	2.00	0.286	**
DMI/day (kg)		0.60	0.24	0.062	**
FCR		9.51	8.84	1.261	NS
Daily weight gain (gm)	17.76	52.46	36.96	4.565	**
Feed cost / kg weight gain (BDT)		211.43	194.07	27.745	NS
Total cost/ kg weight gain (BDT)		274.86	252.30	36.069	NS
Total benefit/ kg weight gain (BDT)		300.00	300.00	0.00	NS
BCR		1.09	1.19	0.200	NS

[ab] = Different superscripts in the same raw differ significantly.
*= $p < 0.05$; **= $p < 0.01$; T_1 = Pellet feeding group in the on-farm condition; T_2 = On-station data of pellet feeding group; T_0 = Traditional semi-intensive feeding group.

Thus, rice straw-based complete pellet feed could be an alternative ready feed for commercial goat production under the stall feeding system.

On-farm performances of goats fed on complete pellet feed

Table 4 shows the performances of goats fed complete pellet feed in the on-farm condition. Performance data of the pellet-feeding group in the on-farm state (T_1) was compared with on-station data of the pellet-feeding group (T_2). On the contrary, the traditional semi-intensive group (T_0) was considered a control group. Similar DMIs were observed for both on-farm (T_1) and on-station groups (T_2). Likewise, FCR, feed cost per kg weight gain, and total price per kg weight gain did not differ between T_1 and T_2 groups. Results suggested that the goats fed with the developed pellet feed performed consistently in both on-station and on-farm conditions. A similar suggestion was also stated by Rashid et al. [11,13]. In the traditional system of rearing (T_0), farmers got only 17.76 gm daily weight gain, while goats feed on developed complete pellet feed were able to achieve 52.46 and 36.96 gm daily weight gain at on-farm (T_1) and on-station (T_2) condition, respectively.

Moreover, Reddy et al. [24] reported that a complete pelleted diet subjected to expander extrusion showed a higher dressing percentage and proportion of lean in Nellore ram lambs than the conventional form of diet feeding. In the case of Deccani lambs, paddy straw-based complete diets showed higher dressing percentage, bone meat ratio, and non-edible to the edible ratio than conventional diet (concentrate mixture and roughage fed separately) and with no difference in wholesale cuts [25]. It can be concluded that paddy straw incorporated in complete diets improved the carcass characteristics in various ways.

The results (Table 4) indicated that daily weight gain increased significantly ($p < 0.01$), about two or three times due to complete pellet feeding for both on-farm (T_1) and on-station (T_2) group compared to the conventional rearing (T_0) group. Sultana et al. [26,27] reported that Black Bengal goats' average daily weight gain is 27.6, 35.1, 43.2, and 43.8 gm per day when offered *ad libitum* green grass with 150, 200, 250, and 300 gm concentrate mixture, respectively. Sultana et al. [28] reported on intensive and scavenging systems of on-farm Black Bengal goat rearing, the average daily weight gain, according to them, was about 45.83 and 35.56 gm, respectively, during the weaning period of kids. For this study, weaned kids of about 4–5 months age were used, and it is well known that after weaning, growth rate reduces compared to the pre-weaning phase (self-accelerating phase). Rashid et al. [13,16] found higher growth rates under the self-accelerating period of growth in the case of younger goats and sheep. Although the BCR did not differ significantly between T_1 (1.09) and T_2 (1.19) groups, the values were higher than 1, indicating that farmers would be benefited by using complete pellet feed for the production of the goat.

Conclusion

Complete pellet feeding enhanced the DMI and the daily weight gain for goat production at the research station and farmers level. It also reduced FCR that finally helps in reducing the feed cost for goat production. Thus, it can be expected that this technology will help to increase goat production under stall feeding conditions as arable lands for grazing are declining day by day.

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Conflict of interest

There is no potential conflict of interest in this study, including preparing the manuscript and publications.

Authors' contribution

This work was carried out in collaboration between all authors. SA designed the study, interpreted the data, and drafted the manuscript. MRHR conducted the field research trial, managed the literature searches, and contributed to manuscript preparation. MAH, BKR, and NJ took part in preparing and critically checking this manuscript. All authors read and approved the final manuscript.

References

[1] Hamada DHM, Sameh GAR, Mohamed AYH, Enas AKA. Effect of maternal feeding in late pregnancy on behaviour and performance of Egyptian goat and sheep and their offspring. Glob Vet 2013; 11(2):168–76.

[2] Gül S, Keskin M, Kaya S. Olive cake usage as an alternative to cotton seed meal in dairy goat feeding. Afr J Agric Res 2010; 5(13):1643–6.

[3] Melanie EB, Karen K, Lynn, FK, Jayson KH. Meat goat production. Agriculture Alternatives, The Pennsylvania State University, State College, PA, 2012.

[4] Barkley ME, Knoll K, Kime LF, Harper JK. Meat goat production. Penn State Extension, The Pennsylvania State University, State College, PA, 2012.

[5] Ahmed S, Rakib MRH, Yesmin M, Sultana N, Jahan N, Ershaduzamman M. Evaluation of lamb production potentiality of the Barind, Jamuna river basin and coastal region sheep of Bangladesh under intensive management. J Adv Vet Anim Res 2018; 5(1):37–43; https://doi.org/10.5455/javar.2018.e243

[6] DLS (Directorate of Livestock Services). General information related to livestock. Monthly Fisheries and Livestock Bulletin, published by Fisheries and Livestock Information Office, Khamarbari, Farmgate, Dhaka, Bangladesh. 2011.

[7] BER (Bangladesh Economic Review). Ministry of Planning, Government of the People's Republic of Bangladesh. 2012.

[8] FAO. Selected indicators of Food and Agriculture Development in Asia pacific region, 1993-2003. Food and Agriculture Organization of the United Nations, Bangkok, Thailand, pp 119–121, 2010.

[9] BBS (Bangladesh Bureau of Statistics). Preliminary Report of Agricultural Census, Bangladesh Bureau of Statistics, Ministry of Planning, Government of the People's Republic of Bangladesh. 2016.

[10] Chander M, Subrahmanyeswari B, Mukherjee R, Kumar S. Organic livestock production: an emerging opportunity with new challenges for producers in tropical countries. Rev Sci Tech 2011; 30(3):969–83; https://doi.org/10.20506/rst.30.3.2092

[11] Rashid MA, Khan MJ, Khandoker MAMY, Akbar MA, Monir MM. Study on the effect of feeding different levels of energy in compound pellet on performance of growing black bengal goat. IOSR J Agric Vet Sci 2016a; 9(2):43–50.

[12] Hassan MR, Talukder MAI. Comparative performance of different regional native sheep in Bangladesh. Bangladesh Vet 2011; 28(2):85–94; https://doi.org/10.3329/bvet.v28i2.10692

[13] Rashid MA, Khan MJ, Khandoker MAMY, Monir MM. Feeding different forms of ration including compound pellet and performance of growing black bengal goat. IOSR J Agric Vet Sci 2016b; 9(5):01–8.

[14] Huque KS. Changes in and challenges of Bangladesh livestock. BLRI Newsletter 3: Bangladesh Livestock Research Institute, Dhaka, Bangladesh, p 1, 2012.

[15] Sultana N, Rakib MRH, Hossain SMJ, Ahmed S, Ershaduzamman M, Talukder MAI. Effect of replacement of conventional concentrate in a rice straw diet by moringa foliage on lamb production performances. J Exp Agric Int 2017; 15(5):1–14. https://doi.org/10.9734/JEAI/2017/31329

[16] Rashid MA, Khan MJ, Khandoker MAMY, Akbar MA, Monir MM. Performance of growing black bengal goat fed compound pellet of different diameters. IOSR J Agric Vet Sci 2016c; 9(4):18–23.

[17] Roy BK, Ahmed S, Sarker NR, Roy A, Singh Y. The effect of feeding different roughages in pelleted diets on growth performance of Black Bengal Goats. Indian Vet J 2010; 87(9):905–7.

[18] AOAC. Official Methods of Analysis (21st edition). Association of Official Analytical Chemists : AOAC International, Washington, DC, 2019.

[19] Sarker NR. PhD thesis, College of Animal Sciences, CCS Hariyana Agricultural University, Halishar, India. 2000.

[20] Nagalakshmi D, Reddy DN. Effect of feeding expander extruder processed complete diet containing sugarcane bagasse on performance of Murrah buffaloes. Anim Nutr Feed Technol 2010; 10(1):01–8.

[21] Reddy GVN, Reddy JK, Nagalakshmi D. Effect of expander-extruder processed complete diet containing sugarcane bagasse on growth and nutrient utilization in Ongole bull calves. Indian J Anim Sci 2002; 72(5):406–9.

[22] Sultana N, Hossain SMJ, Chowdhury SA, Hassan MR, Ershaduzzaman M. Effects of age on intake, growth, nutrient utilization and carcass characteristics of castrated native sheep. Bangladesh Vet 2010; 27(2):62–73; https://doi.org/10.3329/bvet.v27i2.7556

[23] Patel KM, Patel KS, Wadhwani KN, Parnerkar S, Pandya PR, Patel AM. Comparative growth performance of weaner lambs on non-conventional based ration under intensive production system. Int J Agric Biol 2004; 6(5):860–4.

[24] Reddy GVN, Wilhelmina PD, Reddy MS. Effect of rapeseed meal based expander extruder processed complete diets on milk & meat production in field conditions. Indian J Anim Sci 2005; 75(1):74–76.

[25] Nagi PRS, Reddy DN, Nagalakshmi D, Reddy YR, Raghunandan T. Effect of paddy straw particle size on carcass characteristics of lambs fed complete diets. Indian J Small Rum 2006; 12(2):146–51.

[26] Sultana N, Alimon AR, Huque KS, Baba M, Hossain J. Evaluation of moringa foliage (*Moringa oleifera*) as goat feed. Iran J Appl Anim Sci 2015a; 5(4):865–71.

[27] Sultana N, Alimon AR, Huque KS, Sazili AQ, Yaakub H, Hossain J, et al. The feeding value of *Moringa* (*Moringa oleifera*) foliage as replacement to conventional concentrate diet in Bengal goats. Adv Anim Vet Sci 2015b; 3(3):164–173; https://doi.org/10.14737/journal.aavs/2015/3.3.164.173

[28] Sultana N, Alimon AR, Huque KS, Sazili AQ, Yaakub H, Hossain J. The effect of cutting interval on yield and nutrient composition of different plant fractions of *Moringa oleifera* tree. J Food Agric Environ 2014; 12(2):599–604.