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.

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...
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 (T₁), and ad libitum Urea molasses straw (UMS) (T₂) with concentrate supplementation (at 1.5% of body weight), and the treatment group (T₃) 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.
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\textsubscript{0} and T\textsubscript{1}) having six male goats in each group. In T\textsubscript{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\textsubscript{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\textsubscript{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\textsubscript{2}SO\textsubscript{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\textsubscript{1}, T\textsubscript{2}, and T\textsubscript{3}, respectively), a numerically higher amount of DMI was observed in the pellet-feeding group (T\textsubscript{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\textsubscript{3}) than the other two conventional feeding groups (33.80 gm in T\textsubscript{1} and 34.78 gm in T\textsubscript{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.
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 T3) than in other groups (8.32 in T2 and 8.03 in T1). 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 203.85 in T3) compared to the other groups (BDT 214.74 in T2 and 214.74 in T1) 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 T3) compared to the other groups (1.23 in T2 and 1.16 in T1).

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 T3 group (feeding on common grass and concentrate feed separately) compared to the other groups (BDT 203.85 in T1 and BDT 214.74 in T2) due to better FCR and higher average daily gain. This may be due to high-quality green oat grass as a basal roughage source for T3 group animals. But the average daily gain was numerically higher in the T2 group, and better FCR also observed in the T3 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.
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 ($T_3$) 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 ($T_3$), farmers got only 17.76 gm daily weight gain, while goats fed 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 ($T_3$) 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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**Table 3.** Nutrient digestibility (%) by the different treatment groups of goats fed different feeds.

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

$^a$, $^b$, $^c$ = 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 | $T_0$  | $T_1$  | $T_2$  | SEM  | Level of sig. |
|------------------|------------|--------|--------|--------|------|---------------|
| Initial weight (kg) |           | 9.51   | 9.48   | 7.51   | 0.397 | NS            |
| Final weight (kg)   |           | 10.76  | 12.98  | 9.51   | 0.493 | NS            |
| 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 | **            |
| Total cost/kg weight gain (BDT) | | 211.43 | 194.07 | 252.30 | 36.96 | NS            |
| Total benefit/kg weight gain (BDT) | | 300.00 | 300.00 | 0.00   | 0.00  | NS            |
| BCR               |           | 1.09   | 1.19   | 2.00   |      | NS            |

$^a$, $^b$, $^c$ = Different superscripts in the same row differ significantly.

*$^p < 0.05$; **$^p < 0.01$; $T_0$ = Pellet feeding group in the on-farm condition; $T_1$ = On-station data of pellet feeding group; $T_2$ = Traditional semi-intensive feeding group.
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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.

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