Project ID 788

Competitive Research Grant

Sub-Project Completion Report

on

Development of cost effective complete pellet feed and its utilization for commercial goat and sheep production

Project Duration

May 2017 to September 2018

Bangladesh Livestock Research Institute
Savar, Dhaka-1341, Bangladesh

Submitted to

Project Implementation Unit-BARC, NATP 2
Bangladesh Agricultural Research Council
Farmgate, Dhaka-1215

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Citation
Development of cost effective complete pellet feed and its utilization for commercial goat and sheep production
Project Implementation Unit
National Agricultural Technology Program-Phase II Project (NATP-2)
Bangladesh Agricultural Research Council (BARC)
New Airport Road, Farmgate, Dhaka – 1215
Bangladesh

Edited and Published by:

Project Implementation Unit
National Agricultural Technology Program-Phase II Project (NATP-2)
Bangladesh Agricultural Research Council (BARC)
New Airport Road, Farmgate, Dhaka – 1215
Bangladesh

Acknowledgement
The execution of CRG sub-project has successfully been completed by Bangladesh Livestock Research Institute Savar, Dhaka-1341, Bangladesh using the research grant of USAID Trust Fund and GoB through Ministry of Agriculture. We would like to thanks to the World Bank for arranging the grant fund and supervising the CRGs by BARC. It is worthwhile to mention the cooperation and quick responses of PIU-BARC, NATP 2, in respect of field implementation of the sub-project in multiple sites. Preparing the project completion report required to contact a number of persons for collection of information and processing of research data. Without the help of those persons, the preparation of this document could not be made possible. All of them, who made it possible, deserve thanks. Our thanks are due to the Director PIU-BARC, NATP 2 and his team who have given their whole hearted support to prepare this document. We hope this publication would be helpful to the agricultural scientists of the country for designing their future research projects in order to technology generation as well as increasing production and productivity for sustainable food and nutrition security in Bangladesh. It would also assist the policy makers of the agricultural sub-sectors for setting their future research directions.

Published in: September 2018

Printed by: [Name of press with full address]

Acronyms

ADF	Acid Detergent Fiber
BCR	Benefit Cost Ratio
CP	Crude Protein
DCP	Di-calcium Phosphate
DM	Dry matter
DMI	Dry matter Intake
FCR	Feed Conversion Efficiency
NDF	Neutral Detergent Fiber
OM	Organic Matter
TMR	Total Mixed Ration
UMS	Urea Molasses Straw

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Executive Summary

The project was undertaken to develop roughage based complete pellet feed to enhance commercial goat and sheep production under intensive or stall fed condition. A complete pellet feed was developed by using 40% roughage (Rice straw) and 60% concentrate (Rice polish 50%, Maize crush 16%, Soybean meal 20%, Molasses 10%, Salt 2%, DCP 1%, Vitamin-mineral premix 0.5%, Pellet binder 0.5%) for commercial goat and sheep production. To know the effect of developed complete pellet feed on animal performances, two on-station and two on-farm trials were conducted on growing goats and sheep. The results of the experiment on the effect of developed complete pellet feed on goat production under stall feeding condition demonstrated that feeding complete pellet feeds helped increasing daily body weight gain of goats (36.96 for on-station and 52.46 g for on-farm) compared to traditional semi-intensive feeding (17.76 g). Similarly for sheep, in traditional system of rearing only 22.42 g daily weight gain was observed while, feeding of developed complete pellet feed achieved 84.98 g and 100.67 g daily weight gain at on-farm and on-station condition respectively suggesting that pelleting enhanced the efficiency of utilization of feed. For goats, considerably low FCR (5.7) was observed in pellet feeding group compared to other groups where no pellet feed was used (8.32 and 8.03). Feed cost per kg weight gain for goats was also significantly ($p<0.05$) lower in pellet feeding group (Tk 124.22) compared to other groups (Tk 203.85 and Tk 214.74). In case of sheep, no differences were observed for the feed cost per kg weight gain and FCR among the pellet feeding group and other groups. For goats, the best BCR ($p<0.05$) was observed in pellet feeding group (1.93) compared to other groups (1.23 and 1.16). In case of sheep BCR did not differ significantly among the pellet feeding group and other groups. Results suggest that complete pellet feed would be more economic 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. No disease or clinical symptoms were observed in the animals during experimental period, suggests that developed pellet feeds has no negative effect on sheep health and were well accepted by the sheep and goats. Finally, it is concluded that complete pellet feed could be an alternative ready feed for commercial goat and sheep production under intensive or stall fed condition.

CRG Sub-Project Completion Report (PCR)

A. Sub-project Description

1. Title of the CRG sub-project:
Development of cost effective complete pellet feed and its utilization for commercial goat and sheep production

2. Implementing organization:
Bangladesh Livestock Research Institute, Savar, Dhaka-1341

3. Name and full address with phone, cell and E-mail of PI/Co-PI (s):

Principal Investigator:
Dr. Sadek Ahmed
Senior Scientific Officer
Goat and Sheep Production Research Division
Bangladesh Livestock Research Institute, Savar, Dhaka-1341
Cell: +8801712189212, E-mail: sadek_11@yahoo.com

Co-PI: Md. Rezaul Hai Rakib, Scientific Officer, Goat and Sheep Production Research Division, Bangladesh Livestock Research Institute, Savar, Dhaka-1341. Cell: +8801720405323, E-mail: rakib_rezaul@blri.gov.bd
Co-PI: Md. Abu Hemayet, Scientific Officer, Goat and Sheep Production Research Division, Bangladesh Livestock Research Institute, Savar, Dhaka-1341. Cell: +8801722105931, E-mail: hemayet_blri@yahoo.com

4. Sub-project budget (Tk):

4.1 Total : Tk. 1296880.00
4.2 Revised (if any) : N/A

5. Duration of the sub-project:

5.1 Start date (based on LoA signed) : 15 May 2017
5.2 End date : 30 September 2018

6. Justification of undertaking the sub-project:

Goats and sheep represents the second important species of ruminant livestock and most popular in smallholder farmers of Bangladesh. Being smaller than cattle, they require less money to purchase and need little investment. They are usually grazed freely or tethered in natural and harvested fallow lands. With changing climatic and socio-economic conditions, presently there is a little scope for free grazing of goats and sheep. In developing countries feeds and fodder scarcity is the major limiting factor for low productivity and poor reproduction of animals. The high demand for animal products could only be met in a sustained manner through the efficient use of crop residues and unconventional feed resources that do not compete with human food. Feeding system based on complete pellet feed is one of the promising methods for improving the utilization of poor quality crop-residues and agro industrial by products and this may help in developing stall-feeding methods for the commercial sheep and goat

production as well as feed manufacturing entrepreneurs for the commercial production of complete pellet feed . This system also ensures the supply of balanced nutrients reduces feed wastage and feeding cost, maximizes production by converting poor quality, non-edible by-products into palatable and highly nutritious animal feed. Thus, the project was undertaken to enhance meat production, employment generation and to ensure food security of the country.

7. Sub-project goal:

Development of cost effective complete pelleted feed for the commercial goat and sheep production

8. Sub-project objective (s):

i) To develop pellet feeds for commercial goats and sheep
ii) To study the effect of pellet feeding on the performance of goats and sheep
iii) To investigate the economic benefit of pellet feeding in goat and sheep

9. Implementing location (s):

a) Goat and sheep research farms, Bangladesh Livestock Research Institute, Savar, Dhaka for on-station research.
b) Subarnachar, Noakhali and Bhaluka, Mymensingh for on-farm research.

10. Methodology in brief:

10.1. Development of pellet feeds for goats and sheep:

Sources of crop residues

Rice straw and agro industry based concentrate feed ingredients were purchased from the local sources for the preparation of pellet feed.

Processing of feedstuffs

Rice straw was used as roughage source with the agro industry based concentrate mixture to formulate the basal total mix ration (TMR) for pelleting according to the nutrient requirement of the animals. For the pelleting of feed, a small scale pelleting machine was designed and fabricated locally. All the roughages were grinded to 5 mm size using Hammer mill machine containing 5 mm size sieve.

Preparation of Pellet feed

Different researches in BLRI (Ahmed *et al.,* 2008 and Roy *et al.,* 2010) suggest that 40% roughage and 60% concentrate would be a good composition to develop complete pellet feed for small ruminants. So, 40% roughage (Rice straw) and 60% concentrate (Rice polish 50%, Maize crush 16%, Soybean meal 20%, Molasses 10%, Salt 2%, DCP 1%, Vitamin-mineral premix 0.5%, Pellet binder 0.5%) was used for the formulation of complete pellet feed. The grinded roughage was mixed very well with concentrate mixture. Required amount of water and pellet binder was added and mixed very well before passing it to the pelleting machine. The prepared pellet was sun dried and stored for animal feeding.

Chemical Composition of experimental diet

Samples of the experimental diets were dried and grinded in a grinding mill to 2 mm size before analysis. Crude protein (CP) content of the experimental diet was determined using the automated Kjeldahl method (AOAC, 1995). Dry matter (DM) content of the feed was determined by drying the samples at 105^{o}C overnight, while ash was measured by burning further at 500^{o}C for 4 hours. The neutral detergent fiber (NDF) and acid detergent fiber (ADF) composition were analyzed using the method described by Goering and Van Soest (1970).

10.2. Study the effect of pellet feeding on the performance of goats and sheep:

Experiment 1: Effect of the developed pellet feed on goat production under stall feeding condition

For this study, 18 Intact male Black Bengal goats of 4 to 5 months of age were selected. The goats were divided into 3 treatment groups (having 6 animals in each group) by stratified randomization on the basis of their average body weight. The control groups were fed Ad libitum Oat grass (T_1) and Ad libitum UMS (T_2) with concentrate supplementation (@ 1.5% of body weight) and the treatment group (T_3) was fed Ad libitum developed complete pellet feed. The animals were housed in individual pens on plastic slated floor equipped with separate feeder and waterer. The goats were dewormed at the onset of the experiment. The feed was supplied two times daily (9 am and 4 pm) and orts were collected before morning feeding to know the feed intake. Animals were weighed weakly before morning feeding. The duration of the experiments was 90 days.

Experiment 2: Effect of the developed pellet feed on sheep production under stall feeding condition

For this study 18 Intact male Native Bengal lambs of the age of 4 to 5 months were selected. The lambs were divided into 3 treatment groups (having 6 animals in each group) by stratified randomization on the basis of their average body weight. The control groups were fed Ad libitum Oat grass (T_1) and Ad libitum UMS (T_2) with concentrate supplementation (@ 1.5% of body weight) and the treatment group (T_3) was fed Ad libitum developed complete pellet feed for the intensive production of sheep. The animals were housed in individual pens on plastic slated floor equipped with separate feeder and waterer. The sheep were dewormed at the onset of the experiment. The feed were supplied two times daily (9 am and 4 pm) and orts were collected before morning feeding to know the feed intake. Animals were weighed weakly before morning feeding. The duration of the experiments was 90 days.

Experiment 3: On-farm performances of sheep fed on complete pellet feed

The experiment was conducted at Subornachar Upazila under Noakhali district of Bangladesh. Total 14 farmers were selected having at least one male lamb with 4 to 5 months of age. They were equally distributed in to two treatment groups (T_0 and T_1) having 7 lambs in each group. In T_0, lambs were reared under traditional semi intensive system (allowed 8 hours grazing in fallow land, no or very little concentrate supplementation and provided night shelter), while T_1 lambs were reared under stall feeding condition and fed complete pellet feed. The duration of the experiment was 90 days. Data from above two treatments were compared with on-station pellet feeding data, which was designated as T_2.

Experiment 4: On-farm performances of goats fed on complete pellet feed

The experiment was conducted at Bhaluka Upazila under Mymensingh district of Bangladesh. Total 12 farmers were selected having at least one castrated male goat with 4-5 months of age. They were equally distributed in to two treatment groups T_0 and T_1 having 6 male goats in each group. In $T_{0,}$ goats were reared under traditional semi intensive system (allowed 8 hours grazing in fallow land, no or very little concentrate supplementation and provided night shelter), while in $T_{1,}$ goats were reared under stall feeding condition and fed complete pellet feed allowing 10 days adjustment period. The duration of the experiment was 60 days. Data from the above two treatments were compared with the on-station pellet feeding data, which was designated as T_2.

Parameters Studied

The following parameters were studied in different experiments:

- DM intake
- Nutrients intake and digestibility
- Live weight gain
- FCR
- Health status of the animals
- Production cost of per kg meat
- Benefit cost ratio (BCR) analysis

Digestibility and nitrogen balance

Immediately after the growth trial; three animals from each of the dietary group were randomly selected for determining digestibility of the feeds and nutrients using the total collection method. Metabolic trays were placed under individual pens for the collection of feces and urine separately. The animals were continued to feed the experimental diets. They were allowed 3 days to adjust with the additional management system prior to start of the total collection of urine and feces for 7 days. The feces of each of the animals were collected, weighed, and sampled (10%), and kept in a freezer (-20°C) for further analysis. The total urine of each of the animal was weighed, sampled (10%), and kept in plastic containers containing 100 ml 6N H_2SO_4 to prevent ammonia loss. The containers were kept in a freezer. The samples of feed and refusals of the total collection period were mixed thoroughly, and a composite sample for each animal was taken for analysis of the chemical components.

FCR and Feed cost analysis

The feed conversion ratio (FCR) was calculated as a proportion of live weight gain to feed intake of whole experimental period. Feed cost per kg gain was calculated as a ratio of cost of total feed consumed to total weight gain.

10.3. Economics of feeding experimental pellets:

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

11. Results and discussion:

11.1. Development of pellet feeds for goats and sheep:

The chemical composition (%) of the pellet feed is given in the Table 1.

Table1. Chemical composition (%) of the experimental diets

Ingredients/feed	DM	OM	Ash	CP	ADF	NDF
Complete pellet feed	91.70	85.71	14.29	13.40	32.24	51.56
Oats grass	13.74	94.22	5.78	16.54	51.6	78.8
UMS	61.73	87.7	12.3	9.45	61.31	73.8
Concentrated mixture	88.55	94.07	5.93	18.65	9.98	35.81

DM, dry matter; OM, organic matter; CP, crude protein; ADF, acid detergent fiber, NDF, neutral detergent fiber

11.2. Effect of developed pellet feed on goat and sheep production under stall feeding condition and economic analysis

Experiment 1: Effect of the developed pellet feed on goat production under stall feeding condition

Table 2 shows the effect of complete pellet feed on the performances of goats compared to conventional stall feeding. Although, Dry matter 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) but numerically higher amount of DMI was observed in pellet feeding group (T_3) that indicates grinding and pelleting increased voluntary feed intake. Consequently, average 16 g more daily weight gain (50.29-34.29=16) was observed in pellet feeding group (50.29g for T_3) compared to other two conventional feeding groups (33.80g for T_1 and 34.78g for T_2) of goats although daily weight gain did not differ significantly. Similar observation was also found by Roy *et al.* (2010) by feeding Rice straw based complete pellet feed to growing Black Bengal goats and Sarker (2000) by feeding wheat straw based treated pellet in lambs. Rashid *et al.* (2016) found significantly higher DMI by feeding roughage and concentrate in a compound pellet form to Black Bengal goats. In case of daily cattle, Knaus *et al.* (1999) also reported average daily forage DMI was increased from 12.8 to 18.6 kg when grass clover and whole plant maize were fed in the pellet form.

The FCR did not differ significantly among the treatment groups but considerably low FCR was observed in pellet feeding group (5.7 for T_3) compared to other groups (8.32 for T_1 and 8.03 for T_2). Rashid *et al.* (2016) also observed the best FCR in compound pellet feeding group although that did not differ significantly among the different treatment groups. The most important parameter, the feed cost per kg weight gain was significantly lower ($p<0.05$) in pellet feeding group (Tk 124.22 for T_3) compared to other groups (Tk 203.85 for T_1 and Tk 214.74 for T_2) due to better FCR and higher average daily gain. This result is in agreement with the findings of Rashid *et al.* (2016) who reported lowest feed cost (Tk. 150.93) per kg weight gain by complete feed compared to conventional grass and concentrate based feeding system (Tk. 226.08). Bahu *et al.* (2013) also reported the cost of feed/100 kg and per kg weight gain was lower for 50% Sorghum bagasse and 50% concentrate based complete pellet diet in goats due to lower feed cost and better FCR. In case of Murrah buffaloes, Nagalakshmi and Narsimha Reddy,

(2010) also reported the cost of feeding per kg milk production to be lower when complete pellet diet containing sugarcane bagasse as a roughage source was used. Processed diets also reported to reduce feed cost per kg weight gain in Sheep (Bush *et al*., 1978) and calves (Reddy *et al.,* 2002). This may be due to efficiency of feed that enhanced by grinding and pelleting. The best BCR ($p<0.05$) also observed in pellet feeding group (1.93 for T_3) compared to other groups (1.23 for T_1 and 1.16 for T_2).

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
FCR	8.32	8.03	5.7	0.607	NS
Daily weight gain (g)	33.80	34.78	50.29	3.866	NS
Feed cost/kg gain (Tk)	203.85^a	214.74^a	124.22^b	17.297	*
Total cost/kg weight gain (Tk)	265.00	279.16	161.48	22.486	.052
Total benefit/kg weight gain (Tk)	300.00	300.00	300.00	0.00	NS
BCR	1.23	1.16	1.93	0.133	*

ab, different superscript in the same row differ significantly; T_1, Ad libitum oats grass + concentrate mixture @ 1.5% of body weight; T_2, Ad libitum UMS + concentrate mixture @ 1.5% of body weight; T_3, Ad libitum developed complete pellet feed

Results suggest that complete pellet feed would be more economic 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.* (2016) 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 stall fed condition.

The DM, OM, CP and NDF digestibility percent was significantly higher (78.74, 80.98, 85.24 and 77.23 respectively) in T_1 group (feeding on conventional 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 the use of high quality green oat grass as a basal roughage source for T_1 group animals. But, average daily gain was numerically higher in T_3 group and better FCR also observed in T_3 group indicated that grinding and pelleting to prepare complete pellet feed enhances the palatability and the efficiency of utilization of the diet (Nicholson *et al.,* 1996; Reddy and Reddy, 1999; Reddy *et al.,* 2002). Nevertheless, Rashid *et al.* (2016) 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) form fed to the growing Black Bengal goats.

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

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]	73.12a	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 superscript in the same raw differ significantly; T_1, Ad libitum oats grass + concentrate mixture @ 1.5% of body weight; T_2, Ad libitum UMS + concentrate mixture @ 1.5% of body weight; T_3, Ad libitum developed complete pellet feed

No disease or clinical symptoms were observed during experimental period due to using rice straw based complete pellet feed indicates that pellet feeding did not alter the normal rumen function of the animals and animal Physiology. Thus, Rice straw based complete pellet feed could be an alternative ready feed for commercial goat production under stall feeding system.

Experiment 2: Effect of the developed pellet feed on sheep production under stall feeding condition

Table 4 shows the Effect of complete pellet feed on the performances of growing sheep compared to conventional stall feeding. The DMI and daily weight gain was significantly ($p<0.01$) increased (0.768 kg and 100.67 g respectively) in Pellet feeding group (T_3) compared to other groups (0.415 kg and 63.27 g respectively for T_1 and 0.427 kg and 64.78 g respectively for T_2). Higher amount of DMI was observed in pellet feeding group indicating that grinding and pelleting increased the palatability and voluntary feed intake. Similar result was also found by Roy *et al.,* 2010. Rashid *et al.* (2016) found significantly higher DMI by feeding roughage and concentrate in a compound pellet form to Black Bengal goats. In case of dairy cattle, Knaus *et al.* (1999) also reported the average daily forage DMI to be increased from 12.8 to 18.6 kg when grass clover and whole plant maize were fed in the pellet form.

Table 4. Effect of complete pellet feed on the performances of growing sheep compared to conventional stall feeding.

Parameters	Treatments			SEM	Level of sig.
	T_1	T_2	T_3		
Initial weight (kg)	10.69	11.01	10.80	0.325	NS
Final weight (kg)	16.38[a]	16.84[a]	19.86[b]	0.639	*
Weight gain (kg)	5.694[a]	5.83[a]	9.06[b]	0.485	**
Weight gain/day (g)	63.27[a]	64.78[a]	100.67[b]	5.388	**
DMI (kg)	0.415[a]	0.427[a]	0.768[b]	0.045	**
DMI (% body weight)	3.07[a]	3.21[a]	5.13[b]	0.261	**
FCR	7.11	6.87	7.39	0.201	NS
Feed cost/kg gain (Tk)	166.35	176.33	169.06	4.992	NS
Total cost/kg gain (Tk)	219.84	224.99	219.15	6.532	NS
Total benefit/kg gain (Tk)	300.00	300.00	300.00	0.00	NS
BCR	1.37	1.33	1.37	0.037	NS

*ab, different superscript in the same raw differ significantly; * $p<0.05$; ** $p<0.01$; T_1, Ad libitum oats grass + concentrate mixture @ 1.5% of body weight; T_2, Ad libitum UMS + concentrate mixture @ 1.5% of body weight; T_3, Ad libitum developed complete pellet feed*

Daily weight gain was significantly increased ($p<0.01$) in Pellet feeding group (T_3) compared to other conventional feeding groups. Rashid *et al.* (2016) found significantly higher ($p<0.05$) daily live weight gain in case of goat fed with compound pellet diet than the same amount of mash or grass and concentrate feed fed separately. No differences were observed for the feed cost per kg weight gain and FCR among the groups.

Table 5 shows the nutrient digestibility of different feed fed by different treatment group of sheep. The CP digestibility (%) found significantly ($p<0.05$) high in T_1 group (69.77) followed by T_3 (54.75) and T_2 (45.72), but the DM, OM, ADF and NDF did not differ significantly among the treatment groups. This may be due to the use of high quality green Oats grass as a basal roughage source for T_1 group animals. Although CP digestibility was low but, average daily gain was significantly higher in T_3 group, suggest that pelleting enhanced the efficiency of utilization of feed More or less similar results were found by the other researchers (Nicholson *et al*., 1996; Reddy and Reddy, 1999; Reddy *et al*., 2002).

Table 5. Nutrient digestibility of feed (%) fed by different treatment groups of sheep

Parameter	Treatment			SEM	Level of Sig.
	T_1	T_2	T_3		
DM digestibility	63.89	56.02	60.60	2.529	NS
OM digestibility	71.03	61.35	63.04	2.430	NS
CP digestibility	69.77^{b}	45.72^{a}	54.75^{ab}	4.283	*
ADF digestibility	44.48	52.43	47.16	3.637	NS
NDF digestibility	57.88	52.43	52.00	2.946	NS

*ab, different superscript in the same row differ significantl; * p<0.05; T_1, Ad libitum oats grass + concentrate mixture @ 1.5% of body weight; T_2, Ad libitum UMS + concentrate mixture @ 1.5% of body weight; T_3, Ad libitum developed complete pellet feed*

No disease or clinical symptoms observed during experimental period due to using rice straw based complete pellet feed indicates that pellet feeding did not alter the normal rumen function of the animals and animal Physiology. Arable land for grazing sheep is decreasing day by day due to increasing population and urbanization. Therefore, farmers has to be encouraged to adopt stall feeding system for sheep farming using agro-industrial by-products based alternative feed. Complete pellet feed could be an alternative ready feed for commercial sheep production under intensive or stall fed condition.

Experiment 3: On-farm performances of Sheep fed on complete pellet feed

This study was conducted at Subarnachar upazila under Noakhali district to know the performances of sheep fed on the developed complete pellet feed at farmer's level. Table 6 shows the performances of lambs fed on complete pellet feed at on-farm condition. Performance data of the pellet feeding group at on-farm condition (T_1) was compared with on-station data of pellet feeding group (T_2) while the performances of traditional semi-intensive group (T_0) was considered as control group.

Similar DM intake observed both for on-farm (T_1) and on-station group (T_2). Likewise, FCR, feed cost per kg weight gain and total cost per kg weight gain did not differ between T_1 and T_2 groups. Results suggest that the sheep fed with the developed pellet feed performed evenly both for on-station and

on-farm groups. In traditional system of rearing (T_0) only 22.42 g daily weight gain was observed while, feeding of developed complete pellet feed achieved 84.98 g and 100.67 g daily weight gain at on-farm (T_1) and on-station (T_2) condition respectively. The results (Table 6) indicate that daily weight gain was increased significantly ($p<0.01$) about 4-5 times due to complete pellet feeding both for on-farm (T_1) and on-station (T_2) compared to the traditional system of rearing (T_0). Better (1.37) Benefit cost ration (BCR) was observed in T_2 group compared to T_1 group (1.18) although, the figures did not differ significantly. BCR for both the on-farm and on-station feeding group was higher than 1, indicating that the farmers will be benefited by using complete pellet feed for the production of sheep.

No disease or clinical symptoms were observed during experimental period due to using rice straw based complete pellet feed indicate that pellet feeding did not alter the normal rumen function of the animals and animal Physiology. Both on-farm and on-station results confirm that straw based complete pellet feed could be an alternative ready feed for the commercial sheep production under intensive or stall fed condition.

Table 6. Performances of Sheep fed on complete pellet feed at On-farm condition

Parameters	**Treatments**			**SEM**	**Level of sig.**
	T_0	**T_1**	**T_2**		
Initial weight (kg)	9.25	9.85	10.78	0.741	NS
Final weight (kg)	10.82^a	15.80^b	19.86^b	1.2497	**
Body weight change (kg)	1.57^a	5.95^b	9.08^c	0.783	**
DMI (kg/day)	-	0.73	0.77	0.025	NS
FCR	-	8.93	7.68	0.450	NS
Daily weight gain (g)	22.42^a	84.98^b	100.67^b	9.066	**
Feed cost /kg gain (Tk)	-	197.70	168.58	10.053	NS
Total cost/kg weight gain (Tk)		257.01	219.15	13.069	NS
Total Benefit/kg weight gain (Tk)		300.00	300.00	0.000	NS
BCR		1.18	1.37	0.069	NS

*ab, different superscript in the same row differ significantly; * p<0.05; ** p<0.01; T_1, pellet feeding group at on-farm condition; T_2, on-station data of pellet feeding group; T_0, traditional semi-intensive feeding group*

Experiment 4: On-farm performances of goats fed on complete pellet feed

This study was conducted Valuka upazila under Mymensingh district to know the performances of growing goat fed on developed complete pellet feed at farmers level (On-farm). Table 7 shows the performances of goats fed on complete pellet feed at on-farm condition. Performance data of the pellet feeding group at on-farm condition (T_1) was compared with on-station data of pellet feeding group (T_2) while the performances of tradition semi-intensive group (T_0) was considered as control group.

Similar DM intakes were observed both for on-farm (T_1) and on-station groups (T_2). Likewise, FCR, feed cost per kg weight gain and total cost per kg weight gain did not differ between T1 and T2 groups. Results suggested that the goats fed with the developed pellet feed performed consistently both in on-station and on-farm condition. In traditional system of rearing (T_0) farmers got only 17.76 g daily weight

gain while goats feed on developed complete pellet feed were able to achieve 52.46 and 36.96 g daily weight gain at on-farm (T_1) and on-station (T_2) condition respectively. The results (Table 7) indicated that daily weight gain increased significantly ($p<0.01$), about 2-3 times due to complete pellet feeding both for on-farm (T_1) and on-station (T_2) group compared to the conventional rearing (T_0) group. Sultan *et al*. (2012) reported the average daily weight gain of Black Bengal goats to be 27.6g, 35.1g, 43.2g, 43.8g per day when offered ad-libitum green grass with 150g, 200g, 250g and 300g concentrate mixture, respectively in case of stall fed condition and the results are in consistent with this study. Islam *et al.* (2009) reported for 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 g, respectively during weaning period of kids. While, for this study weaned kids of about 4 to 5 months age were used and it is well known that after weaning, growth rate reduces compared to pre-weaning phase (self-accelerating phase). Devendra and McLeroy (1982) stated that younger goats and sheep showed higher growth rate under self-accelerating phase of growth. Although, the BCR did not differ significantly between T_1 (1.09) and T_2 (1.19) groups but the values were higher than 1, indicated that farmers will be benefited by using complete pellet feed for the production of goat.

No disease or clinical symptoms were observed during experimental period due to using rice straw based complete pellet feed indicate that pellet feeding did not alter the normal rumen function of the animals and animal Physiology. Both on-farm and on-station results confirm that straw based complete pellet feed could be an alternative ready feed for the commercial goat production under intensive or stall fed condition.

Table 7. Performances of goat fed on complete pellet feed at 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(g)	17.76	52.46	36.96	4.565	**
Feed cost /kg weight gain (Tk)		211.43	194.07	27.745	NS
Total cost/kg weight gain (Tk)		274.86	252.30	36.069	NS
Total benefit/kg weight gain (Tk)		300.00	300.00	0.00	NS
BCR		1.09	1.19	0.200	NS

*ab, different superscript in the same raw differ significantly; * p<0.05; ** p<0.01; T_1, pellet feeding group at on-farm condition; T_2, on-station data of pellet feeding group; T_0, traditional semi-intensive feeding group*

12. Research highlight/findings:

- A cost effective complete pellet feed was developed by using 40% roughage (Rice straw) and 60% concentrate (Rice polish 50%, Maize crush 16%, Soybean meal 20%, Molasses 10%, Salt 2%, DCP 1%, Vitamin-mineral premix 0.5%, Pellet binder 0.5%) for commercial goat and sheep production
- The results of the on-station and on-farm experiments suggest that feeding complete pellet feeds helped increasing daily body weight gain of goats (36.96 and 52.46 g respectively) compared to traditional semi-intensive feeding (17.76 g).
- Similarly for sheep, in traditional system of rearing only 22.42 g daily weight gain was observed while, feeding of developed complete pellet feed achieved 84.98 g and 100.67 g daily weight gain at on-farm and on-station condition respectively.
- For goats considerably low FCR was observed in pellet feeding group (5.7) compared to other groups where no pellet feed was used (8.32 and 8.03).
- Feed cost per kg weight gain for goats was also significantly lower in pellet feeding group (Tk 124.22) compared to other groups (Tk 203.85 and Tk 214.74)
- In case of sheep no differences were observed for the feed cost per kg weight gain and FCR among the pellet feeding group and other groups.
- For goats, the best BCR ($p<0.05$) was observed in pellet feeding group (1.93) compared to other groups (1.23 and 1.16).
- In case of sheep BCR did not differ significantly among the pellet feeding group and other groups

B. Implementation Position

1. Procurement:

Description of equipment and capital items	PP Target		Achievement		Remarks
	Phy (#)	Fin (Tk)	Phy (#)	Fin (Tk)	
(a) Office equipment	Bookshelf: 01 Secretariat table: 01 Secretariat chair: 01	36850.00	100 %	100 %	-
(b) Lab &field equipment 1. Lab & field equipment 2. Grinding machine	01	99420.00 248950.00	100 %	100 %	-
(c) Other capital items	by-cycle: 01	14994.00	100 %	100 %	-

2. Establishment/renovation facilities:

Description of facilities	Newly established		Upgraded/refurbished		Remarks
	PP Target	Achievement	PP Target	Achievement	
Pellet machine	-	-	01	01	-
Roughage grinding machine	01	01	-	-	-

3. Training/study tour/ seminar/workshop/conference organized:

Description	Number of participant			Duration (Days/weeks/ months)	Remarks
	Male	Female	Total		
(a) Training	-	-	-	-	-
(b) Workshop	-	-	-	-	-

C. Financial and physical progress

Fig in Tk

Items of expenditure/activities	Total approved budget	Fund received	Actual expenditure	Balance/ unspent	Physical progress (%)	Reasons for deviation
A. Contractual staff salary	235142.00	235142.00	235142.00	0.00	100	-
B. Field research/lab expenses and supplies	510693.00	464199.00	464199.00	46494.00	90.90	Fund not released
C. Operating expenses	86102.00	74809.00	77549.00	8553.00	86.88	Fund not released
D. Vehicle hire and fuel, oil & maintenance	41610.00	37992.00	37992.00	3618.00	91.31	Fund not released
E. Training/workshop/seminar, etc.	0.00	0.00	0.00	0.00	-	Fund not released
F. Publications and printing	97100.00	80593.00	00.00	0.000	00.00	Return to PIU-BARC
G. Miscellaneous	25439.00	19975.00	19975.00	5464.00	78.52	Fund not released
H. Capital expenses	300794.00	295815.00	295815.00	4979.00	98.35	Fund not released

D. Achievement of Sub-project by objectives: (Tangible form)

Specific objectives of the sub-project	Major technical activities performed in respect of the set objectives	Output (i.e. product obtained, visible, measurable)	Outcome (short term effect of the research)
To develop pellet feeds for commercial goats and sheep	Formulation of total mix ration to prepare pellet feed Evaluate the nutrient quality and digestibility of the developed pellet feed	A cost effective complete pellet feed was developed by using 40% roughage (Rice straw) and 60% concentrate (Rice polish 50%, Maize crush 16%, Soybean meal 20%, Molasses 10%, Salt 2%, DCP 1%, Vitamin-mineral premix 0.5%, Pellet binder 0.5%) for commercial goat and sheep production	Entrepreneurship may develop for the commercial production of complete pellet feed for goat and sheep production Research outcomes may help to increase commercial goat and sheep farming under intensive or stall feeding system
To study the effect of pellet feeding on the performance of goats and sheep	Farmer selection Feeding the developed pellet feed to the animals and evaluate animal production performances Evaluate the health problems Evaluate the cost benefit ratio of pellet feeding	Feeding complete pellet feeds helped increasing daily body weight gain of goats (36.96 and 52.46 g respectively) compared to traditional semi-intensive feeding (17.76 g). For sheep, in traditional system of rearing only 22.42 g daily weight gain was observed while, feeding of developed complete pellet feed achieved 84.98 g and 100.67 g daily weight gain at on-farm and on-station condition respectively. For goats considerably low FCR was observed in pellet feeding group (5.7) compared to other groups where no pellet feed was used (8.32 and 8.03).	
To investigate the economic benefit of pellet feeding in goat and sheep	Compare on-farm data to respective on-station data	Feed cost per kg weight gain for goats was significantly lower in pellet feeding group (Tk 124.22) compared to other groups (Tk 203.85 and Tk 214.74) For goats, the best BCR ($p<0.05$) was observed in pellet feeding group (1.93) compared to other groups (1.23 and 1.16).	

E. Materials Development/Publication made under the Sub-project:

Publication	Number of publication		Remarks (e.g. paper title, name of journal, conference name, etc.)
	Under preparation	Completed and published	
Technology bulletin/ booklet/leaflet/flyer etc.	01	-	-
Journal publication	02	-	-
Information development	-	-	-
Other publications, if any	-	-	-

F. Technology/Knowledge generation/Policy Support (as applied):

i. Generation of technology (Commodity & Non-commodity)

Roughage based cost effective complete pellet feed for commercial goat and sheep production under intensive/stall fed condition developed.

ii. **Generation of new knowledge that help in developing more technology in future**

More research is needed before using this technology by the Feed manufacturers for commercial production of roughage based complete pellet feed.

iii. Technology transferred that help increased agricultural productivity and farmers' income

Not applicable

iv. Policy Support

The output of this project activities will helps to increase commercial small ruminant farming under stall fed/intensive system of management. It would also assist the policy makers of the livestock sector for setting their future research directions as well as the production of small ruminant.

G. Information regarding Desk and Field Monitoring

i) Desk Monitoring (description & output of consultation meeting, monitoring workshops/seminars etc.):

Bangladesh livestock Research Institute organized a meeting monthly to evaluate different project running in the institute from Annual Development Programme (ADP) and other sources of funds. The financial and technical progress of this project was also evaluated during these meetings. The recommendation and suggestions came from these meetings helped a lot for the execution of the project. Beside this, Project implementation unit – PIU-BARC also organized following workshops to evaluate the project activities and results.

Workshop	Date
Progress workshop	24-25 April, 2018
Monitoring workshop	15-16 May, 2018
Annual workshop	22-23 September, 2018

ii) Field Monitoring (time& No. of visit, Team visit and output):

Monitoring team	Date(s) of visit	Total visit till date (No.)	Output
Livestock Division, BARC	20/02/2018	01	Satisfactory
Internal team monitoring, BLRI	30 July, 2018	01	Satisfactory

H. Lesson Learned (if any)

i) Scientist/Research Associate was needed to complete on-station trials smoothly
ii) For on-station research activities, fund was not sufficient
iii) Fund from different sources should have been released in the same time
iv) Project duration was very short to complete all the activities in time

I. Challenges (if any)

i) One field assistant (for 6 months) was not enough to perform on-farm research activities in two locations
ii) In sufficient fund for continuing two on-farm trials in two different locations
iii) To keep pace with time was a big challenge

Signature of the Principal Investigator
Date …….
Seal

Counter signature of the Head of the organization/authorized representative
Date ……..
Seal

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