

*Full Length Research Paper*

# Feed intake, digestibility and growth performance of Begait sheep kept under different feeding options

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Thirty intact growing lambs were used to evaluate feed intake, digestibility and growth performance of Begait sheep breed kept under different feeding options. Animals were used in randomized completely block design with three dietary treatments in ten replicates. Treatments were grass hay fed *ad libitum* to all treatments plus a mixed diet of 48% wheat bran, 15% molasses, 35% cotton seed cake, 1% salt and 1% limestone (T1); 43% wheat bran, 20% sorghum grain, 35% Noug seed cake, 1% salt and 1% limestone (T2) and 47% wheat bran, 16% molasses, 35% sesame seed cake, 1% salt and 1% limestone (T3). Sheep in T3 (1123 g DM/day) consumed more feed ( $P < 0.001$ ) as compared to sheep in T2 (1077 g DM/day) and T1 (1057 g DM/day). Higher apparent digestibility of DM, OM, CP, NDF and ADF were obtained in T3 groups than in the other treatment groups ( $P < 0.05$ ). Average daily gain was significantly higher for T3 (158 g/day) than T2 (120 g/day) and T1 (118 g/day) ( $P < 0.001$ ). Diet 3 was better as compared to the other feeding options.

**Key words:** Apparent digestibility, average daily gain, feed consumption, sheep.

## INTRODUCTION

Ethiopia is a nation that is blessed with possession of huge livestock population. A recent report of CSA (2018) show that the country holds about 60.39 million cattle, 31.30 million sheep, 32.74 million goats and 56.06 million chickens. Livestock contribute economic and social benefits both at national and household level. Livestock contribute about 15-17% of national gross domestic product (GDP), 35-40% of agricultural GDP and 37-87% of the household incomes (Gebremariam et al., 2013). In addition, livestock offer food products like milk and meat that play important roles in improving the nutritional status and income gain of people. Despite this fact, production and productivity of livestock remains low for many reasons. The meat production and consumption is

by far low as compared to other countries. Empirical evidences show that the national cattle carcass weight (110 kg) is very low compared to other nations with 25-30% lower than Eastern Africa average (143 kg/head) and 50% lower than the world average (212 kg/head) (EIAR, 2016). Similarly, the average carcass weight of Ethiopian sheep (10 kg) is the lowest relative to all countries and the world average, by about 1, 3 and 6 kg from east African countries, least developed countries, and the world, respectively (Getachew and Mehamadou, 2014). The reduced production of meat is attributed to many complicated problems such as inadequate feeds and nutrition, non-commercial oriented animal husbandry practices, poor genetic potential of indigenous animal

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breeds and occurrence of diseases and pests (Shapiro et al., 2017).

The feed resource bases for sheep production in Ethiopia are mainly natural grazing and crop residues, which have seasonal variability on both their quality and quantity. Due to seasonal changes, there is a serious shortage of feedstuff that results in the fluctuation of animal production and therefore many farmers in Ethiopia feed their livestock with crop residues, mainly various straws. However, the use of such straw has limitations due to their low nutritive value indicated by their high cellulose, hemicellulose and lignin contents, and their low protein content and digestibility (McDonald et al., 2010). The roughage based feeding system needs strategic supplementation for improved livestock productivity. Agro-industrial by-products have special value in feeding livestock mainly in situations where the productive potential of the animals is relatively high and require high nutrient supply. The current trends of increasing urban population have a significant effect on the establishment of agro-industries due to the corresponding increasing demand for the edible main products (Yayneshet, 2010). These agro-industrial by-products can be utilized as good sources of supplementary animal feed throughout the year for producers.

Begait sheep breed is one of the indigenous Ethiopian sheep breeds located in the western zone of Tigray with promising meat production potential. The breed is believed to have tremendous meat potential that requires research attention for validation. The previous research pieces of evidence on Begait lambs noted 36 to 107 g/day average daily gain and 32 to 35 kg final body weight when fed various types of natural grass hay and supplement diets (Yirdaw et al., 2017; Gebrekidan et al., 2019; Haymanot et al., 2019). These studies might have been conducted with a limited amount of supplementation and the weight gains reported are not adequate to bring Begait sheep to its full genetic potential for growth, implying a better growth performance could be achieved beyond the reported one by putting the breed under optimum supplementation regimes. The breed could have also a different response to different supplementation feeding options. Hence, this study was to investigate the feed intake, diet digestibility and growth performance of Begait lambs under different feeding options.

## MATERIALS AND METHODS

### Study location

The feeding trial was carried out at the small ruminant research unit of Humera Agricultural Research Center, Northern Ethiopia. Geographically, the study area is located at 14° 15' N latitude and 36° 37' E longitude. The altitude of the experimental site is 608.9 m above sea level. The annual rainfall ranges from 400 to 650 mm and the annual temperature is in the range of 22.2 to 42°C. The climatic condition of the area is hot and semi-arid with a uni-modal rainfall pattern (Tadesse and Abay, 2011).

### Animal care

The experiment was approved (19641ET-27/2020) by the Ethics Committee of the Tigray Agricultural Research Institute following guidelines of the European Union directive number 2010/63/EU (2010) regarding the care and use of animals for experimental and scientific purposes.

### Animal and feeding management

The feeding trial was conducted using 30 intact growing Begait lambs (32.81±2.39kg) which were sourced from the local market. The lambs were put in quarantine when they were sprayed, dewormed and vaccinated against external parasites, internal parasites and common diseases, respectively. Mixed grass hay was obtained from the research center while concentrate feeds were sourced from local markets. Grass hay and clean drinking water were offered in free choice for all experimental lambs. Concentrate diets were offered twice a day in two equal portions (09:00 am and 02:00 pm). Lambs were confined in an individual pen for a total of 104 days with 90 days of data collection and 14 days adaptation period when animals were made adaptive with pen environment, feeds and feeding schedule.

### Experimental design and dietary treatments

The experiment was conducted using a randomized complete block design with 3 dietary treatments in 10 replicates. Lambs were blocked based on their initial body weight which was determined as a mean of two consecutive weighings after overnight fasting. They were grouped into ten blocks of three animals each and treatment diets were randomly assigned to each animal. Each lamb had an equal chance of receiving one of the following treatment diets: natural grass hay fed *ad libitum* common to all groups plus a mixed diet of 48% wheat bran, 15% molasses, 35% cottonseed cake, 1% salt and 1% limestone (T1); 43% wheat bran, 20% sorghum grain, 35% Noug seed cake, 1% salt and 1% limestone (T2) and 47% wheat bran, 16% molasses, 35% sesame seed cake, 1% salt and 1% limestone (T3). The amount of supplement to grass hay offered was 444.23, 467.22 and 492.54 g/head/day for T1, T2 and T3, respectively. The diet composition was set to meet the requirements for sheep following the recommendation of NRC (2007).

### Data measurements

#### Feed intake

Daily offered andorts of each treatment diet were measured and recorded throughout the experiment period for each experimental animal. Samples of feeds offered were collected on batches of feeds and that of orts was collected for each animal and pooled for each treatment and was sub-sampled for chemical analysis. Daily feed intake of individual sheep was calculated as a difference between feed offered and refused on DM bases. Feed conversion efficiency was computed as a proportion of average daily weight gain to average daily dry matter intake.

#### Live weight change

Each sheep was weighed at the beginning of the experimental period and every 10 days interval throughout the experiment after overnight fasting at 6:00 AM before daily feed offering to avoid feed effect. The weight taken every 10 days was used to show the

**Table 1.** Chemical compositions of experimental feeds and treatment diets.

Experimental diets	DM %	% DM					
		OM	CP	NDF	ADF	ADL	TDN*
Grass hay	91.28	84.32	7.39	61.38	41.15	9.25	51.46
Wheat bran	91.89	93.35	15.84	37.73	12.90	3.82	72.69
Sorghum grain	91.28	97.38	14.97	26.84	6.73	2.54	77.32
Molasses	74.50	91.00	3.80	0.20	0.00	0.00	82.38
Cotton seed cake	91.60	94.22	33.10	54.22	40.97	9.94	51.59
Noug seed cake	91.55	86.83	34.52	32.83	26.86	4.21	62.19
Sesame seed cake	90.73	89.28	41.45	21.11	8.73	2.19	75.82
Concentrate mixture							
Diet 1	91.44	92.66	20.25	33.93	17.85	4.67	68.97
Diet 2	90.89	92.50	20.66	32.43	15.59	5.79	70.66
Diet 3	90.52	90.89	20.84	28.35	13.45	2.84	76.03

ADF= acid detergent fiber; ADL= acid detergent lignin; CP= crude protein; DM= dry matter; NDF= neutral detergent fiber; TDN = Total digestible nutrient, \*TDN =  $82.38 - (ADF \times 0.7515)$  (NRC, 2001).

growth pattern of the experimental sheep. Average daily gain (gram/day) was calculated as the difference between the final live weight and initial live weight of the animal divided by the number of feeding days.

#### Diet digestibility

The digestibility trial was conducted following the feeding trial on the same animals to assess the utilization of different dietary nutrients. The animals were adapted to the harnessing of fecal bags for three days followed by a fecal collection for seven consecutive days. The collection of fecal material was performed daily and weighed every morning before offering feed and water. About 15% of the sub-sample was taken daily from the feces of an individual animal, composited in a container (airtight plastics) and stored at -20°C till the end of the collection period. At the end of the trial, fecal samples per treatment from the collected composite was taken for further chemical analysis. Daily feed offer and orts were recorded for each animal during the digestibility trial period. Thereafter, a weekly composite sample of each feed and orts for each animal was taken and pooled per treatment. The usual amount of feed offer and orts for each experimental animal was measured daily and body weight gain of each animal was taken at the first and last days of the fecal collection period during the activity of apparent digestibility trial. The apparent digestibility coefficient of feed DM, CP, NDF, and ADF was calculated by a method using McDonald et al. (2010).

#### Chemical analysis

Composite samples of representative samples of daily feed offered, orts and feces were dried at 55°C for 72 h and then grounded to pass a 1-mm sieve. Analysis for DM, ash and N contents were done according to the Association of Official Analytical Chemists (AOAC, 2005) procedures. Dry matter and ash contents were determined by oven drying at 105°C and by igniting in a muffle furnace at 550°C for 6 h, respectively. Nitrogen (N) content was determined by using Kjeldahl method and crude protein (CP) was calculated as  $N \times 6.25$ . Neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) were determined by using the procedures of Van Soest et al. (1991) in the ANKOM<sup>2000</sup> fiber analyzer apparatus

(ANKOM Technology Cooperation, Fairport, NY, USA) at Animal Science Nutrition Laboratory, Hawassa University, Ethiopia.

#### Statistical analyses

The data on all the feed intake, live body weight gain, digestibility and feed conversion efficiency were subjected to analyses of variance (ANOVA) according to a Randomized Complete-Block Design using the General Linear Models (GLM) procedure of SAS version 9.3 (SAS, 2010). Significant treatment means were separated using Tukey HSD at a 95% confidence interval.

## RESULTS

#### Chemical composition of feedstuff

The chemical composition of feed ingredients and experimental diets is presented in Table 1. The dry matter content was more or less comparable across the feed ingredients except that of molasses. Grass hay had moderate crude protein (7.39%) and higher fiber content (61.38% NDF and 9.25% ADL). Crude protein of hay (7.39%) was lower when compared to concentrate feeds (14.97-41.45%) except molasses (3.80%). Sesame seed cake contained the highest protein content followed by that of the Noug seed cake, cottonseed cake, wheat bran, sorghum grain, and molasses in that order. Energy content was highest for molasses (82.38% TDN) followed by sorghum grain (77.32%), sesame seed cake (75.82%), wheat bran (72.69%), Noug seed cake (62.19%) and cottonseed cake (51.59%) in descending order. Cottonseed cake had highest lignin content (9.94%) as compared to other concentrate feeds (2.19-4.21% ADL) but the value was comparative with hay (9.25%). The experimental diets (T1, T2 and T3) had similar protein contents while the energy value was higher for T3 (76.03%

**Table 2.** Dry matter and nutrient intake of Begait sheep kept under different feeding regimes.

Intake (gram/day)	T1	T2	T3	SEM	LS
Grass hay DM	613.45 <sup>b</sup>	610.54 <sup>b</sup>	631.34 <sup>a</sup>	2.213	***
Supplement DM	444.23 <sup>c</sup>	467.22 <sup>b</sup>	492.54 <sup>a</sup>	4.342	***
Total DM	1057.68 <sup>b</sup>	1077.68 <sup>b</sup>	1123.88 <sup>a</sup>	6.036	***
Total DM (g/kg BW <sup>0.75</sup> )	63.99	64.91	64.24	0.453	ns
Total DM (%BW)	2.51	2.54	2.48	0.025	ns
Nutrient intake (gram/day)					
Crude protein (CP)	187.29 <sup>c</sup>	199.59 <sup>b</sup>	234.51 <sup>a</sup>	7.333	**
Organic matter (OM)	1330.73	1383.84	1400.95	15.476	ns
Neutral detergent fiber (NDF)	690.87	699.29	666.94	7.482	ns
Acid detergent fiber (ADF)	420.80 <sup>a</sup>	407.30 <sup>a</sup>	338.80 <sup>b</sup>	7.683	***
Acid detergent lignin (ADL)	100.14 <sup>a</sup>	101.47 <sup>a</sup>	83.02 <sup>b</sup>	1.855	***
Metabolizable energy (MJ/day)	11.76 <sup>c</sup>	12.62 <sup>b</sup>	14.64 <sup>a</sup>	0.406	**

<sup>a-b</sup> means within a row not bearing common superscript are significantly different; \*\*\*= significant at  $p < 0.001$ ; \*\*= significant at  $p < 0.01$ ; ns= not significant at  $p > 0.05$ ; SEM= Standard error of mean; LS= Level of significance; DM = Dry matter; BW = Body weight. ME = metabolize energy, it was estimated from digestible organic matter intake (DOMI) values by using the equation of AFRC (Agricultural Food and Research Council) (1992) as  $ME (MJ/day) = 0.0157 \times DOMI \text{ g/kg DM}$ .

**Table 3.** Apparent digestibility of dry matter and nutrients of Begait sheep kept under different feeding options.

Digestibility (%)	T1	T2	T3	SEM	SL
Dry matter	58.71 <sup>b</sup>	59.37 <sup>b</sup>	66.42 <sup>a</sup>	2.373	***
Organic matter	56.31 <sup>b</sup>	58.09 <sup>b</sup>	66.55 <sup>a</sup>	2.341	***
Crude protein	71.23 <sup>b</sup>	71.62 <sup>b</sup>	85.13 <sup>a</sup>	1.636	***
Neutral detergent fiber	51.17 <sup>b</sup>	53.28 <sup>b</sup>	72.41 <sup>a</sup>	2.622	***
Acid detergent fiber	42.66 <sup>b</sup>	43.07 <sup>b</sup>	59.71 <sup>a</sup>	3.128	*

<sup>a-b</sup> means within a row not bearing common superscript are significantly different; \* = significant at  $p < 0.05$ ; \*\*\*= significant at  $p < 0.001$ ; SEM= Standard error of mean; LS= Level of significance.

TDN) followed by T2 (70.66%) and T1 (68.97%) in reducing order.

### Feed consumption

Table 2 shows the mean daily dry matter and nutrient intake of experimental sheep during the feeding trial. Significant differences ( $P < 0.001$ ) were observed among treatments in daily natural grass hay and total dry matter intakes. Natural grass hay and total DM intakes were greater ( $P < 0.001$ ) for T3 than T1 and T2. Sheep groups supplemented with T3 consumed more DM (1124 g/head/day) than that of sheep groups in T2 (1078 g/head/day) and T1 (1058 g/head/day). The total DM intake as a percent of body weight in the current study was 2.51, 2.55 and 2.48% for T1, T2 and T3, respectively. Crude protein intake was significantly higher in lambs fed on T3 than those in T2 and T1 ( $P < 0.001$ ). Similarly, energy consumption was highest for sheep supplemented with T3 than those reared in other diets.

Fiber intake was observed to be higher in sheep fed on T1 followed by that of T2 and T3 in that order.

### Diet digestibility

Apparent DM and nutrient digestibility of experimental feeds are shown in Table 3. Higher apparent digestibility of DM, OM, CP, NDF and ADF ( $p < 0.05$ ) were obtained in T3 groups than in the other treatment groups. However, there was no significant difference in the DM and nutrient digestibility between T1 and T2 ( $p > 0.05$ ).

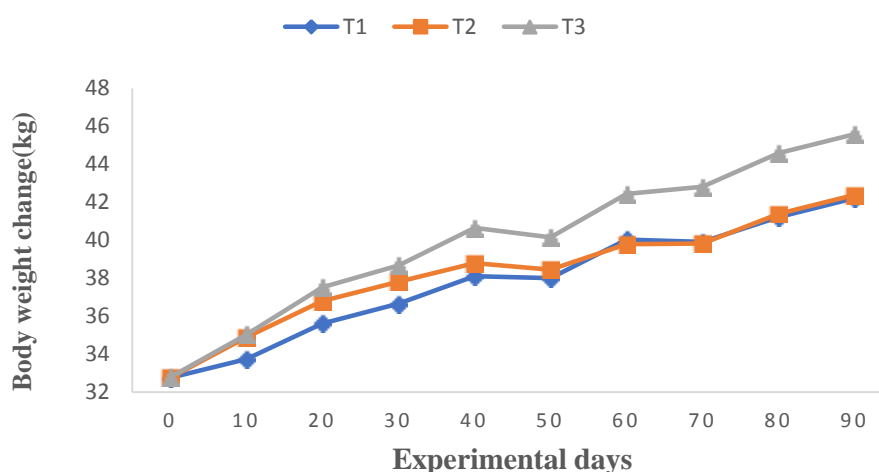
### Growth performance and gain efficiency

Final body weight, body weight change, daily body weight gain (ADG) and feed conversion efficiency (FCE) of Begait sheep reared under different feeding options is presented in Table 4. Final body weight and total gain were higher for sheep in T3 than those in other diets ( $P <$

**Table 4.** Growth performance and feed conversion efficiency of Begait lambs fed under different feeding regimes.

Parameter	T1	T2	T3	SEM	LS
Initial body weight (kg)	32.76 <sup>a</sup>	32.77 <sup>a</sup>	32.91 <sup>a</sup>	0.781	ns
Final body weight (kg)	42.22 <sup>b</sup>	42.40 <sup>b</sup>	45.60 <sup>a</sup>	0.964	*
Body weight gain (kg)	9.46 <sup>b</sup>	9.63 <sup>b</sup>	12.69 <sup>a</sup>	7.369	***
Average daily gain (g)	118.25 <sup>b</sup>	120.37 <sup>b</sup>	158.62 <sup>a</sup>	2.806	***
Daily DM intake (g)	1057.68 <sup>b</sup>	1077.68 <sup>a</sup>	1123.88 <sup>a</sup>	6.036	***
Feed conversion efficiency	0.112 <sup>b</sup>	0.112 <sup>b</sup>	0.141 <sup>a</sup>	0.007	***

<sup>a-b</sup> means within a row not bearing common superscript are significantly different; \* = significant at  $p < 0.05$ ; \*\*\* = significant at  $p < 0.001$ ; ns = not significant at  $p > 0.05$ ; SEM = Standard error of mean; LS = Level of significance; DM = Dry matter; BW = Body weight.

**Figure 1.** Trends of body weight gain of Begait sheep under different feeding options.

0.05). Likewise, sheep group supplemented with T3 ration had significantly ( $p < 0.001$ ) higher average daily gain (158.6 g/day) than that of sheep groups in T2 (120 g/day) and T1 (118 g/day). Gain efficiency (ADG: daily DM intake) was higher for lambs of T3 than for lambs in other diets.

The trend of body weight change across the feeding period for Begait sheep in the current study is shown in Figure 1. As shown in the figure, growth performance had increased linearly during the 90 days feeding period in all experimental groups. There was an increasing trend for all treatment groups throughout the study period; however, a sharp increase in body weight was observed for T3.

## DISCUSSION

### Chemical composition of feedstuff

The crude protein (CP) content of natural grass hay (7.39%) in this experiment is above the 7% CP required

for microbial protein synthesis in the rumen that can support at least the maintenance requirement of ruminants (Van Soest, 1995; Minson, 1990). Comparable CP values were reported by others (Gashu et al., 2017; Ayele and Urge, 2019) but lower than the 8.99 to 9.91 values reported in different parts of Ethiopia (Bekele et al., 2013; Brhanu and Gebremariam, 2019). The NDF of hay (61.38%) was smaller than the value of 76.20% (Yirdaw et al., 2017), 77.15% (Gebrekidan et al., 2019) and 79.40% (Ayele et al., 2019). The difference in nutritional contents among the hays might be due to variation in species, variety, soil fertility, climate, stage of maturity at cutting and post-harvest management (McDonald et al., 2002).

The CP content (15.84%) of wheat bran reported in this study were in the range of 15.5-17.31% reported by others (Yirdaw et al., 2017; Ayele et al., 2019; Gebrekidan et al., 2019; Zewide et al., 2019). The CP obtained from Noug seed cake was in line with previous reports that noted by (Gashu et al., 2017; Brhanu and Gebremariam, 2019; Zewide et al., 2019), and lower than the previous values of 36% reported by Ayele et al. (2019). The CP

recorded from sesame seed cake was 41.45%, which is higher than the results of Brhanu and Gebremariam (2019) who reported 31.80%. The CP content of the cottonseed cake was 33.10% of DM which was comparable with previous studies (Worku and Urge, 2014; Yirdaw et al., 2017). The CP concentration in molasses was comparable with 3.84% reported by Hassen and Ali (2019) but lower than 4.7% observed by Khan et al. (2006) and greater than 3.2% by Sindhu et al. (2002).

According to Lonsdale (1989), feeds that have <12%, 12-20%, and >20% CP are classified as low, medium and high protein sources, respectively. Thus, all the oil seed cakes (Noug, cotton and sesame) are among the high protein sources that can serve as a protein supplement for low quality feeds like straws and hays in the animal feeding system. The differences in nutrient composition of the concentrate feeds among the different studies may be attributed to the varietal difference, agronomic management, soil types, efficiency of the processing method, quality of the raw material used, storage time and condition, and other factors (McDonald et al., 2002). The protein concentration of the three experimental diets was similar as it was made deliberately to be iso-nitrogenous in order to see the effect of diet composition on lamb performance. However, the energy content, measured in TDN, was higher for T3 followed by that of T2 and T1 in descending order.

### Feed consumption

The greater DM intake observed in T3 could be due to increased protein intake that contribute more nitrogen supply to the rumen microorganisms (Van Soest, 1994). This could lead to an increase in microbial population and efficiency, thereby facilitating the rate of breakdown of the digesta, which eventually leads to increment in feed intake. The higher the CP content, the higher the DM intake and the higher the growth rate (Yasin and Animut, 2014). In addition, the greater energy consumption of lambs in T3 ration might have contributed to the increased feed utilization. Further, the higher growth performance in T3 could be attributed to increasing body weight to compensate for increased maintenance requirements and the ratio of fat: lean in body weight gain (Warmington and Kirton, 1990). Besides, the comparative higher content of NDF, ADF, and ADL of T2 and T1 as compared to the T3 group diet might have a limited intake of dry matter. In favor of this study, Cheeke (2001) stated that one of the major factors that affect forage intake and digestibility is NDF and ADF content because it is the major component limiting rumen fill and has a high correlation with rumination.

The total daily DM intake (1058 -1103 g/day) in the present study was comparable to 1140-1160 g/head/day in Sudan desert sheep supplemented with a mixture of Karkadeh seeds, sorghum grain, wheat bran, groundnut

cake, groundnut hulls, limestone and salt (Beshir et al., 2009). Lower values of 788 g/day (Bishaw and Melaku, 2008), 710-775 g/day (Sefa et al., 2016) and 851-948 g/day (Nyako, 2015) were reported by supplemented 300 g on DM basis of concentrate mixtures for local lambs. The higher DM intake observed in the current study could be due to the good quality of the diets, which was characterized by low ADL and NDF content since a major factor regulating forage intake is NDF content due to its effects on rumen fill, which is directly correlated with rumination or chewing time (McDonald et al., 2002). The difference in DM intake among the studies could be due to differences in the animal breed and chemical composition of the experimental diets. Begait sheep is considered as having relatively larger body size amongst the indigenous Ethiopian sheep breeds. The total DM intake as a percent of body weight in the current study was 2.51, 2.55 and 2.48% for T1, T2 and T3, respectively, which was within the range of 2-5% recommended by NRC (1985) for small ruminants. It was also comparable with the values (1.9-3.2%) reported by Tekletsadik (2008) for Arsi Bale sheep fed faba bean haulm supplemented with 300 g concentrate mix (barley bran, linseed meal and their mixture). It was, however, below the estimated 5% of body weight for a moderately growing sheep (NRC, 1985).

The higher and lower CP intake obtained from T3 and T1, respectively was in part due to greater and lower DM intake. The CP intake value was higher than the values ranged from 85.50 to 129.72 gday<sup>-1</sup> reported by previous studies (Bishaw and Melaku, 2008; Bekele et al., 2013; Haymanot et al., 2019). The higher CP intake in the present study could be expressed due to the higher intake of dry matter which is closely associated with body weight. The CP intake as a percent of total DM intake was 17.71, 18.52 and 20.87%, respectively for T1, T2, and T3. This indicates all treatment groups have no negative impact on overall feed intake as their CP intake was above 8% of DM intake (Van Soest, 1994). According to Minson (1990), the lowest energy density at which sheep does not lose weight is between 8 and 10 MJ ME/kg DM and the minimum protein level required for maintenance is about 8% CP in DM, which indicates that the result of the current study is above the satisfactory energy and protein requirement (Table 2) for maintenance and growth of Begait sheep. Moreover, the feed consumption could be explained by the fiber intake which was observed to be higher in T1 and T2 than that of T3. Feed intake is negatively impacted by the number of indigestible fractions (such as lignin) or fractions with low digestibility like NDF and ADF content due to the need for more retention time in the rumen for further fermentation (Bruinenberg et al., 2003).

### Diet digestibility

The higher DM and nutrient digestibility observed in T3

lambs might be attributed to the combination reason of lower fiber content in their diet and higher CP intake. Scientific evidences proved that improved nutrient digestibility with increment in CP intake from the supplements could be a function of increased CP availability to rumen micro-organisms which help them to increase their mass that results in attacking and digesting more fibrous feeds (Van Soest, 1994; McDonald et al., 2002). The result of DM, OM, CP and NDF digestibility of T3 in the present study was higher than the values reported by Haymanot et al. (2019), for the same breed fed grass hay basal diet supplemented with concentrate mixture (75% rice bran and 25% sesame seed cake). The variation in DM and nutrient digestibility of the current result with earlier findings might be related to breed and age of the animals, level of feeding, and feed and ration composition (Ranjhan, 1999). Besides, the digestibility of a feed is influenced not only by its composition but also by the composition of other feeds consumed with it. The digestibility of DM and nutrients is more affected by the nature of the diet than by the composition of the diet itself (McDonald et al., 2002).

### **Growth performance and gain efficiency**

The higher sheep growth performance in T3 is attributed to the higher DM intake, lower fiber content and greater CP intake as compared with that of T1 and T2. According to McDonald et al. (2002), the higher level of NDF in ruminant feed reduces the feed digestibility, which would have a direct influence on the performance of the animal. Consequently, daily gain in T3 was superior by about 38-40 g/day as compared to lambs in T2 and T1 containing group diets. The non significant difference in growth performance between T1 and T2 is attributed to the comparable feed consumption. The average daily gain (118-159 g) obtained in this study was higher than the findings of Yirdaw et al. (2017), Gebrekidan et al. (2019) and Haymanot et al. (2019) who reported 49-71, 36-53 and 51-107 g/day, respectively, for the same sheep breed (Begait) implying that the experimental sheep in these previous studies performed below their genetic potential for growth. This could be attributed to limited feed intake, which is much less than the requirement for growth (NRC, 1985; McDonald et al., 2002). This also agreed with a report of Ayele and Urge (2019) who stated that the variation in growth rate within the same sheep breed could be attributed to the difference for feed.

The FCE value observed in this study was consistent with the trend of ADG for all group of treatments, which is in agreement with the idea reported by Pond et al. (1988) who state diets that promote high rates of gain will usually result in greater efficiency than diets that do not allow rapid gain, as the rapidly gaining animals utilize less of the total feed intake for maintenance and more of it for body weight gain. Feed conversion efficiency value

(0.112-0.141) of sheep in the present study was superior to the value of 0.08-0.11 (Yirdaw et al., 2017), 0.05-0.04 (Gebrekidan et al., 2019), and 0.03-0.092 (Haymanot et al., 2019) reported for the same breed fed concentrate to grass natural grass hay. Beshir et al. (2009) reported similar values (0.134-0.144) on Sudan desert sheep fed natural grass hay as basal diet supplemented with different concentrate mixture. Supplementation with concentrate enhanced growth rate of sheep in general, and as the concentrate to roughage ratio increased in the diet, feed consumption increased and feed conversion improved, so the final weight and average daily gain also increased. Indeed, the higher daily gain *Begait* sheep breed recorded in this study was superior to the Ethiopian indigenous sheep breed reported in the literature by Ayele and Urge (2019).

### **Conclusions**

The current study asserted the effect of diet composition on feed consumption and animal performance. Among the diets evaluated, the diet group with molasses 16% + wheat bran 47% + sesame seed cake 35% + salt 1% + limestone 1% promoted better apparent digestibility of nutrients, average daily gain and feed conversion efficiency of *Begait* sheep breed. However, the use of either diet depends on the availability and cost of feed ingredients. This study also demonstrates that the *Begait* breed is superior to the entire growth performance of Ethiopian indigenous sheep breeds reported previously. Further studies should investigate the effects of feeding this breed with diets containing molasses 16% + wheat bran 47% + sesame seed cake 35 % + salt 1% + limestone 1% on carcass and meat quality traits.

### **Compliance with ethical standards**

The experiment was approved (19641ET-27/2020) by the Ethics Committee of the Tigray Agricultural Research Institute following guidelines of the European Union directive number 2010/63/EU (2010) regarding the care and use of animals for experimental and scientific purposes.

### **CONFLICT OF INTERESTS**

The authors have not declared any conflict of interests.

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## REFERENCES

- Agricultural Food Research Council (AFRC) (1992). Technical Committee on responses to nutrients, Report Number 9, Nutritive Requirements of Ruminant Animal: protein. Nutrition Abstracts and Reviews 62(12):787-835.
- Association of Official Agricultural Chemists (AOAC) (2005). Official methods of analysis. 18<sup>th</sup> ed. Gaithersburg, MD, USA.
- Ayele S, Urge M (2019). Productive and reproductive performances of indigenous sheep in Ethiopia: A review. Open Journal of Animal Sciences 9(1):97-120.
- Ayele S, Urge M, Anmut G, Yusuf M (2019). Comparative slaughter performance and carcass quality of three Ethiopian fat-tailed hair sheep breeds supplemented with two levels of concentrate. Tropical Animal Health and Production 51(1):187-198.
- Bekele W, Melaku S, Mekasha Y (2013). Effect of substitution of concentrate mix with *Sesbania sesban* on feed intake, digestibility, body weight change and carcass parameters of Arsi-Bale sheep fed a basal diet of native grass hay. Tropical Animal Health and Production 45(8):1677-1685.
- Beshir AA, Yagoub YM, Babiker SA (2009). Performance of Sudanese desert lambs fed graded levels of water melon (*Citrullus Lanatus*) seed cake instead of groundnut cake. Pakistan Journal of Nutrition 8(5):525-529.
- Bishaw F, Melaku S (2008). Effects of supplementation of Farta sheep fed hay with sole or mixtures of noug seed meal and wheat bran on feed intake, digestibility and body weight change. Tropical Animal Health and Production 40(8):597-606.
- Brhanu A, Gebremariam T (2019). Using khat (*Catha edulis*) leftover meal as feed for sheep: its implication on feed intake, digestibility and growth. Online Journal of Animal and Feed Research 9(5):191-197.
- Bruinenberg MH, Valk H, Struik PC (2003). Voluntary intake and *in vivo* digestibility of forages from semi-natural grasslands in dairy cows. NJAS-Wageningen Journal of Life Sciences 51(3):219-235.
- Central Statistical Agency (CSA) (2018). Agricultural Sample Survey. Volume II: Report on livestock and livestock characteristics (Private peasant holdings). Statistical Bulletin 587, Addis Ababa, Ethiopia.
- Cheeke PR (2001). Actual and potential applications of Yucca schidigera and Quillaja saponaria saponins in human and animal nutrition. Recent Advances in Animal Nutrition in Australia 13:115-126.
- Ethiopian Institute of Agricultural Research (EIAR) (2016). Livestock research strategy (2016-2030). Addis Ababa, Ethiopia.
- European Parliament and Council Directive EU (2010). Directive 2010/63/EU of 22 September 2010 on the protection of animals used for scientific purposes. The Official Journal of the European Union 276:33-79.
- Gashu M, Urge M, Anmut G, Tadesse D (2017). Slaughter performance and meat quality of intact and castrated Washera sheep kept under feedlot condition. African Journal of Agricultural Research 12:3072-3080.
- Gebrekidan G, Teklebrhan T, Tesfay Z (2019). Growth performance and carcass traits of Begait lambs fed diets of cowpea (*Vigna unguiculata*) hay, wheat bran and their mixtures. Journal of Agriculture and Ecology Research International 20(1):1-12.
- Gebremariam S, Amare S, Baker D, Solomon A, Davies R (2013). Study of the Ethiopian live cattle and beef value chain. ILRI discussion paper 23. International Livestock Research Institute (ILRI), Addis Ababa, Ethiopia.
- Getachew L, Mohamadou F (2014). Small ruminant value chain development in Ethiopia: Situation analysis and trends. ICARDA/ILRI project report. International Center for Agricultural Research in the dry Areas/International Livestock Research Institute, Nairobi, Kenya.
- Hassen AS, Ali MY (2019). Effect of different level of molasses inclusion on feed intake, body weight gain and carcass parameters of Afar sheep in Ethiopia. Asian Journal of Medical and Biological Research 5(1):20-30.
- Haymanot AT, Anmut G, Tesfay Y (2019). Effect of supplementing Tsara (*Pterocarpus lucens*), pigeon pea (*Cajanes cajan*) leaves and concentrate mixture on carcass characteristics of Begait sheep fed hay as a basal diet. International Journal of Livestock Production 10(9):198-203.
- Khan MA, Sarwar M, Nisa M, Iqbal Z, Khan MS, Lee WS, Lee HJ, Kim HS (2006). Chemical composition, *in situ* digestion kinetics and feeding value of Oat grass (*Avena sativa*) ensiled with molasses for Nili-Ravi Buffaloes. Asian-Australasian Journal of Animal Sciences 19(8):1127-1133.
- Lonsdale C (1989). Raw materials for animal feeds compounders and farmers. Chalcombe Publications, Great Britain pp. 17-47.
- McDonald P, Edwards RA, Greenhalgh JED, Morgan CA (2002). Animal Nutrition. 6th ed. Prentice Hall, Edinburgh, UK.
- McDonald P, Edwards RA, Greenhalgh JFD, Morgan CA, Sinclair LA, Wilkinson RG (2010). Animal Nutrition, 7<sup>th</sup> ed.. Prentice hall, Harlow, England, London.
- Minson DJ (1990). Forages in Ruminant Nutrition. Academic Press, San Diego, California pp. 208-229.
- National Research Council (NRC) (1985). Nutrient requirements of sheep, 6<sup>th</sup> revised ed. National Academies press, Washington DC.
- National Research Council (2007). Committee on the Nutrient Requirements of Small Ruminants, Board on Agriculture, Natural Resources, Division on Earth and Life Studies. Nutrient requirements of small ruminants: sheep, goats, cervids, and new world camelids. National Academies press, Washington DC.
- National Research Council (NRC) (2001). Nutrient Requirements of Dairy Cattle, 7<sup>th</sup> revised ed. National Academy of Science, Washington, DC. <https://doi.org/10.17226/9825>.
- National Research Council (NRC) (2007). Nutrient Requirements of Small Ruminants: Sheep, Goats, Cervids, and NewWorld Camelids. National Academic Science, Washington, DC P 384. <https://doi.org/10.17226/11654>.
- Nyako HD (2015). Effect of feeding different supplements on the performance of Yankasa rams offered a basal diet of cowpea hay in the semi-Arid region of Nigeria. Journal of Biology, Agriculture and Health Care 6:111-117.
- Pond KR, Ellis WC, Matis JH, Ferreira HM, Sutton JD (1988). Compartment models for estimating attributes of digesta flow in cattle. British Journal of Nutrition 60(3):571-595.
- Ranjhan SK (1999). Dairy feeding systems: smallholder dairying in the tropics. International Livestock Research Institute (ILRI), Nairobi, Kenya.
- Statistical Analysis System (SAS) (2010). Statistical Analysis System, Version 9.3. SAS Institute Inc., Cary, NC, USA.
- Sefa S, Mengistu U, Getachew A (2016). Effects of supplementation with different forms of barley on feed intake, digestibility, live weight change and carcass characteristics of Hararghe highland sheep fed natural pasture. Journal of Food Processing and Technology 7(3):1-5.
- Shapiro BI, Gebru G, Desta S, Negassa A, Nigusie K, Aboset G, Mechal H (2017). Ethiopian Livestock Master Plan. ILRI Project Report, Nairobi, Kenya.
- Sindhu AA, Khan MA, Nisa MU, Sarwar M (2002). Agro-industrial by-products as a potential source of livestock feed. International Journal of Agriculture and Biology 4(2):307-310.
- Tadesse H, Abay F (2011). Additive main effects and multiplicative interactions analysis of yield performance of sesame genotypes across environments in Northern Ethiopia. Journal of the Drylands 4:259-266.
- Tekletsadik E (2008). The effect of supplementation with barley bran, linseed meal and their mixtures on the performance of Arsi-Bale sheep fed a basal diet of faba bean haulms. MSc thesis, Haramaya University, Haramaya, Ethiopia.
- Van Soest PJ (1994). Nutritional Ecology of the Ruminant. 2<sup>nd</sup> Edition. Cornell University Press, London.
- Van Soest PJ (1995). Comparative aspects of animal models. Dietary



- Fiber in Health and Disease P 321.
- Van Soest PJ, Robertson JB, Lewis BA (1991). Methods for dietary fiber, neutral detergent fiber, and non starch polysaccharides in relation to animal nutrition. *Journal of Dairy Science* 74(10):3583-3597.
- Warmington BG, Kirton AH (1990). Genetic and non-genetic influences on growth and carcass traits of goats. *Small Ruminant Research* 3(2):147-165.
- Worku T, Urge M (2014). Body weight change and carcass yield performance of Somali goats fed with groundnut pod hulls and a mixture of wheat bran and mustard seed cake. *Science, Technology and Arts Research Journal* 3(1):57-63.
- Yasin M, Animut G (2014). Replacing cottonseed meal with ground *Prosopis juliflora* pods effect on intake, weight gain and carcass parameters of Afar sheep fed pasture hay basal diet. *Tropical Animal Health and Production* 46(6):1079-1085.
- Yayneshet T (2010). Feed Resources Availability in Tigray Region, Northern Ethiopia, For Production of Export Quality Meat and Livestock. Ethiopia Sanitary and Phytosanitary Standards and Livestock & Meat Marketing Program (SPS-LMM) Report. Addis Ababa, Ethiopia.
- Yirdaw M, Mengistu A, Tamir B, Brhane G (2017). Effect of feeding cotton seed cake, dried *Acacia saligna*, *Sesbania sesban* or *Vigna unguiculata* on growth and carcass parameters of Begait sheep in North Ethiopia. *Agriculture, Forestry and Fisheries* 6(5):149-154.
- Zewide TM, Wossen AM, Yadeta AT, Geesink GH (2019). Carcass and meat quality characteristics of two hair type breed lambs fed tef (*Eragrostis tef*) straw ensiled with effective micro-organisms and supplemented with concentrates. *International Journal of Livestock Production* 10(4):110-121.