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Effect of different dietary levels of concentrate and roughage for optimum growth performance in Thalli lambs

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This study was planned to evaluate the effects of different dietary levels of concentrate and roughage supplementation on feed intake, growth performance and nutrient digestibility in Thalli lambs. Twenty-one male lambs, weighing an average of 16.15 ± 2.33 kg, were allotted to three treatments in such a way that each treatment had seven lambs. Experimental lambs were arranged in a randomized complete block design and blocking was done on the basis of initial body weight. Lambs were confined in individual cages and stall-fed experimental diets twice daily. One week was given as adaptation period to experimental diets. The duration of trial was 12 weeks. Experimental treatments were: T1 = 100% hay; T2 = 80% hay + 20% concentrate and T3 = 60% hay + 40% concentrate. Growth performance parameters were analyzed by ANOVA using GLM procedure of Minitab and mean values were compared using Tukey's test. Results indicated that body weight gain and daily dry matter intake increased linearly (P<0.05) with an increase in concentrate percentage from 0 to 40% in the rations. Similarly, feed conversion ratio was significant among the treatments (P<0.05). Lambs fed hay supplemented with concentrate @ 20% had better feed conversion ratio as compared to other treatments. Experimental treatments had no effect (P>0.05) on feed intake, water intake and body condition score. The digestibility of dry matter and acid detergent fiber were increased as the level of concentrate was increased in the diet (P<0.05) whereas crude protein, crude fiber and neutral detergent fiber digestibility were not affected by the treatments (P>0.05). Based on the findings of the current study it is concluded that increasing concentrate ratio @ 40% in the diet of lambs containing Lucerne hay as forage source increased body weight gain, daily dry matter intake, dry matter and acid detergent fiber digestibility. However, concentrate ratio @ 20% in the diet of lambs showed better feed conversion ratio in Thalli lambs.

Keywords: Forage, concentrate, performance, digestibility

INTRODUCTION

In Pakistan, sheep production is a source of living for many small farmers, particularly in arid areas where optimal animal farming is not feasible. However, the productivity of sheep production is low in these areas (Nasrullah, 2012). Whereas, the productivity and profitability is mainly influenced by the feeding regimen. In Pakistan, roughages are mainly offered to rear the lambs and it has been reported different factors including salinity is decreasing forage production (Malik *et al.* 2021) that directly influencing growth of the lambs. Moreover, feeding of only roughage based diet could not meet the nutrient requirement of the lambs. It is evidenced that the provision of imbalanced diet compromises the growth performance of lambs (Bernes *et al*., 2012). Ultimately, it negatively impacts the profitability of the farmers. Therefore, it is an imperative to offer the roughage based diets with the inclusion of appropriate level of the concentrate for optimized growth performance and profitability.

In lamb production, feeding dense ration such as concentrate along with forage are practiced for maximum growth rate and productivity (Jabbar and Anjum, 2008). Concentrate increases growth performance of lambs by providing energy for growth (Jacques *et al*., 2011). It has been reported that higher quantity of concentrate improves feed efficiency and growth performance in lambs (Murphy *et al*., 1994). Fattening

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of lambs on concentrate-based diets results in faster, more efficient growth and heavier carcasses (Murphy *et al*., 1994). However, the higher level of concentrate in the diet negatively influence the feed intake and conversion ratio of feed (Karim *et al*., 2007) in lambs. Because, higher level of fermentable carbohydrate promote the possibility of rumen acidosis (Muhammad *et al.* 2016; Aziz ur Rahman *et al.* 2017; Aziz ur Rahman *et al*. 2019; Chen *et al.* 2020) by decreasing the pH of rumen and thus affect rumen health and animal performance. This necessities the provision of forage source along with the concentrate.

Use of agriculture by products are common in livestock production, while forages and agricultural by products like wheat straw, rice straw, corn stover are used to avoid ruminal acidosis by increasing the pH of rumen (Buchanan-Smith and Beauchemin 1989; Yeniçeri *et al.* 2021). It was also reported that rumination, mastication activity and salivation that has characteristics of buffering rumen pH are enhanced by forages (Alvarez-Rodriguez *et al.,* 2010). However, forage is a cheap source in developing countries for rearing of lambs (Gatenby, 1986). Rearing of lambs on forage did not fulfill the nutrient requirement of lambs to improve their performance (Bernes *et al*., 2012). It was also reported that diet based only on forage may produce desirable body weight, however, such diets resulted in higher feed intake and poor feed efficiency (Casasús *et al*., 2012). Whereas, the feed intake and growth performance of lambs is improved by adding concentrate in forage based diet (Alhidary *et al*., 2016).

Therefore, combination of adequate amount of concentrate along with the roughage is necessary for optimum growth of lambs. Thus, the objective of the study was to evaluate the effect of different dietary levels of the concentrate and roughage on nutrient intake, digestibility, and growth performance of Thalli lambs.

MATERIALS AND METHODS

This research was conducted at Animal Nutrition Research Station, University of Agriculture, Faisalabad, Pakistan (31º25'49.03"N 73º4'1.916"E) with average temperature 34.5°C having relative humidity approximately 39%. The duration of the trial was twelve weeks.

Different housing systems are being used for livestock production (Khalid *et al.* 2021) and in the current study open housing was chosen for experiment. The experiment was approved by the Institutional Animal Care and Use Committee of the Institute of Animal and Dairy Sciences, Faculty of Animal Husbandry, University of Agriculture, Faisalabad (Permit Number: DGS/35157-60, dated 15-12-2019).

***Parameters studied*:** This study has evaluated the effect of different dietary levels of concentrate and roughage on the dry matter intake, live weight gain, feed conversion efficiency, body condition score, and nutrient digestibility in Thalli lambs.

***Experimental animals, design, and diets*:** Twenty-one weaned male Thalli lambs with an initial live weight of 16.15 ± 2.33 kg, kg were selected for the experiment. All lambs were blocked into three groups (each group was almost homogenous in weight) equally. Three dietary treatments were assigned randomly for the trial. All experimental diets were formulated to meet the maintenance and the growth requirement according to the National Research Council (NRC, 2007).

Minimum requirements of lambs were met while formulating experimental diets as per standard of NRC (2007). Alfalfa is

Table 1. Ingredients and chemical composition of experimental diets.

Ingredients %	**Experimental diets**		
	T1, Hay: Conc. (100:0)	**T2, Hay: Conc. (80:20)**	**T3, Hay: Conc. (60:40)**
Alfalfa hay	100.00	80.00	60.00
Concentrate	-	20.00	40.00
Ingredients composition of concentrate			
Corn		45.00	45.00
Maize oil cake		10.00	10.00
Corn gluten 30%		8.50	8.50
Canola meal		10.00	10.00
Wheat bran		14.00	14.00
Molasses		10.00	10.00
NaCl		1.00	1.00
Limestone		1.00	1.00
Urea		0.50	0.50
Chemical composition of experimental diets			
CP (%)	15.16	15.67	16.18
ME (MCl/kg)	2.05	2.22	2.40

T1 = 100% hay; T2=20% concentrate+80% hay and T3=40% concentrate +60% hay; NaCl=Sodium chloride; CP=Crude protein; ME=Metabolizable energy

one of best roughages with great potential to be used in livestock production (Karadavut *et al.* 2021). Dietary treatments were consisted of different levels of roughage (alfalfa hay) and concentrate ratios as T1= (R100:0 C), T2= (R 80:20 C) and T3= (R 60:40 C) respectively. Chemical composition of dietary treatments is presented in Table 1.

***Feeding Management*:** Chopped alfalfa hay along with concentrate was offered to all animals according to experimental treatments. At the onset of the trial, the experimental feed was evaluated to determine the nutrient composition. Along with hay, the concentrate was offered according to treatment groups. All diets were offered as total mixed ration twice daily at 7:30 am, 7:30 pm. Feeding was done according to the metabolic body weight @ 85 g per kg of metabolic body weight. Offered and ort feed was recorded daily. The amount of offered feed was adjusted weekly according to the change in the metabolic body weight. Water was provided as a free choice. Feed intake and refusals were determined on daily basis (Qiu *et al.,* 2020).

Table 1. Chemical composition of all experimental diets (DM basis)

#	Alfalfa Hay	Concentrate
1DM (%)	86.40	90.20
2CP (%)	15.16	17.72
3CF (%)	35.90	17.90
Ash (%)	9.60	4.90
4EE (%)	2.80	3.10
5NDF (%)	51.00	43.50
6ADF (%)	45.00	10.50
7ME (MCal/kg)	2.05	2.93

[1]DM-dry matter; [2]CP-crude protein; [3]CF-crude fibre; [4]EE-ether extract; [5]NDF-neutral detergent fibre; [6]ADF-acid; [7]ME-metabolisable energy

***Animal Management*:** Before the initiation of the experiment, all lambs were identified individually by their tag number. All the lambs were allowed two weeks adjustment period for their adaptation to feeds and the housing conditions. All the experimental lambs were housed in individual metallic cages having dimensions 1 x 1.25 meter. Water was provided as a free choice. The trial duration was 12 weeks. For ectoparasites, all animals were dewormed during the adaptation period by the medication Ivomec 1% (i.e. Ivermectin) @ 200 mg/kg of body weight injected subcutaneously. Deworming of all the lambs was also done (i.e. endo-parasites) while using the medication Niliverm (active ingredient- Levamisole) @ 7.5 mg/kg per orally.

***Growth Performance*:** Weighing of all lambs was done weekly by keeping them off feed. An electronic scale (XK3188-T20 Weighing Indicator, Master scales, Faisalabad, Pakistan) was used for weighing and recorded manually for the two consecutive days. Intake of feed was determined by recording the offered and ort feed. It was calculated by taking the difference of offered feed and refused feed. Live weight gain was also calculated by subtracting the final weight from the initial weight, then it was divided by the number of feeding days to obtain the growth rate or average daily gain (Zhang *et al.* 2015). Calculation of the Feed conversion ratio (FCR) was done as the ratio of the DMI to average daily gain (kg of DMI /kg of body weight gain (Saleem and Singer, 2018). Efficiency of feed was calculated as dividing the average daily gain by the DMI (Estrada-Angulo *et al.,* 2004).

***Sampling Procedures*:** For the determination of dry matter all samples were evaluated weekly. However, offered and refusal feed samples were collected daily. All the samples of offered or ort feed from each animal were combined to make a composite sample for chemical analysis. All composite samples were maintained at −20 °C in the airtight bags of plastic and labelled properly. For further chemical analysis, a representative sample was taken from the composite sample.

***Digestibility Trial*:** The digestibility trial was conducted in the last week of the experiment after the growth trial. The fecal collection period was seven days along with the three days adjustment period. The fecal collection was done according to the total collection method as suggested in a recent study by Li *et al.* (2014). Feces were collected from three lambs selected randomly from each treatment group (Saleem and Singer, 2018). Fecal collection sheets were harnessed to the selected lambs. After three days of the adaptation, the fecal collection was done for seven consecutive days. Refusals of feed and feces were collected and weighed after every 24 hours and mixed thoroughly. After weighing, 20% of the samples were kept in the airtight plastic bags and stored in the refrigerator until the completion of the digestibility trial. Subsamples representing the 10% of the daily output of feces were maintained at −20°C until the completion of the collection period. These represented samples were used for dry matter and further chemical analysis determination. The apparent percentage of digestibility of DM, CP, Ash, NDF, and ADF was determined using the following formula (McDonald *et al*., 2002).

$$\text{Digestibility \%age} = \frac{\text{Intake} - \text{Outgo}}{\text{Outgo}} \times 100$$

***Chemical Analysis*:** Feed and fecal samples were analyzed for DM, CP, EE, and total ash according to AOAC (1990) as described in recent study. CF, NDF and ADF were determined according to procedures described by (Van Soest *et al*. 1991). Samples of the feed and orts were dried at 60°C in the air draft type of oven and then ground through 1.15 mm sieve in Willey mill for further analysis as described in recent study (Onunkwo *et al.* 2021; Yagmur *et al.* 2021). DM content was measured at 105°C (AOAC, 1990). Determination of ash was done by combustion of the sample in the muffle furnace at 550 °C for four hours. Organic matter was determined by the difference between dry matter and ash. The CF was calculated via filter bag technique. CP was analysed by Kjeldahl method, and EE was calculated according to the Soxhlet procedure (AOAC 1990). For DM

934.01 method number, for organic OM 930.05 and CP method number 981.10. EE was analyzed by Soxhlet extraction with petroleum ether, by the 920.39 method number. Total digestible nutrient intake was determined according to (Sanson and Kercher, 1996).

***Statistical Analysis*:** Growth performance parameters were analysed by ANOVA using GLM procedure of Minitab and mean values were compared using Tukey's test.

RESULTS

Effect of diets on daily dry matter intake: The effect of all dietary treatments comprising of different proportions of roughage and concentrate designated as (T1, T2, T3) on daily dry matter intake of the Thalli lambs is shown in Fig. 1. The results showed that all dietary treatments (T1, T2, T3) had affected daily dry matter intake (DMI) of lambs ($P<0.05$). However, the lambs fed T3=40% concentrate +60% hay exhibited the highest daily DMI following the T2= 80% hay + 20% concentrate. Whereas, lowest daily DMI was observed in Lambs fed T1=100% hay. Moreover, similar daily DMI was observed between lambs fed T3=40% concentrate +60% hay and T2=20% concentrate+80% hay ($P<0.05$). Whereas, lambs fed T1=100% hay and T2=80% hay + 20% concentrate also showed the similar DMI ($P<0.05$). Furthermore, it is elaborated that the lambs fed T3=40% concentrate +60% hay and T1=100% hay have shown the considerable variation in daily DMI ($P<0.05$). The mean values for T1=100% hay; T2=20% concentrate+80% hay and T3=40% concentrate +60% hay were 639.8, 667.2 and 779.3 g/d.

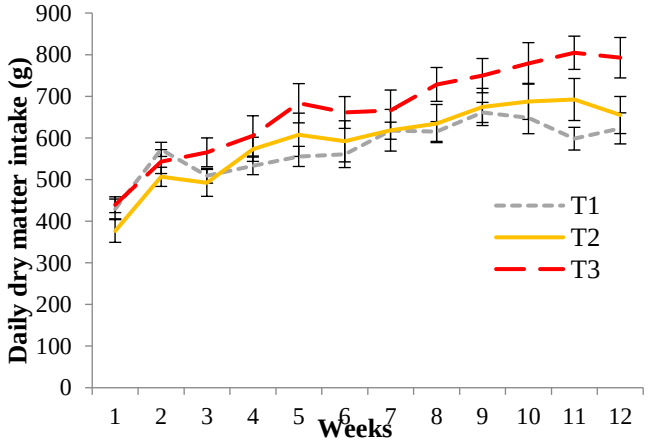

Figure 1. Effect of various concentrate forage ration on daily DMI in Thalli lambs. T1 = 100% hay; T2=20% concentrate+80% hay and T3=40% concentrate +60% hay.

***Effect of experimental rations on total body weight gain*:** Results of experimental diets effect on the total body weight gain in lambs are given in Fig. 2. All the dietary treatments (T1, T2, T3) have affected on total body weight gain in lambs ($P<0.05$). Total body weight gain was increased linearly with an increase in concentrate level in the ration ($P<0.05$). The mean values of total weight gain by lambs fed T1=100% hay; T2=80% hay + 20% concentrate and T3=40% concentrate +60% hay were 2.9, 4.4 and 5.0 kg respectively. However, similar total body weight gain was observed between T3=40% concentrate +60% hay and T2=80% hay + 20% concentrate (P>0.05). Moreover, it is elaborated that the lambs fed T3=40% concentrate +60% hay and T1=100% hay showed a considerable effect on the live body weight gain ($P<0.05$). Highest total body weight gain was found in lambs fed T3=60% hay + 40% concentrate as compared with the 80% hay + 20% concentrate ($P<0.05$). Whereas, the lambs fed only T1=100% hay attained the lowest total body weight gain ($P<0.05$). The average daily weight gain by lambs in T1=100% hay; T2=20% concentrate+80% hay and T3=40% concentrate +60% hay were 34.5, 52.3 and 59.5g/d respectively.

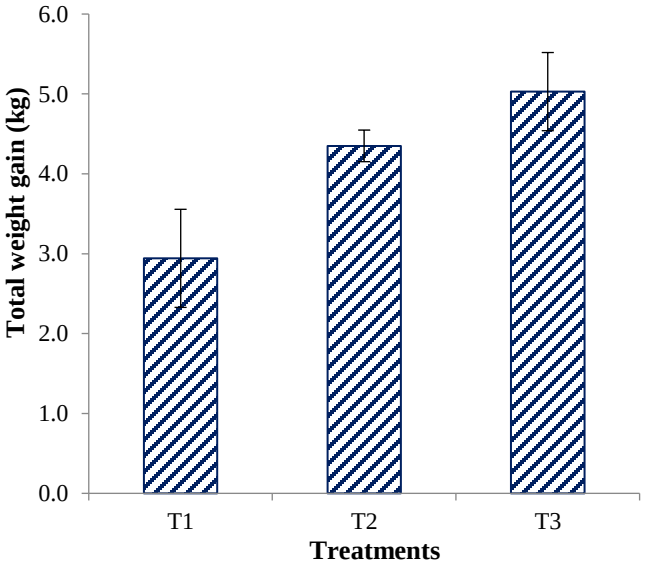

Figure 2. Effect of various concentrate forage ration on total body weight gain in Thalli lambs. T1 = 100% hay; T2=20% concentrate+80% hay and T3=40% concentrate +60% hay

***Effect of treatments on feed conversion ratio (FCR)*:** The effect of all dietary treatments (T1, T2, T3) on feed conversion efficiency is presented in Fig. 4. The results showed that all the treatments (T1, T2, and T3) had affected the FCR in lambs ($P<0.05$). Improved FCR was observed in the lambs fed T3=60% hay + 40% concentrate and T2=80% hay + 20% concentrate ratios ($P<0.05$). However, lambs fed T1=100% hay exhibited the lowest FCR ($P<0.05$). Whereas, the similar FCR was observed in lambs fed T2=20% concentrate+80% hay and T3=40% concentrate +60% hay groups (P>0.05). The mean values of FCR for T1=100% hay; T2=20% concentrate+80% hay and T3=40% concentrate

+60% hay were 24.31, 13.04 and 13.17 respectively. Lower mean value indicates better FCR.

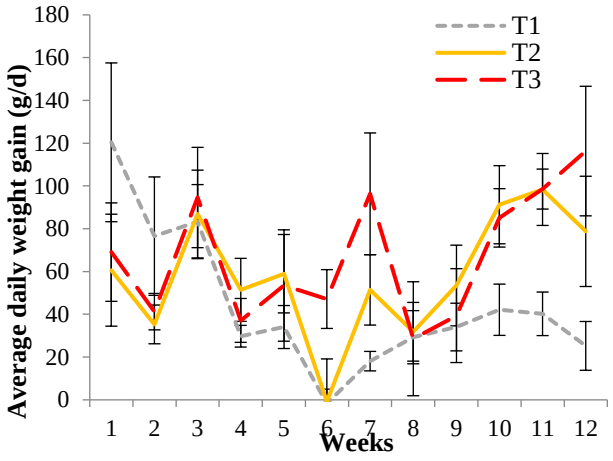

Figure 3. Effect of various concentrate forage ration on total body weight gain and daily weight gain in Thalli lambs. T1 = 100% hay; T2=20% concentrate+80% hay and T3=40% concentrate +60% hay

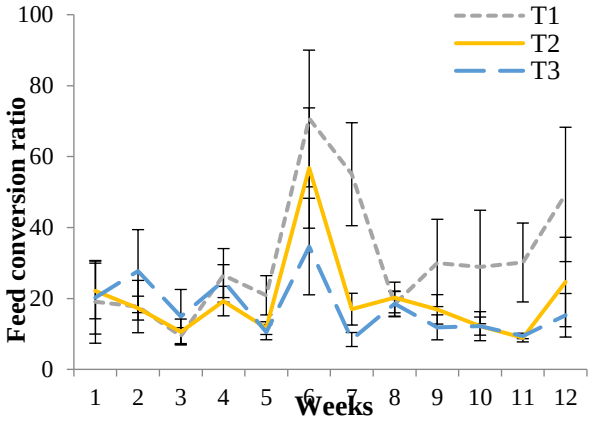

Figure 4. Effect of **various concentrate to forage ration on feed conversion ratio in Thalli lambs.** T1 = 100% hay; T2=20% concentrate+80% hay and T3=40% concentrate +60% hay

***Effect of treatments on body condition score*:** The effect of the treatments (T1, T2 and T3) is shown in Fig. 5. The results showed that the treatments had not effected on body condition score in lambs (P>0.05). The average body condition scores of lambs in T1 = 100% hay; T2= 20% concentrate+80% hay concentrate and T3=40% concentrate +60% hay were 2.27, 2.29 and 2.67 respectively.

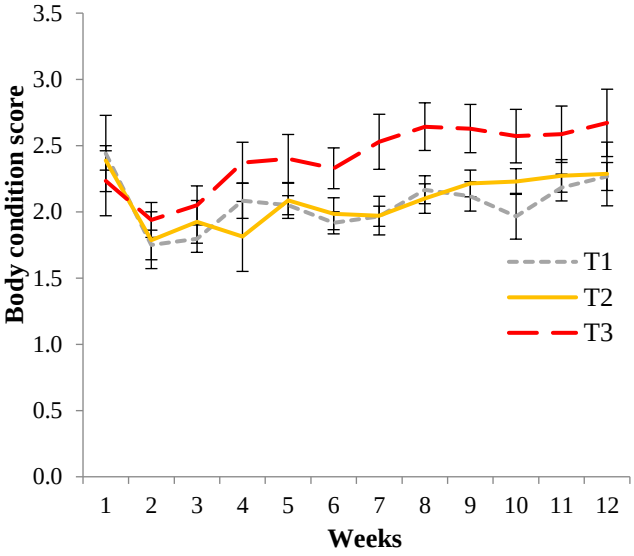

Figure 5. Effect of various concentrate forage ration on body condition scoring in Thalli lambs. T1 = 100% hay; T2=20% concentrate+80% hay and T3=40% concentrate +60% hay

***Effect of experimental diets on nutrient digestibility*:** All results for the digestibility of nutrients are presented in Table 2. Results showed a considerable effect of the treatments (T1, T2, T3) on DM digestibility in lambs (P<0.05). Highest DM digestibility was observed in lambs fed T3=60% hay + 40% concentrate followed by the T1=100% (P<0.05). Lowest DM digestibility was found in lambs fed T2=80% hay + 20% concentrate (T2) (P<0.05). However, no difference was observed in nutrient digestibility between T1=100% hay and T2=20% concentrate+80% hay (P>0.05). The average values for DM digestibility for the three treatment groups T1=100% hay; T2=20%

Table 2. Effect of different dietary concentrate fiber ration on nutrient digestibility in Thalli lambs (Mean & SEM)

Nutrients	Treatments			SEM	*P*-value
	T1	T2	T3		
Dry matter digestibility (%)	67.4[b]	61.5[b]	83.2[a]	2.93	0.035
Protein digestibility (%)	68.8	65.0	76.3	2.43	0.095
Crude Fiber digestibility (%)	73.0	62.7	72.9	3.79	0.359
ADF digestibility (%)	74.0[a]	63.1[b]	78.7[a]	1.29	0.007
NDF digestibility (%)	71.5	61.6	76.0	5.01	0.373

T1 = 100% hay; T2=20% concentrate+80% hay and T3=40% concentrate +60% hay; Dissimilar alphabets mean differences were significant at P<0.05

concentrate+80% hay and T3=40% concentrate +60% hay were 67.4, 61.5 and 83.2% respectively.

All dietary treatments had affected on ADF digestibility in lambs ($P<0.05$). Highest ADF digestibility was found in lambs fed T3=60% hay + 40% concentrate followed by the T1=100% hay ($P<0.05$). Lowest ADF digestibility was observed on lambs fed T2=80% hay + 20% concentrate ($P<0.05$). The mean ADF values for the treatments T1=100% hay; T2=20% concentrate+80% hay and T3=40% concentrate +60% hay were 74.0, 63.1 and 78.7 % respectively.

However, no effect of all treatments (T1, T2, and T3) was observed on CP digestibility in lambs ($P>0.05$). The mean values for CP digestibility were 68.8, 65.0 and 76.3 % for lambs fed Lucerne hay T1=100 % Hay, T2=80% hay + 20% concentrate and T3=60% hay + 40% concentrate respectively.

Moreover, results showed no effect of all treatments (on crude fiber digestibility in lambs ($P>0.05$). The average values for CF digestibility were 73.0, 62.7 and 72.9 % for lambs fed 100% Lucerne hay (T1), 80% hay + 20% concentrate (T2) and 60% hay + 40% concentrate (T3) respectively. Furthermore, the digestibility of NDF was not affected among the all treatments ($P>0.05$). The average values for NDF digestibility for the treatment groups T1=100% hay; T2= 80% hay + 20% concentrate and T3=40% concentrate +60% hay were 71.5, 61.6 and 76.0 respectively.

DISCUSSION

The results of our study has indicated that the supplementation of increased amount of concentrate resulted in the higher dry matter intake and improved growth performance in lambs. Findings of the current study were similar to the results of Kabir *et al.* (2002) who reported an increased dry matter intake of sheep while receiving the concentrate supplementation. Moreover, Jabbar and Anjum (2008) also reported a higher dry matter intake in lambs following the increased level of concentrate. The possible reason of higher feed consumption while receiving the higher proportion of the concentrate could be explained by the theory that stated that addition of concentrate level in the ration decrease the intake of roughages. It might be due to the higher content of dietary fiber in the roughage based diets. Whereas, the increased intake of dry matter following the higher proportion of the concentrate (i.e. T2, T3) in the roughage based diet reflects the higher proportion of the non-structural carbohydrates in addition to the higher content of the digestible energy.

However, contrasting results were also reported by Papi *et al.* (2011) who found that DMI is decreased while receiving the higher proportion of the concentrate along with the forage. It is because of the acidosis which is linked with the amount of concentrate. It has been reported that the addition of the very high level of the concentrate promote ruminal acidosis. Ultimately, it reduces the dry intake of the lambs. The results of our study have depicted that the live body weight gain is increased following the increased level of the concentrate supplementation along with the roughage in Thalli lambs under intensive management system. These results are linked with the findings of the (Jabbar and Anjum, 2008; Nasrullah, 2012).

Moreover, Salim *et al.* (2002) also observed the improved daily weight gain in sheep while receiving the concentrate supplementation in the forage based system. It might be due to the increased concentration of the energy because of the supplementation of the concentrate in the roughage based diets. The higher weight gain in lambs in current study could be explained by the theory of Jacques *et al.* (2011) who observed that high starch consumption resulted in higher production of propionate in the rumen of lambs, which eventually increases production of insulin and enhance synthesis of fat. Ultimately, it increases the live weight gain of the lambs.

However, the results of our study were also contradicted with the findings of Papi *et al.* (2011) who described the reduced live body weight gain while receiving the increased concentrate portion in the ration. Negative results of Papi *et al.* (2011) could be explained by the higher inclusion of concentrate levels in the ration which resulted in rumen acidosis and stasis which lower their feed intake and ultimately resulted in the reduced the growth in growing lambs.

Feed conversion ratio obtained in current study were in agreement with the results of Jabbar and Anjum (2008) who reported the considerable difference in FCR of lambs fed different concentrate to roughage ratios. Jabbar and Anjum (2008) reported that lambs on higher levels of concentrate diet had better FCR as compare to those on high forage diets. It might be due to the increased energy density of the diets comprising the higher proportion of the concentrate in addition to the forage. It is evidenced that the higher concentration and availability of the metabolisabale energy has improved the feed conversion ratio.

In this study the digestibility of DM and ADF were increased by increasing levels of concentrate in ration. Results of present study were in agreement with Parente *et al.* (2016) who stated that digestibility of DM in lambs increased with the supplementation of the additional levels of concentrate. It is because of the increased content of the metabolisable energy of the concentrate based diets. Hence, it exhibited the increased digestibility of the dry matter. Moreover, it is well documented that the higher proportion of concentrate also exhibits the lower fiber content; ultimately it also increases the ADF digestibility. Whereas, CF, CP and NDF digestibility was not affected by the treatments. These results are in line with the study of the Fimbres *et al.* (2001) who reported that the inclusion of concentrate in the roughage based diet may result in the increased rate of passage. This increased passage rate has facilitated the efficient nutrient intake and digestion.

However, it was not noticed because of the faster rate of digestion.

Furthermore, contrasting results were reported by the findings of Tripathi *et al.* (2006) who described that supplementation of concentrate might depress digestibility in rations containing forage in sheep and cattle that is associated with reduction in rumen pH, a preferred by microbes in the rumen for readily fermentable carbohydrates. They suggested that the degree of concentrate effect on digestion is influenced by the nature and proportion of concentrate and quality of the forage species.

***Conclusion*:** It was concluded that the improved growth performance in Thalli lambs can be achieved through feeding diet @ 40% concentrate and 60% hay in terms of higher weight gain, dry matter intake, DM and acid detergent fiber digestibility. However, the supplementation of concentrate @ 20% in the diet of lambs showed better feed conversion ratio. Moreover, further research is required to evaluate the optimized level of forage to concentrate ratio in Thalli lambs for optimum growth performance and nutrient digestibility.

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***Author's contribution*:** All the authors worked in a coordinated way. Karamon Jatta and Muhammad Farhan Ayaz Chishti has done experimentation, data analysis, manuscript drafting,

Muhammad Aziz ur Rahman: Conceived experiment, manuscript preparation. Sajjad Khan, Muhammad Riaz, and Qamar Bilal: Data analysis and manuscript finalization.

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***Conflict of interest*:** The authors declare no conflict of interest related to this study.

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