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# Growth Performance, Nutrient Utilization and Carcass Characteristics of Sheep Fed Hydroponic Barley Fodder

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## ABSTRACT

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A 120 d growth study was conducted in Deccani sheep to evaluate the effect of feeding hydroponically grown barley fodder (HBF) on growth performance, nutrient utilization and carcass characteristics. Eighteen Deccani ram lambs of 3 months age (13.0±0.42 kg) were divided into three groups of six in each in a completely randomized design. Three iso-nitrogenous rations were formulated, in which the control ration (CON) was prepared by using roughage (chopped sorghum stover) and concentrate at 60:40 ratio; the other two experimental rations were formulated by replacing 50 (L-HBF) and 75 (H-HBF), per cent of CP of concentrate mixture with HBF at low and high levels, respectively. The replacement of concentrate mixture at 50% in L-HBF significantly ($P<0.05$) improved the ADG compared to other dietary treatments accompanying a higher ($P<0.05$) DM intake. The cost per kg production was significantly ($P<0.05$) lowered in the L-HBF group compared to CON. Digestibility of DM, CP and NFE were significantly ($P<0.05$) improved with replacement of concentrate mixture with HBF in L-HBF group compared to control. The N balance was significantly ($P<0.05$) higher in the L-HBF lambs which were found to be on a higher plane of nutrition with greater intakes of DCP and TDN. The carcass characteristics did not vary among the three groups. The results indicated that replacement of concentrate mixture with hydroponic barley fodder at 50 per cent level of CP in the ration of growing lambs improved the nutrient utilization, N balance, plane of nutrition and growth performance and reduced the production cost.

**Keywords:** Barley, Digestibility, Growth, Hydroponic fodder, Sheep

## INTRODUCTION

Fodder production is an important aspect of the sustainability of livestock products and productivity in India (Gupta *et al*., 2014). Small ruminants like sheep

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and goats, depend mostly on pastures and grazing lands for their green fodder requirement under extensive system. Now-a-days, the sheep and goat farming has been shifting to semi-intensive and intensive systems due to shrinkage of grazing lands and pastures. With the very limited land allocation (about 5% of the gross cropped area) for fodder cultivation, water scarcity and frequent drought-like conditions in many parts of the world, the production of sufficient fodder to meet the requirement of the huge livestock population is a big challenge for the scientific and farming community throughout the world (Birthal and Jha, 2005). In this situation, hydroponics technology is emerging as an alternative to grow fodder for farm animals (Naik *et al.*, 2013).

Hydroponically grown fodder is the transformation of grains into high quality, very lush, disease-free grass and root combination as animal feed produced in a versatile and intensive hydroponic unit (Gebremedhin, 2015). Production of hydroponics fodder in low cost greenhouses is an effective solution for fodder scarcity and is a very promising technology for sustainable livestock production in developing countries like India (Naik *et al.*, 2015). Sprouting of grains activates the enzyme performance, increased total protein and changes in amino acid profile, increased sugars, crude fiber, certain vitamins and minerals, but decreased starch and total dry matter (Lorenz, 1980). The hydroponics green fodder is produced from forage grains, having high germination rate and grown for a short period in a special chamber that provides the appropriate growing conditions. Fresh forage can be produced from oats, barley, wheat and other grains by using hydroponics (Rodriguez-Muela *et al.*, 2004). Depending to the type of grain, the forage mat reaches 15 to 20 cm height where production rate is about 7 to 9 kg of fresh forage equivalent to 0.9 to 1.1 kg of dry matter (Mukhopad, 1994). Therefore, to resolve nutrient deficiency in livestock, supplementation of inferior quality roughages with hydroponic green fodder is coming up as a practical approach for improving roughages utilization and digestibility. However, limited research has been carried out on feeding value and utilization of hydroponic fodders in augmentation of livestock productivity. In view of this, the present study was aimed to evaluate the effect of feeding hydroponic barley fodder (HBF) on growth performance, nutrient utilization and carcass characteristics in Deccani sheep.

## MATERIALS AND METHODS

The experiment was conducted at the Department of Animal Nutrition and the approved guidelines of the Institute Animal Ethical Committee (IAEC) and the Committee for the Purpose of Control and Supervision of Experiments on Animals (CPCSEA) were followed.

### *Experimental animals and diets*

In a growth trial of 120 d, 18 growing Deccani ram lambs of 3 months age (13.0±0.42 kg) were randomly divided into three groups with 6 animals in each and allotted to three iso-nitrogenous rations. The control ration (CON) was prepared by using roughage (chopped sorghum stover) and concentrate at 60:40 ratio while the other two experimental rations were formulated by replacing 50 (L-HBF) and 75 (H-HBF) per cent of CP of the concentrate mixture with HBF. All the experimental animals were reared under uniform management conditions and allowed to feed individually on respective amounts of feeds namely sorghum stover, concentrate mixture and hydroponic fodder, separately. Animals were weighed at 15 d intervals after a 16 h feed deprivation to calculate the BW gains.

*Chemical analysis*

The proximate composition of the diets were determined as per AOAC (1997) and the NDF and ADF as described by Van Soest *et al.* (1991). Feed and meat samples were analyzed for N using automated micro-Kjeldhal system (Gerhard, Germany). Metabolizable energy was calculated based on NRC (1989) formula i.e., 1 kg TDN=15.13 MJ of ME.

*Hydroponic barley fodder production*

Hydroponic barley fodder has been produced in the machine supplied by United Fodder Solution Company, Hyderabad, India. Barley grains were spread on the specialized plastic trays measuring 592×220×30 mm (L×W×H) and watered at pre-determined intervals with overhead sprayers. Temperature of 18-22°C with relative humidity of 70-80 per cent was maintained inside the growing chamber using an air-circulation system. The barley seeds procured from local market were subjected to a germination test to check for their viability before being used. Then the seeds were cleaned and sterilized by soaking for 30 min in a 20% sodium hypochlorite solution to control the formation of mould. Planting hydroponic trays were cleaned and disinfected by using 0.1% sodium hypochlorite and later on washed by tap water to remove any chemical traces. The seeds were then re-soaked in tap water overnight (about 12 h) before planting. The seeding rate used in this experiment was 3 kg per tray. After 6 d of incubation, fodder biomass as green fodder mats were removed from the tray and hand-shredded 1 h before feeding to the sheep. Samples of green fodder were taken weekly to determine the DM and nutrient contents.

*Metabolism study*

At the end of growth trial, experimental animals were shifted to metabolic cages and allowed to feed on their respective diets at 90% of their required intake. Animals were acclimatized to metabolic cages for 5 d prior to the collection period. During the 7-d collection period, the amounts of feed offered and individual refusals, faeces, and urine were weighed daily on 24 h basis. Collection of feces was made using faecal bags harnessed to the ram lambs. Urine was collected in glass bottles containing 5% sulphuric acid to avoid nitrogen loss. Representative samples of each feed offered, refusals, and faeces were collected over the 7-d period and composited. After the estimation of DM, the samples were ground in a laboratory

Wiley mill through 1-mm screen and preserved in airtight bottles for subsequent analysis. For balance studies, 5% total urine voided daily by each animal was composited and preserved in glass bottles and kept in refrigerator until analyzed for nitrogen content.

*Carcass studies*

At the end of growth trial, three representative animals from each group were slaughtered to study the effect of diet on carcass characteristics (Brandly *et al.*, 1968) and chemical composition of meat. Carcass parameters were determined by adopting the standard procedures described by Gerrand (1964).

*Economics and statistical analysis*

The cost of experimental rations was calculated based on prevailing market price of ingredients and processing cost. The cost per kg LW gain was obtained by dividing the total cost of ration consumed with total weight gain. The results obtained were subjected to analysis through software (SPSS version 17.0; 2005) by applying one-way analysis of variance through generalized linear model and the treatment means were ranked using Duncan's multiple range test with a test of significance at $P<0.05$. All the statistical procedures were done as per Snedecor and Cochran (1994).

## RESULTS AND DISCUSSION

The proximate composition of the sorghum stover was within the reported range (Table 1) but DM was lower than the values reported by Reddy *et al.* (2015). The CF and EE values of concentrate mixture were higher and lower, respectively,

Table 1. Chemical composition† of experimental feeds (% DM basis)

| Parameter | Sorghum stover | Concentrate mixture‡ | Hydroponic barley fodder |
|---|---|---|---|
| Dry matter | 96.0 | 90.0 | 12.0 |
| Organic matter | 89.5 | 91.9 | 95.7 |
| Crude protein | 4.12 | 22.1 | 16.2 |
| Ether extract | 1.10 | 3.20 | 3.42 |
| Crude fibre | 43.5 | 16.2 | 14.5 |
| Nitrogen free extract | 40.8 | 50.4 | 61.6 |
| Total ash | 10.5 | 8.12 | 4.30 |
| NDF | 68.8 | 31.4 | 32.5 |
| ADF | 47.2 | 19.3 | 21.0 |
| Hemicellulose | 21.6 | 12.1 | 11.5 |
| Cellulose | 35.1 | 13.0 | 16.5 |
| Lignin | 10.7 | 4.88 | 2.32 |

†Each value is the average of three observations.
‡Composed of (parts/100 kg): maize 29, groundnut cake 25, cottonseed cake 14, de-oiled rice bran 23, urea 1, molasses 5, 2 mineral mixture, and salt 1.

than the values reported by Verma *et al.* (2015). This might be due to varying the ingredient composition of the concentrate mixture.

*Growth performance*

The ADG was significantly ($P<0.05$) higher in L-HBF ration where 50% of CP content of the concentrate mixture was replaced with hydroponic barley fodder and it was comparable between CON and H-HBF lambs (Table 2). The increase in ADG with L-HBF ration might be due to the observed improvements ($P<0.05$) in nutrient digestibility and plane of nutrition (Table 3). In consistent with our findings, Verma *et al.* (2015) noticed higher ADG in Haryana male calves with dietary replacement of concentrate mixture with HBF at 50% level. Similarly, Rajkumar *et al.* (2018) also observed higher weight gain in calves fed hydroponic maize fodder.

Table 2. Growth performance of ram lambs fed with hydroponic barley fodder based rations

| Parameter | Dietary groups[†] | | | SEM |
|---|---|---|---|---|
| | CON | L-HBF | H-HBF | |
| *BW changes* | | | | |
| Initial BW (kg) | 13.0 | 13.6 | 13.2 | 0.42 |
| Final BW (kg) | 19.2 | 21.0 | 19.1 | 0.51 |
| Net gain (kg) | 6.15[b] | 7.37[a] | 5.97[b] | 0.26 |
| Average daily gain (g) | 51.3[b] | 61.4[a] | 49.7[b] | 2.17 |
| *Feed (DM) intake* | | | | |
| Concentrate mixture (g/d) | 239[a] | 131[b] | 61.7[c] | 18.0 |
| Sorghum stover (g/d) | 362 | 370 | 330 | 9.09 |
| Hydroponic barley fodder (g/d) | 0.00[c] | 155[b] | 213[a] | 22.2 |
| Total DM intake (g/d) | 601 | 657 | 605 | 14.3 |
| (% BW) | 3.76[b] | 3.87[a] | 3.63[c] | 0.03 |
| ($g/kgW^{0.75}$) | 75.2[b] | 78.4[a] | 73.3[b] | 0.63 |
| FCR (kg feed/kg gain) | 11.1 | 10.7 | 12.2 | 0.15 |
| Feed cost/kg gain (Rs) | 141[b] | 128[a] | 146[ab] | 4.11 |

[†]Feeding of a control ration (CON) or experimental rations with 50 (L-HBF) and 75 (H-HBF) per cent of the crude protein of the CON replaced by hydroponic barley fodder.
[abc]Means bearing different superscripts in a row differ significantly ($P<0.05$).

Feeding hydroponic green forage that could activate some enzymes (during sprouting) and change the starch, protein, and lipids into simpler forms, might affect the performance of animals (Mayer and Poljakoff-Mayber, 1975).

The dietary variations influenced the DMI of lambs significantly (Table 3). The total DMI was significantly ($P<0.05$) higher in L-HBF ration when compared to CON and H-HBF rations ($P<0.05$). Similarly, Verma *et al.* (2015) found that DMI was higher in Hariana male calves fed hydroponic barley fodder at 50%

Table 3. Nutrient digestibility, the plane of nutrition and nutritive value of HBF-based rations during the metabolism trial

| Parameter | Dietary groups† | | | SEM |
|---|---|---|---|---|
| | CON | L-HBF | H-HBF | |
| *Digestibility (%)* | | | | |
| Dry matter | 51.4$^{b}$ | 60.9$^{a}$ | 58.4$^{a}$ | 0.90 |
| Organic matter | 59.8$^{b}$ | 64.7$^{a}$ | 62.2$^{ab}$ | 0.70 |
| Crude protein | 66.6$^{b}$ | 79.7$^{a}$ | 71.4$^{a}$ | 1.68 |
| Ether extract | 66.8 | 73.1 | 74.9 | 2.45 |
| Crude fibre | 58.5$^{a}$ | 53.9$^{ab}$ | 48.0$^{b}$ | 2.92 |
| Nitrogen free extract | 55.6$^{b}$ | 65.4$^{a}$ | 69.4$^{a}$ | 2.03 |
| Neutral detergent fibre | 59.7 | 60.2 | 54.3 | 1.47 |
| Acid detergent fibre | 50.4 | 49.5 | 44.2 | 1.28 |
| Hemicellulose | 69.4 | 68.4 | 66.1 | 2.23 |
| Cellulose | 48.3 | 49.7 | 50.1 | 0.80 |
| *Plane of nutrition* | | | | |
| DM intake (g/d) | | | | |
| Sorghum stover | 412$^{b}$ | 448$^{a}$ | 358$^{b}$ | 18.1 |
| Concentrate mixture | 280$^{a}$ | 153$^{b}$ | 70.3$^{c}$ | 26.1 |
| Hydroponic barley fodder | 0.00 | 198$^{b}$ | 247$^{a}$ | 32.3 |
| Total (g/d) | 692$^{b}$ | 798$^{a}$ | 675$^{b}$ | 18.1 |
| (g/kg$W^{0.75}$) | 75.05$^{b}$ | 80.36$^{a}$ | 73.29$^{b}$ | 1.92 |
| *Nutrient intake* | | | | |
| DCP intake (g/d) | 52.7$^{b}$ | 66.4$^{a}$ | 50.2$^{b}$ | 2.19 |
| (g/kg$W^{0.75}$) | 5.71$^{b}$ | 6.69$^{a}$ | 5.46$^{b}$ | 0.17 |
| ME intake (MJ/d) | 5.71$^{b}$ | 7.18$^{a}$ | 6.07$^{b}$ | 0.20 |
| (MJ/kg$W^{0.75}$) | 0.62$^{c}$ | 0.72$^{a}$ | 0.66$^{b}$ | 0.01 |
| *Nutritive value of the composite ration* | | | | |
| DCP (%) | 7.61$^{b}$ | 8.32$^{a}$ | 7.45$^{b}$ | 0.12 |
| TDN (%) | 54.6$^{b}$ | 59.5$^{a}$ | 59.5$^{a}$ | 0.70 |
| ME (MJ/kg DM) | 8.25$^{b}$ | 9.00$^{a}$ | 9.01$^{a}$ | 0.11 |

†Feeding of a control ration (CON) or experimental rations with 50 (L-HBF) and 75 (H-HBF) per cent of the crude protein of the CON replaced by hydroponic barley fodder.
abcMeans bearing different superscripts in a row differ significantly ($P<0.05$).

replacement of concentrate mixture. The low DM content of HBF would have a limitation effect on intake of fodder when animals fed H-HBF ration (Fazaeli *et al.*, 2012). In addition, the very high water content in the fodder made it bulky, which may have limited DM intake of lambs fed the green fodder (Hillier and Perry, 1969; Fazaeli *et al*., 2011). Similar to our results, Rajkumar *et al*. (2018) observed higher DMI in calves fed hydroponic maize fodder to replace concentrate mixture. The FCR was not significantly different among the experimental rations. Similar to our results, Naik *et al.* (2014 and 2017) also observed no change in FCR in lactating cows fed with hydroponic maize fodder as a replacement of maize in the concentrate mixture.

The cost per kg gain was significantly ($P<0.05$) lower in the lambs fed L-HBF ration when compared to CON, whereas CON and H-HBF were comparable. The decreased cost of feed per kg gain in L-HBF fed lambs might be due to the replacement of concentrate mixture with HBF, which has higher nutrient digestibility; especially, a significantly ($P<0.05$) higher CP digestibility. In agreement with present study, Verma *et al.* (2015) and Rajkumar *et al.* (2018) reported that the cost per kg gain was lowest in hydroponics barley fodder fed group of calves compared to those fed the control diets. Al-Saadi (2016) also reported economic profit in lambs fed hydroponic barley fodder. Similar to the present findings, Dhawale *et al.* (2018) reported that replacement of the concentrate mixture at 25 and 50 per cent levels with hydroponic maize fodder resulted in lower cost of production per kg gain in goats.

*Nutrient digestibility*

Digestibility of DM, CP and NFE was higher ($P<0.05$) in L-HBF and H-HBF when compared to the CON ration (Table 3). The present results are in agreement with Verma *et al.* (2015) who observed higher ($P<0.05$) digestibility of DM and CP in calves fed hydroponic barley fodder based diets. Higher CP digestibility might be a reflection of its sprouting activity, which may increase the enzymatic activity in the seeds and lead to many changes as seed proteins are converted to essential amino acids (Chavan and Kadam, 1989). However, the digestibility of CF was reduced ($P<0.05$) with the level of inclusion of HBF, but the data was significant only at 75% replacement level. Similarly, Dhawale *et al.* (2018) observed that 50% replacement of the concentrate mixture with hydroponic maize fodder resulted in lower digestibility of CF in goats. No significant difference ($P>0.05$) was observed among the digestibility of fiber fractions of experimental rations. The tenderness of the fodder due to its lower age might have improved the nutrient digestibility in cattle fed hydroponic fodder based diets (Naik *et al.,* 2017).

*Plane of nutrition*

The highest ($P<0.05$) DMI was observed in lambs fed L-HBF compared to CON and H-HBF whereas CON and H-HBF were similar. Similarly, Verma *et al.* (2015) observed higher DMI in calves fed with 50% level of HBF based diets compared to control. In contrast to our study, Naik *et al.* (2014) reported higher DMI in control diet than those fed hydroponic maize fodder diet which might be due to relatively higher fibre contents (NDF and ADF) in green fodder diet. Low DMI of lambs fed H-HBF than L-HBF ration might be due to the higher moisture level by the HBF replacing 75% of CP of concentrate mixture leading to 30% of the total ration.

The intake of DCP, TDN and ME was significantly ($P<0.05$) higher in L-HBF compared to CON and H-HBF while the latter two rations were comparable. The significant difference in DCP intake of lambs fed L-HBF was due to the higher ($P<0.05$) DMI and CP digestibility than the lambs fed CON and H-HBF rations. Significantly lower ($P<0.05$) TDN and ME values were observed in rations without inclusion of HBF and it was comparable between CON and H-HBF rations. The DCP intakes were slightly lower in CON and H-HBF rations and TDN intake was lower in CON than requirements when compared to ICAR (2013) feeding standards. All the ram lambs fed experimental rations met the DMI requirements as per ICAR (2013) nutrient specifications.

*Nitrogen balance*

All the lambs fed the three experimental rations were on positive nitrogen balance and significantly ($P<0.05$) higher nitrogen balance was found in ram lambs fed L-HBF ration, whereas CON and H-HBF were comparable (Table 4). The higher nitrogen intake was due to the higher DMI, while the lambs fed H-HBF excreted lowered ($P<0.05$) nitrogen in faeces and lambs fed CON had significant ($P<0.05$) higher amounts of urinary nitrogen compared to L-HBF. Similar results were reported by Fayed (2011) in sheep fed rice straw based diets supplemented with sprouted barley fodder.

Table 4. Nitrogen balance in experimental Deccani ram lambs fed with hydroponic barley fodder based rations

| Parameter | Dietary groups[†] | | | SEM |
|---|---|---|---|---|
| | CON | L-HBF | H-HBF | |
| N intake (g/d) | $12.6^{b}$ | $13.5^{a}$ | $11.3^{c}$ | 0.30 |
| Fecal N (g/d) | $3.32^{a}$ | $3.46^{a}$ | $2.56^{b}$ | 0.14 |
| Urinary N (g/d) | $4.65^{a}$ | $3.81^{b}$ | $4.05^{ab}$ | 0.15 |
| N balance (g/d) | $4.65^{b}$ | $6.22^{a}$ | $4.64^{b}$ | 0.29 |
| (% N-intake) | $36.7^{b}$ | $46.1^{a}$ | $41.2^{ab}$ | 1.75 |
| (% N-absorbed) | $49.8^{b}$ | $62.0^{a}$ | $53.2^{ab}$ | 2.05 |

[†]Feeding of a control ration (CON) or experimental rations with 50 (L-HBF) and 75 (H-HBF) per cent of the crude protein of the CON replaced by hydroponic barley fodder.
[abc]Means bearing different superscripts in a row differ significantly ($P<0.05$).

*Carcass characteristics and meat quality*

The wholesale cuts, edible and non-edible percentages and their ratio did not vary significantly among the lambs fed with different levels of hydroponic barley fodder (Table 5). Replacement of concentrate mixture at 50 and 75 per cent levels with HBF did not affect the yield of visceral organs as percentage of pre-slaughter BW. No significant variations could be seen in bone, meat and fat yield percentages and their

Table 5. Carcass characteristics of Deccani ram lambs fed hydroponic barley fodder based rations

| Parameter | Dietary groups† | | | SEM |
|---|---|---|---|---|
| | CON | L-HBF | H-HBF | |
| Pre-slaughter BW (kg) | 19.6[ab] | 21.6[a] | 19.4[b] | 0.69 |
| Empty BW (kg) | 15.7 | 17.0 | 15.6 | 0.48 |
| Carcass weight (kg) | 8.31 | 9.10 | 8.26 | 0.25 |
| *Dressing percentage* | | | | |
| % Pre-slaughter BW | 42.5 | 42.5 | 42.5 | 0.35 |
| % Empty BW | 52.9 | 53.7 | 53.0 | 0.53 |
| *Wholesale cuts (% carcass weight)* | | | | |
| Fore shank-brisket | 17.5 | 18.3 | 15.9 | 0.34 |
| Neck-shoulder | 25.9 | 24.0 | 24.9 | 0.66 |
| Rack | 10.5 | 11.0 | 11.2 | 0.43 |
| Loin | 10.6 | 10.7 | 10.6 | 0.38 |
| Leg | 35.8 | 35.9 | 35.2 | 0.59 |
| *Visceral organs (% pre-slaughter BW)* | | | | |
| Pluck | 3.47 | 3.59 | 3.55 | 0.04 |
| Liver | 1.55 | 1.55 | 1.54 | 0.02 |
| Kidney | 0.26 | 0.28 | 0.29 | 0.00 |
| Heart | 0.51 | 0.56 | 0.59 | 0.04 |
| Testes | 0.51 | 0.53 | 0.52 | 0.01 |
| GI tract (empty) | 7.21 | 7.44 | 7.06 | 0.11 |
| Spleen | 0.34 | 0.32 | 0.28 | 0.01 |
| Lungs with trachea | 1.53 | 1.57 | 1.58 | 0.01 |
| Lean fat | 0.66 | 0.69 | 0.68 | 0.02 |
| *Composition of carcass (% of carcass)* | | | | |
| Meat | 60.4 | 58.9 | 59.5 | 1.30 |
| Bone | 35.1 | 34.7 | 36.0 | 0.47 |
| Fat | 4.54 | 6.42 | 4.61 | 0.39 |
| Bone/Meat ratio | 1.80 | 1.75 | 1.79 | 0.12 |

†Feeding of a control ration (CON) or experimental rations with 50 (L-HBF) and 75 (H-HBF) per cent of the crude protein of the CON replaced by hydroponic barley fodder;
[abc]Means bearing different superscripts in a row differ significantly ($P < 0.05$).

ratios in various wholesale cuts among different groups. The moisture, protein, fat and ash contents (Table 6) were not significantly affected by replacement of concentrate mixture with hydroponic barley fodder with different levels in growing lambs.

Table 6. Chemical composition of *Longissimus dorsi* muscle on fresh basis of Deccani ram lambs fed hydroponic barley fodder based rations

| Parameter | Dietary groups† | | | SEM |
|---|---|---|---|---|
| | CON | L-HBF | H-HBF | |
| Moisture (%) | 74.8 | 75.0 | 75.0 | 0.07 |
| Protein (%) | 21.2 | 21.2 | 21.1 | 0.03 |
| Fat (%) | 2.9 | 2.74 | 2.71 | 0.07 |
| Ash (%) | 1.08 | 1.09 | 1.14 | 0.14 |

†Feeding of a control ration (CON) or experimental rations with 50 (L-HBF) and 75 (H-HBF) per cent of the crude protein of the CON replaced by hydroponic barley fodder.

## CONCLUSIONS

Replacement of concentrate mixture with hydroponics barley fodder at 50 per cent level in the ration of growing lambs improved the nutrient utilization, N balance, plane of nutrition, growth performance and cost of production. Hence, it can be concluded that, hydroponics barley fodder can be incorporated in the rations of growing ram lambs to replace 50 per cent level of CP of the concentrate mixture.

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