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Effect of pellet from total mixed ration on growth performance, blood metabolomics, carcass and meat characteristics on Bangladeshi garole sheep

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Abstract

Six indigenous Bangladeshi Garole sheep (*Ovis aries*) (BW: 8±0.5 kg; Age: 1yr) were divided into two groups using a randomized block design to investigate the effect of total mixed ration (TMR) pellet feeding on growth parameter, blood metabolomics, carcass and meat characteristics. Control diet was composed of road side grass, rice straw, wheat bran, mustard oil cake, molasses, common salt which considered as loose total mixed ration (L-TMR) and treatment diet was pelleted form of L-TMR (P-TMR).In both the dietary treatments the animals were fed at 1.5 times of maintenance energy and protein requirement. P-TMR revealed a positive impact ($p < 0.05$) on live weight gain and feed conversion ratio than L-TMR. Total digestible nutrients (TDN) and digestible crude fibre (DCF) was significantly higher ($p < 0.05$) in P-TMR group whereas there was no significant difference ($p < 0.05$) in other digestible nutrients as well as plasma metabolites like plasma glucose, triglyceride, total cholesterol, HDL-cholesterol and LDL- cholesterol concentration between two dietary group. Dressing percentage and eye muscle area was significantly higher ($p < 0.05$) in P-TMR group but no significant difference was found between dietary treatments in term of disposition of body fat, proximate composition of mutton, all the sensory parameters except tenderness and overall acceptability. So, it could be concluded that, the P-TMR might be fed to sheep for better growth performance and higher meat production rather than production of functional mutton.

Key words: Blood metabolomics, carcass characteristics, digestibility, total mixed ration, sheep

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Introduction

There are about 3.34 million sheep in Bangladesh (DLS, 2015). They are mostly reared by family members under zero input in char or coastal areas and also in plane land (Sultana *et al*., 2011). Most of the sheep (84.80% of the total) is reared under low input system and the rest 15.20% is found under medium input system (BBS, 2000). Sheep are generally reared in extensive system in Bangladesh (Hasan *et al*., 2011). In adverse climatic condition farmers have to house their sheep providing stall feeding with tree leaves, natural grasses and kitchen wastes. Sheep reared in the villages of Bangladesh solely depend upon the grasses, which contain higher percentage of crude fiber (Ghosh *et al*.,1983).Feed and fodder scarcity is a major limiting factor in Bangladesh resulting in low productivity, poor growth and reproduction of sheep(Sultana *et al*., 2011). There is high demand of land for crop production, urbanization and industrialization in our country. For this reason, every year 1% of pasture land is decreasing. If this trend continues, in near future stall feeding or intensive system of sheep rearing will be essential to meet up the demand of meat for increased population. The important characteristics of sheep are prolificacy, lambing twice a year, where twinning is common (Rahman, 1989). The productivity of sheep may be increased by improving nutrition through supplementation of concentrates or compound feed. To ensure balanced nutrition for the sheep in intensive rearing system, there is no alternative of compound pellet diet, since pellet feeding give nutrition to sheep in a balanced form. Pelleting of low quality roughages and other products like wheat bran, molasses helps in increasing the palatability of this feed (Reddy *et al*., 1989). It reduces the wastage of feed ingredients and improve digestibility of animal (Reddy *et al*., 1990). The quality of carcass depends on feed. The feed mainly affects carcass conformation and several physicochemical and organoleptic parameters of meat quality, such as proximal composition, the fatty acid profile, tenderness, and color (Retamal *et al*., 2014). Considering the above state-of-the art, the present experiment has been designed to know the effect of pelleted total mixed ration pellet (P-TMR) feeding on the production performance and carcass characteristics in sheep.

Materials and Methods

Animals, Diet and Management: The whole experimental activities performed at Shahjalal Animal Nutrition Field laboratory and departmental laboratory. Six local Garole sheep (*Ovis aries*), aged around One year and weighing around 8.0±0.5 kg was used to conduct the experiment. The animals were divided into two groups having randomly selected three sheep for each which reared in 0.91 m^2 (120cm × 76cm) cages separately. First group was offered loose form of total mixed ration based on requirement cited by NRC (1985) that considered as control diet (L-TMR) and the second group was offered pellet diet (P-TMR), containing similar feed ingredients and similar proportion mentioned at Table 1. For pellet preparation (P-TMR) all required ingredients were collected and before grinding the grass and straw were dried sufficiently. After grinding grass and straw, all the ingredients were mixed well using mixer machine and then pellet was prepared in pelleting machine using 6 mm die.

Table 1. Composition of supplied ration and its nutrient components

Ingredients	Amounts (%)
Road side grass	29
Rice straw	14
Wheat bran	32
Mustard oil cake	13.5
Molasses	11
Common salt	0.5
Calculated chemical composition diet (%)	
Dry matter	91.08
Crude protein	16.35
Crude fiber	16.94
Ether extract	3.77
Ash	11.54
Nitrogen free extract	54.46
ME* (Kcal/Kg DM)	2384.6

ME=Metabolizable energy; *calculated by using formula adopted from Kienzle (2002)

Sheep were fed twice in a day. Daily required amount of total feed was divided in two parts, one part was supplied in morning (8.00h) and another part was supplied in afternoon (16.00h). The clean and fresh water was provided with *adlibitum* basis. No growth promoter, anti-parasitic drug, antibiotics or feed additives was provided to the animal. The length of feeding for both groups was 75 days.

Record keeping and sample collection**:** Animals were weighed at the onset of trial and one-week interval during the whole experimental period. Feed was offered and refused were weighed, sub-sample was collected daily in the morning during the last21 days of the experimental period. Urine was collected daily in bucket containing 50 mL of 6N H_2SO_4 for urinary N analysis. Feces were also collected from each sheep in the 21 days of collection period. Blood samples (5 ml each) were collected every 15 days after throughout the feeding trial in a heparinized tube and kept in an ice box until centrifugation. Samples were centrifuged at 10000 × g at 4°C for 10 minutes for plasma separation and plasma was stored at -20 °C. On the day 75 the sheep of each group were slaughtered to study the carcass parameters. Before slaughter live weight was observed and after slaughtering some parameters like hot and chilled carcass weight, dressing percentage, color, texture, tenderness, juiciness, and drip loss were observed. Meat samples for chemical analyses i.e. proximate composition and for determination of drip loss and cooking loss were taken from thigh region of each slaughtered sheep. Ten (10) g of meat sample for proximate composition, 50 g for drip loss and 10 g of meat sample for cooking loss determination were taken from thigh region of each animal. The meat sample were weighted carefully and packed with marking separately.

***Sample analysis*:** The proximate components of feeds, leftovers and feces and urine were analyzed according to AOAC (1990). Blood metabolomics like plasma glucose, triglycerides, total cholesterol, HDL-cholesterol, LDL- cholesterol was determined by using different specific enzymatic kit in Agilent 2100 Bioanalyzer. Dressing percentage of the slaughtered animal was estimated by using the following formula.

Dressing percentage (%) =

$$\frac{\text{Weight of the hot carcass weight}}{\text{Live weight during slaughteri ng}} \times 100$$

To measure Eye muscle area the hot carcass was split between 13th and 14th ribs. From the cross section, the area was traced three times onto an acetate paper. Then from the weight-area relationship of the acetate paper the average area of each single 'eye muscle' was estimated.

Eye muscle area (%) =

$$\frac{\text{Weight of acetate paper for total eye muscle area}}{\text{Weight of acetate paper for one cm square}}$$

The drip loss was estimated by using the following formula:

Drip loss (%) =

$$\frac{\text{Weight of meat sample} - \text{Weight of dry meat sample after 24 hrs}}{\text{Weight of meat sample}} \times 100$$

Cooking loss was determined by expressing cooked sample weight as a percentage of precooked sample weight following formula:

Cooking loss (%) =

$$\frac{\text{Weight of precooked sample} - \text{Weight of cooked sample}}{\text{Weight of precooked sample}} \times 100$$

***Statistical analysis*:** The statistical analysis was performed by SPSS Statistics (originally, Statistical Package for the Social Sciences, later modified to read Statistical Product and Service Solutions) using one-way analysis of variance (ANOVA). The level of significance was considered at P≤0..05

Results and Discussion

***Nutrient digestibility*:** There was no significant difference in DCP and DEE between P-TMR group and L-TMR group. But DCF was significantly lower and DNFE was significantly higher (P=0.021 and P=0.004, respectively) for P-TMR than L-TMR. Similarly, TDN was significantly higher (P= 0.048) for P-TMR than L-TMR (Table 2).

In this experiment, we found that higher CF digestibility in P-TMR group than L-TMR group. Petersen RO (1962) also found higher crude fiber digestibility for pelleted than unpelleted rations. Since feed processing involves a combination of shear, heat, residence time and water, it may result to partial denaturation of the proteins in the feed (Thomas *et al*., 1998), by which their digestibility increases (Voragen *et al*., 1995). In general, heating improves the digestibility of proteins by inactivating enzyme inhibitors and denaturing the protein which may expose new sites for enzyme attack (Camire *et al*., 1990). In this experiment, we got more TDN in P-TMR than L-TMR group. Reason behind that cell wall of feed ingredients were destroyed during pelleting that means the aleurone layer of cell walls in cereals which encapsulates significant amounts of nutritive components were available in P-TMR group. Findings from Saunders *et al*. (1969) also support this result. Murdock *et al*. (1951) reported from experiments with yearling sheep that, when compared to coarse ground dehydrated alfalfa, fine ground dehydrated alfalfa was lower in TDN and digestibility of crude fiber. They also found that compared to ground dehydrated alfalfa, the pelleted dehydrated alfalfa was higher in digestibility of crude fiber and TDN.

Table 2. Effect of P-TMR on digestibility of nutrients in sheep (g/100g DM)

Parameters	Treatment		P value
	L-TMR[2]	P-TMR[1]	
DCP	8.33 ± 0.58	8.92 ± 0.89	0.396
DCF	15.39 ± 0.63	12.67± 1.11	0.021
DEE	2.00 ± 0.35	2.32 ± 0.39	0.345
DNFE	23.58± 0.99	27.02± 0.05	0.004
TDN	50.86± 0.79	54.13 ± 1.85	0.048

[2]L-TMR=Road side grass, rice straw wheat bran, wheat bran, mustard oil cake, molasses, common salt; [1]P-TMR= Pelleted form of L-TMR using 6 mm die; DCP=Digestible Crude protein; DCF=Digestible crude fibre; DEE=Digestible ether extract; DNFE=Digestible Nitrogen Free Extract; TDN=Total Digestible Nutrients

***Body weight changes*: ** The live weight of sheep of P-TMR group and L-TMR group at time of experiment are shown in graphically by Figure 1. Significant body weight differences were observed between the two groups. Significantly higher daily gain was found in P-TMR group than L-TMR group (P=0.033) and similarly significantly higher feed efficiency was found in P-TMR diet group than L-TMR group (P=0.027).

Luimes P. (2014) found higher growth in sheep by using pelleted feed compared to loose feed. Neal (1953) tested the effect of pelleting on low-quality roughage, and observed that lambs gained faster and more efficiently on a pellet made of low-quality alfalfa and sorghum grain than lambs being fed a non-pelleted ration of high-quality alfalfa and sorghum grain. Since acute fodder problem is the main problem for quality meat production, so the poor-quality roughage (road side grass and straw) was used in P-TMR formation in the current experiment. Our result agreed with Luimes (2014) and Neal's (1953) experiment.

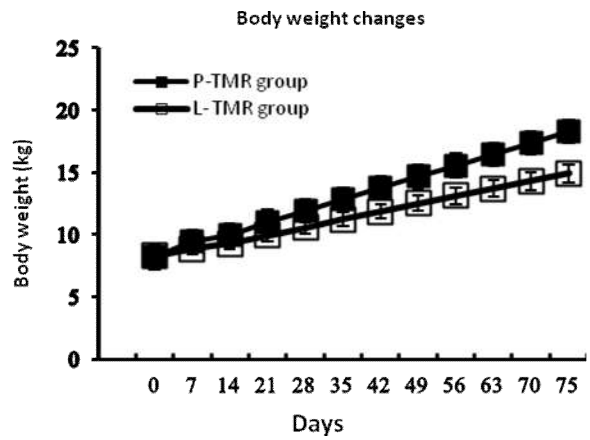

Figure 1. Graphically shown weekly body weight changes (kg/animal) of sheep under two dietary treatments; solid square box indicates P-TMR group and open square box indicates L-TMR group. L-TMR=Road side grass, rice straw wheat bran, wheat bran, mustard oil cake, molasses, common salt, P-TMR= Pelleted form of L-TMR using 6 mm die.

Total live weight gain, daily live weight gain was significantly higher ($p < 0.05$) in P-TMR and FCR was lower in P-TMR group than L-TMR group which indicates the efficient utilization of feed in P-TMR group (Figure 2). Some of the reasons for this increased efficiency in feed utilization might be an increase in the digestibility of the feeds through the pelleting process, increased palatability, inducing greater feed consumption and fewer energy losses in digestion (Petersen, 1962). In another experiment Blaxter *et al.,* (1964) found that lamb feeding loose ration produced higher methane gas and heat losses than pelleted form that also revealed positive favor of our result.

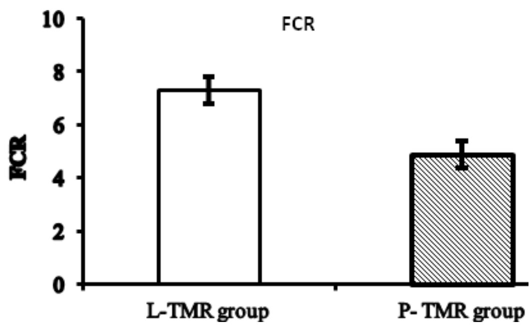

Figure 2. Graphically shown feed conversion ratio (FCR) of sheep under two dietary treatments; striped bar indicates P-TMR and solid bar indicates L-TMR group, L-TMR=Road side grass, rice straw wheat bran, wheat bran, mustard oil cake, molasses, common salt, P-TMR=Pelleted form of L-TMR using 6 mm die.

Blood metabolomics**:** There was no significant difference in plasma glucose, triglyceride, total cholesterol, HDL-cholesterol and LDL-cholesterol between the treatment group (Table 3). Concentration of total cholesterol, HDL-cholesterol and LDL-cholesterol in blood are largely depends on the polyunsaturated fatty acid content of the feed. Altering the form of feed did not offer any changes in blood metabolomics between two dietary groups. Paula *et al.*, (2013) also found similar result with Ile de France male lambs.

Carcass characteristics**:** There was no significant difference ($p < 0.05$) between P-TMR group and L-TMR group rather than dressing percentage, neck, hind leg and liver weight (Table 4). Higher dressing percentage (DP) was found in P-TMR group than L-TMR group (Figure 3). On the other hand, there was significant difference between dietary treatments on eye muscle area and no significant difference between dietary treatments in term of disposition of body fat.

Table 3. Effect of P-TMR on blood metabolomics in sheep

Parameters	Treatments		P-value
	L-TMR[2]	P-TMR[1]	
Plasma Glucose (mmol/dL)	6.15±0.13	6.18±0.08	0.725
Triglycerides (mg/dL)	25.00±2.65	26.00±1.00	0.573
Total Cholesterol (mg/dL)	37.67±1.53	36.67±1.53	0.468
HDL-Cholesterol (mg/dL)	20.22±1.03	18.87±0.39	0.101
LDL-Cholesterol (mg/dL)	14.76±1.14	15.29±0.88	0.559

[2]L-TMR=Road side grass, rice straw wheat bran, wheat bran, mustard oil cake, molasses, common salt; [1]P-TMR=Pelleted form of L-TMR using 6 mm die, HDL=High density lipoprotein, LDL=Low density lipoprotein

Table 4. Effect of P-TMR feeding on carcass characteristics in sheep

Parameter	Treatment		P-value
	L-TMR[2]	P-TMR[1]	
Hot carcass wt. (g)	5260.00 ± 918.00	5593.00 ± 341.00	0.587
Fore limb (g)	451.00 ± 56.50	517.70 ± 110.10	0.404
Hind limb (g)	558.30 ± 121.70	658.30 ± 121.70	0.371
Neck (g)	461.33 ± 10.60	524.30 ± 37.10	0.047
Fore leg (g)	108.00 ± 8.19	116.00± 8.72	0.311
Hind leg (g)	92.67± 3.06	109.00 ± 4.58	0.007
Liver (g)	295.00 ± 5.00	322.67 ± 12.22	0.022
Eye muscle area (cm^2)	4.86± 0.16	6.85 ± 0.31	0.001

[2]L-TMR=Road side grass, rice straw wheat bran, wheat bran, mustard oil cake, molasses, common salt; [1]P-TMR=Pelleted form of L-TMR using 6 mm die

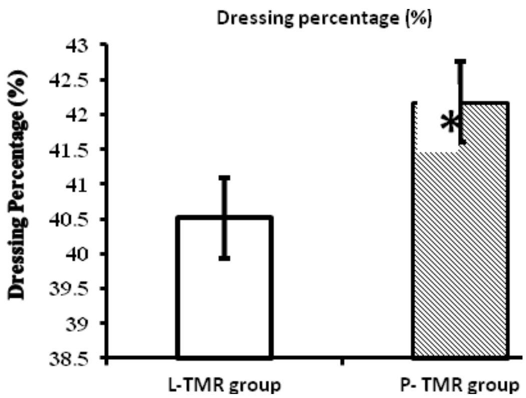

Figure 3. Graphically shown dressing percentage of sheep under two dietary treatments; striped bar indicates P-TMR and solid bar indicates L-TMR group, L-TMR=Road side grass, rice straw wheat bran, wheat bran, mustard oil cake, molasses, common salt, P-TMR= Pelleted form of L-TMR using 6 mm die.

The animals were reared under intensive management system where naturally management system was absent. Conventionally managed steers have been reported to have increased hot carcass weight and rib eye area and decreased marbling score when compared to naturally managed steers (Faulkner *et al*., 2010; Thompson *et al*., 2010). Additionally, conventionally managed steers had increased dressing percent and decreased KPH and yield grade compared to naturally managed steers (Faulkner *et al*., 2010).

Table 5. Effect of P-TMR feeding on body fat deposition in sheep

Parameter	Treatment		P-value
	L-TMR[2]	P-TMR[1]	
Kidney fat (g)	20.00 ± 4.36	21.67± 7.64	0.759
Pelvic fat (g)	56.33 ± 12.50	57.33 ± 11.59	0.924
Heart fat(g)	12.00 ± 2.65	14.67 ± 3.51	0.353

[2]L-TMR= Road side grass, rice straw wheat bran, wheat bran, mustard oil cake, molasses, common salt; [1]P-TMR= Pelleted form of L-TMR using 6 mm die

In this experiment dressing percentage (DP) was higher in P-TMR group than L-TMR group. A lot of evidence shows that DP is directly related with live weight. Kirton *et al*., (1984) reported that lamb DP increases with increasing live weight. Redrawn *et al*., (2000) and Scales *et al*., (2000) also reported that there was a positive effect of growth rate, FCR on dressing percentage of lamb. And there is no significant impact on body fat deposition by feeding pellet. P-TMR group shown numerical higher fat deposition than L-TMR group. Probable reasons behind that is higher energy utilization of P-TMR group. Blaxter, *et al.,* (1964), Noblet *et al.,* (1993) also reported pelleted diet provided more dressing percentage in sheep than loose diet.

***Meat characteristics*:** There was no significant difference ($p < 0.05$) between P-TMR group and L-TMR group on proximate composition, drip loss and cooking loss (Table 6). When we consider sensory parameter normally performed by panel test and found no significant difference in color, flavor and juiciness between two dietary treatment groups. But tenderness and overall acceptability was significantly higher (P=0.024 and P=0.0014, respectively) for P-TMR than L-TMR (Figure 4).

Table 6. Effect of P-TMR feeding on proximate composition, drip loss and cooking loss of mutton

Parameters	Treatment		P-value
	L-TMR[2]	P-TMR[1]	
DM	26.20±0.47	26.51±0.86	0.585
Crude protein	22.09±0.76	21.19 ±0.74	0.218
Crude fiber	0.63±0.12	0.63±0.05	0.967
Ether extract	4.16±0.27	4.16±0.06	0.984
Nitrogen free extract	71.98±0.95	72.88±0.87	0.970
Ash	1.14±0.09	1.14±0.12	0.298
Drip loss	4.25 ±0.11	4.66 ±0.33	0.113
Cooking loss	33.58 ±1.40	36.56 ±2.15	0.115

DM=Dry matter; [2]L-TMR= Road side grass, rice straw wheat bran, wheat bran, mustard oil cake, molasses, common salt; [1]P-TMR= Pelleted form of L-TMR using 6 mm die

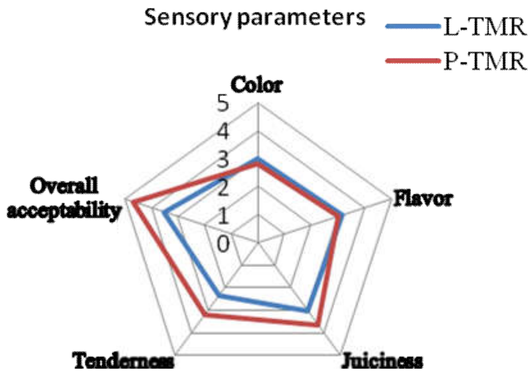

Figure 4. Graphically shown taste parameter of sheep meat under two dietary treatments; blue line indicates L-TMR and red line indicates P-TMR group, L-TMR=Road side grass, rice straw wheat bran, wheat bran, mustard oil cake, molasses, common salt, P-TMR=Pelleted form of L-TMR using6 mm die.

Conclusion

The pelleted diet (P-TMR) provided higher nutrient digestibility, weight gain, feed efficiency and dressing percentage. It is revealed that, under present experimental conditions, the P-TMR could be fed to sheep for better growth and meat production. It can also be concluded that feeding pelleted diet to sheep is one of the best way to optimizing the production performance of native sheep.

Conflict of interest

The authors would like to declare that there is no conflict of interest

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