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Growth Performance and Carcass Traits of Begait Lambs Fed Diets of Cowpea (*Vigna unguiculata*) Hay, Wheat Bran and their Mixtures

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Authors' contributions

This work was carried out in collaboration among all authors. Author GG designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author TT managed the analyses of the study. Author ZT managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

The study was conducted at Humera agricultural research centre farm, northern Ethiopia aimed to evaluate the effects of supplementation of cowpea (*Vigna unguiculata*) hay (CPH), wheat bran (WB) and their mixtures on feed intake, average daily gain (ADG) and carcass characteristics of Begait lambs fed grass hay (GH) as a basal diet. The experimental lambs were divided into five groups based on initial body weight and randomly assigned to the five treatments. Treatments were *ad libitum* feeding of GH and supplemented with 300 g CPH, 225 g CPH + 75 g WB, 150 g CPH + 150 g WB, 75 g CPH + 225 g WB and 300 g WB DM/day for T_1, T_2, T_3, T_4 and T_5, respectively. Total DM intake was 687.1, 669.4, 719.4, 631.0 and 673.47 gd^{-1} for T_1, T_2, T_3, T_4 and T_5, respectively and significantly higher ($p<0.001$) and lower ($p< 0.001$) for T_3 and T_4, respectively and intermediate for others. The ADG was 36.4, 43.6, 52.9, 43.1 and 42.4 gd^{-1} for lambs in T_1, T_2, T_3, T_4

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and T_5, respectively was higher (p<0.001) for T_3. Consequently, the value for hot carcass weight (kg) was significantly higher for T_3 (12.92) than T_2 (12.61), T_1 (11.92), T_4 (11.96) and T_5 (12.42). Therefore, from the findings of this study, it can be suggested that feeding mixture of 150 g of cowpea hay and 150 g of wheat bran improved sheep performance.

Keywords: Body weight; hot carcass; feed intake; grass hay.

1. INTRODUCTION

Sheep and goats are among the major economically important livestock in Ethiopia and playing an important role in the livelihood of resource-poor farmers. They provide their owners with a vast range of products and services such as meat, milk, skin, hair, horns, bones, manure and urine for cash, security, gifts, religious rituals and medicine [1]. Moreover, according to Fikru and Gebeyew [2], they are a source of risk mitigation, security, investment, saving and socio-economic and cultural functions. Generally, indigenous sheep had a potential for the multipurpose role to generate income for smallholders [3]. Likewise, being relatively drought-tolerant, small in size, easily manageable, and are saleable resources that the family can use for ready cash, and can rear in areas characterized by high rural human population pressure, fragmented land holdings and scrubland [4] are some of the driving forces that lead to producing small ruminants.

Even though there are these much opportunities and importance of producing small ruminants, still they are producing below their production potential; for instance, the average carcass weight of Ethiopian sheep and goats is 10 kg on an average, which is the second-lowest in sub-Saharan Africa [1]. Fluctuations [5,6] and inadequate feed supply in both terms of quantity and quality [7] and the low attention given to small ruminants compared to large ruminants [1, 8] are some of the major constraints that lead to low productivity. Crop residues and natural pasture are among the common feed resources in Ethiopia [5,6]; which are inherently low in crude protein (CP), digestibility and minerals, as a result, they cannot support even the maintenance requirements of the animals. Similarly, according to Adane and Girma [1], small ruminants represent only 7% of the average total capital invested in livestock in the mixed crop-livestock production system even if they account on average for 40% of the cash income and 19% of the total value of subsistence food derived from all livestock production.

In most parts of Ethiopia, there is a critical feed shortage in terms of quality and quantity in the western zone of Tigray, northern Ethiopia [9,10]. To address this problem continuous efforts have been done throughout the country in general and in the western zone of Tigray in particular; producing various concentrate feeds and protein supplements are few of them. As a consequence, high quantities of some agro-industrial by-products (AGIBP) like wheat bran are produced throughout the country but, their utilization in livestock feeding is still limited due to proximity of the AGIBP to livestock flock (transportation and storage needs), alternative uses and the relative opportunity costs and the managerial capabilities of the farmer [7]. Therefore, as intervention strategies Humera Agricultural Research Center (HuARC) introduced alternative protein sources such as cowpea (herbaceous legume forage) and pigeon pea (tree legume) to the area. According to monitoring and evaluation of the varieties, one cowpea variety named as *Temesgen* and two pigeon pea varieties (*Kibret* and *Tsigab*) were registered in the national variety release in 2014 G.C as best feed resources of the area as well other similar agro-ecologies of the country [11].

Temesgen was one of the promising varieties that intended to contribute paramount role in addressing the prevailing feed shortage in the area. Its high protein content (17.15% CP) implies the potential for use as a protein supplement for ruminants on low-quality roughages [12,13] such as matured natural pasture hay [14]. But, yet there is scarcity of documentation regarding its supplementation effect on growth performance and carcass traits of Begait lambs. Therefore, this study was conducted to evaluate the effects of supplementation of cowpea (*Vigna unguiculata*) hay, wheat bran and their mixtures on growth performance and carcass traits for Begait lambs.

2. MATERIALS AND METHODS

2.1 Description of the Study Area

This study was carried out at Humera Agricultural Research Center (HuARC), the western zone of Tigray, Northern Ethiopia. It is situated at an altitude of 608.9 m.a.s.l and latitude of 14º15' N and longitude of 36º37' E. The dominant soil type in Vertisol. The site has a semi-arid climate with a unimodal rainfall pattern. The mean maximum and minimum temperature varied from 33 to 41.7 and 17.5 to 22.2ºC, respectively and 581.2 mm was the mean annual rainfall, which was received during the summer/rainy season [15].

2.2 Animals Management

Twenty-five intact male Begait lambs with a bodyweight of 28.02 ± 1.49 kg (mean ± SD) and 5 to 6 months of age were purchased from the local market (Baeker). Information on age was provided by the owners which were verified using dentition. Each sheep was identified with neck chain. They were quarantined and acclimatized for twenty-one and fifteen days of the period respectively. During that time, lambs were drenched with a broad spectrum anthelmintic (Ivermectin) for internal and external parasites treatment and sprayed with accaricide (Diazzinole) 1 ml head^{-1} against external parasites. They provided Ovine pasteurellosis type A vaccine subcutaneously against Ovine pasteurellosis, which is one of the common diseases of the area. The lambs were kept in individual pens, which were equipped with feeding troughs for hay and plastic buckets for supplements and watering separately.

2.3 Feed Preparation

The cowpea variety used was *Temesgen*, which was planted on one hectare of land on July 15, 2016. The inter and intra-row spacings were 40 x 20 cm at a seeding rate of 26 kg ha^{-1}as recommended by Solomon and Kibrom [11]. It was harvested using a sickle at 50% blooming stage after 50 days of establishment. It was dried under shade to minimize nutrient losses (due to bleaching, leaching and shattering) and to keep its green colour, which is one indicator of hay quality. After properly dried, which was checked by twisting, it was stored at the concrete hay barn. It was chopped manually to approximate size of 3-5 cm for efficient utilization, improve palatability and to reduce wastage. The other ingredient of the experimental diets was wheat bran, which was purchased from Gondar flour processing plant.

Moreover, the natural grass hay consisted of predominantly *Cynodone dactylone,* was harvested at late maturity stage due to the inconvenient weather condition for haymaking and was stored at the concrete hay barn. During the time of utilization in feeding and digestibility trials, it was manually chopped to an approximate size of 3-5 cm to minimize wastage and selection by the experimental animals.

2.4 Experimental Design and Treatments

Randomized Complete Block Design (RCBD) with five blocks and five treatments was used (Table 1). Lambs were blocked according to their initial body weight. Lambs in each block were randomly assigned to one of the five treatment diets. The lambs were allocated in the individual pen with a dimension of 85 cm wide and 115 cm long in a naturally ventilated shed. All lambs had free access to clean, freshwater and common salt. The experiment was run for 136 days, consisting of 21 days for quarantine, 15 days for acclimatization, and 90 days for growth study and fitted with a faecal-collection bag for 3 days followed by 7 days of digestibility trial.

2.5 Measurements

2.5.1 Feeding trial

The feeding trial was conducted in the dry season (i.e., November 2016 to January 2017), which lasted for 90 days. Natural grass hay was offered at 500 g DM per animal in the first five days of the study, then the amount was adjusted every five days based on the average feed intake during the previous period on an individual animal basis [16,17,18] by considering 20% leftover. Whereas, supplements were offered on 300 g level per head per day on a DM basis in two equal portions at 08:00 and 16:00h. The 300 g per head per day on DM basis of cowpea hay was applied based on the recommendations of Koralagama, et al. [19], who obtained 48 and 51 gh^{-1}d^{-1} of ADG by supplementing 300 g of genotype 12688 (forage-type) and IT96D-774 (dual-purpose) cowpea haulms, respectively for Ethiopian highland (Arsi) sheep. Moreover, the 300 g level of WB was chosen to provide nitrogen content similar to that supplied by the lowest level of cowpea supplementation, approximately 166.63 g N/kg DM.

Lambs were offered grass hay before the supplements. Amount of feed offered and refused were recorded daily for each experimental animal to determine the daily feed intake of an individual animal. Leftover was collected and weighed every next morning. Samples of feed offer were taken per batch of feed and refusals were taken per animal throughout the experimental period and pooled on treatment basis for determination of chemical composition.

2.5.2 Bodyweight change measurement

Bodyweight was measured by the use of suspended or hanging scale, which had 50 kg weighing capacity, with 100 g of calibration or sensitivity. Lambs were weighed at the beginning of the experiment and subsequently at 10-days interval in the morning hours after overnight fasting of feed and water to avoid feed effect. Daily body weight gain was calculated as the difference between final and initial live weight divided by the number of feeding days. Similarly, feed conversion efficiency (FCE) was computed as a proportion of daily body weight gain to daily feed intake.

2.5.3 Carcass and non-carcass traits

After 90 days of feeding period followed by 7 days of digestibility trials, all lambs were transported to Abergelle International Livestock Development PLC for slaughter. Based on the recommendations of Chambers, et al. [20], the lambs were arrived at the slaughterhouse before one day of slaughter to allow for muscle glycogen to be replaced by the body as much as possible. Before slaughter, lambs were subjected for 12 hours of feed and water deprivation and weighed to obtain slaughter weight (SW). Lambs were slaughtered and dressed down using standard commercial techniques, with subsequent blood collection. The head of the individual lamb was detached from the body and weighed when the blood flow ceased. The skin was flayed and weighed. The forelegs and hind legs were trimmed off at carpal and tarsal joints, respectively and weighed. The alimentary tract was removed and weighed with and without its content. The empty body weight (EBW) was calculated by subtracting the gut fill from slaughter body weight.

After evisceration, carcasses were weighed to obtain hot carcass weight (HCW), which comprises the body after removing the skin, head, forefeet (at the carpal-metacarpal joint), hind feet (at the tarsal-metatarsal joint), viscera and fat depots. Internal organs (kidneys, liver, heart, lungs, spleen and pancreas) and fat depots such as scrotal fat, pelvic, kidney and gut fats (omental + mesenteric) were also removed.

Total edible offal components (TEOC) were taken as the total of blood, heart, empty gut (reticulo-rumen and omasum-abomasum), liver with gall bladder, kidney, kidney fat, testis, tail with its fat, small and large intestines and tongue. Similarly, total non-edible offal components (TNEOC) were considered as the sum of the head without tongue, lung with trachea, penis, skin, spleen, gut fill and feet with hooves.

Moreover, the rib eye muscle (*Musculus longissimus dorsi)* area was determined by cutting the chilled ribs between 12th and 13th ribs and was traced first on transparency waterproof paper then on a graph paper and the area was calculated by counting the squares on graph paper and multiplying with their area after the rib eye area was transferred to graph paper and the average of the two rib-eye muscle areas was taken for each lamb. Finally, dressing percentage (DP) was calculated as the proportion of hot carcass weight to slaughter and empty body weights using the formula [21]:

$$\text{First dressing percentages(DP1)} = \frac{\text{Hot carcass weight}}{\text{slaughter weight}} * 100$$

$$\text{Second dressing percentages (DP2)} = \frac{\text{Hot carcass weight}}{\text{empty body weight}} * 100$$

2.6 Analytical Procedures

Representative samples of feed offered and refusals were taken to determine their nutritional content. They were ground to pass a 1 mm sieve mesh since this is the critical size through which particles passing out of the rumen of sheep.

Table 1. Experimental treatments

Treatment	Grass hay	Amount of CPH supplement (g)	Amount of WB supplement (g)	Supplement amount (g head^{-1}day^{-1})	CP (g)	ME (MJ)
1	Ad libitum	300	0	300	51.4	6.7
2	Ad libitum	225	75	300	50.9	7.9
3	Ad libitum	150	150	300	50.5	7.9
4	Ad libitum	75	225	300	49.9	7.2
5	Ad libitum	0	300	300	49.5	8.2

CPH= cowpea hay; WB = wheat bran; CP= crude protein; ME= metabolizable energy

Analysis for DM, ash and nitrogen contents were done according to the Association of Official Analytical Chemists [22] procedures. Dry matter and ash contents of representative samples of feed and faeces were determined by oven drying at 105ºC overnight and by igniting in a muffle furnace at 550ºC for 6 h, respectively. Nitrogen (N) content was determined by using the Kjeldahl method and crude protein (CP) was calculated as N×6.25. Neutral detergent fibre (NDF), acid detergent fibre (ADF) and acid detergent lignin (ADL) were determined by using the procedures of Van and Robertson [23]. Similarly, organic matter (OM) was computed as 100 minus ash.

2.7 Statistical Analysis

Data on feed intake, live weight, body weight gain, carcass and non-carcass traits were subjected to analyses of variance (ANOVA) procedure according to a Randomized Complete-Block Design using the Generalized Linear Model (GLM) of the Statistical Analysis System for Windows (SAS, 2002) to detect treatment effects. During analysis, treatment was considered as an independent variable whereas feed intake, final body weight, daily weight gain and carcass traits were considered as dependent variables. Treatment means were compared using Fisher's Least Significant Difference (LSD) test at 5% level of probability.

The statistical model used was:

$Y_{ij} = \mu + T_i + B_j + e_{ij}$
Where: Y_{ij} = response variable
μ = the overall mean
T_i = the i^{th} treatment effect
B_j = the j^{th} block effect
e_{ij} = i^{th} random error

3. RESULTS

3.1 Chemical Composition of Experimental Feeds

The crude protein (CP) content of cowpea hay and wheat bran was higher compared to grass hay (Table 2). Meanwhile, the NDF and ADF contents of grass hay were higher compared to that of cowpea hay and wheat bran. Cowpea hay had relatively higher NDF, ADF and ADL content compared with wheat bran. The refused grass had higher NDF, ADF and ADL, and lower CP and ash content compared to the grass on offer.

Table 2. Chemical compositions of experimental feeds

Feed offered		CP	NDF	ADF	ADL	Ash
	DM %	DM %				
Cowpea hay	88.75	17.15	60.00	50.30	14.50	12.50
Wheat bran	88.22	16.50	38.46	16.35	5.75	6.45
Grass hay	90.65	5.46	77.15	53.28	14.76	9.13

CP: crude protein; NDF: neutral detergent fiber; ADF: acid detergent fiber; ADL: acid detergent lignin; DM: dry matter; T1:300 g cowpea hay; T2:225 g cowpea hay + 75 g wheat bran; T3:150 g cowpea hay + 150 g wheat bran; T4:75 g cowpea hay + 225 g wheat bran; T5:300 g wheat bran

Table 3. Daily dry matter and nutrient intake of Begait lambs fed grass hay supplemented with *Vigna unguiculata* hay, wheat bran and their mixtures

Intake ($gday^{-1}$)	T1	T2	T3	T4	T5	SL	PSE
Grass hay DM	387.11^{b}	369.41^{b}	419.41^{a}	330.99^{c}	373.47^{b}	***	6.801
Supplement DM	300.00	300.00	300.00	300.00	300.00	ns	0.000
Total DM	687.11^{b}	669.41^{b}	719.41^{a}	630.99^{c}	673.47^{b}	***	6.801
Total DM (%BW)	2.21^{a}	2.08^{bc}	2.17^{ab}	2.01^{c}	2.11^{b}	**	0.099
Nutrient							
Total OM	682.07^{a}	669.35^{bc}	723.27^{a}	641.55^{c}	689.30^{ab}	**	7.625
Total CP	84.800^{ab}	82.631^{ab}	85.38^{a}	79.218^{c}	82.338^{b}	**	0.599
Total NDF	526.79^{a}	491.04^{a}	514.64^{a}	422.66^{b}	445.37^{b}	***	9.754
Total ADF	400.50^{a}	358.35^{b}	353.70^{b}	277.08^{c}	279.21^{c}	***	11.109
ME(MJ/day)	6.74^{c}	7.91^{ab}	7.85^{ab}	7.24^{bc}	8.17^{a}	**	0.160

*a-c, means with different superscripts in a row are significantly different; ***= (p<0.001); **= (p<0.01); PSE: pooled standard error of mean; SL: level of significance; ME : metabolizable energy; ns: not significant difference; CP: crude protein; NDF: neutral detergent fiber; ADF: acid detergent fiber; DM: dry matter; OM: organic matter; T1: received 300 g cowpea hay; T2: received 225 g cowpea hay + 75 g wheat bran; T3: received 150 g cowpea hay + 150 g wheat bran; T4: received 75 g cowpea hay + 225 g wheat bran; T5: received 300 g wheat bran*

Table 4. Growth performance of Begait lambs fed grass hay supplemented with *Vigna unguiculata* hay, wheat bran and their mixtures

Parameters	T1	T2	T3	T4	T5	SL	PSE
IBW (kg)	27.84	28.26	28.40	27.52	28.08	ns	0.299
FBW (kg)	31.12^{c}	32.18^{ab}	33.16^{a}	31.40^{bc}	31.90^{bc}	**	0.201
BWG (kg)	3.28^{c}	3.92^{b}	4.76^{a}	3.88^{b}	3.82^{b}	***	0.116
ADG(g)	36.44^{c}	43.56^{b}	52.89^{a}	43.11^{b}	42.44^{b}	***	1.286
FCE	0.053^{c}	0.065^{b}	0.074^{a}	0.068^{ab}	0.063^{b}	***	0.002

*a-c, means with different superscripts in a row are significantly different; ***= (P<0.001); ** = (P<0.01); ns: not significant; ADG: average daily gain; BWG: body weight gain; FBW: final body weight; FCE: feed conversion efficiency; IBW: initial body weight; PSE: pooled standard error of mean; SL: level of significance; T1: received 300 g cowpea hay; T2: received 225 g cowpea hay + 75 g wheat bran; T3: received 150 g cowpea hay + 150 g wheat bran; T4: received 75 g cowpea hay + 225 g wheat bran; T5: received 300 g wheat bran*

Table 5. Carcass parameters of Begait lambs fed grass hay supplemented with *Vigna unguiculata* hay, wheat bran and their mixtures

Parameters	Treatments					SL	PSE
	T1	T2	T3	T4	T5		
SW(kg)	29.16^{b}	30.10^{a}	30.74^{a}	29.28^{b}	30.00^{a}	***	0.139
HCW (kg)	11.92^{b}	12.61^{a}	12.92^{a}	11.96^{b}	12.42^{a}	***	0.084
EBW(kg)	21.44^{b}	21.87^{ab}	22.55^{a}	21.30^{b}	21.69^{b}	*	0.137
DP (%)							
DP1	40.89^{b}	41.91^{a}	42.04^{a}	40.87^{b}	41.40^{ab}	*	0.162
DP2	55.62^{c}	57.68^{ab}	58.66^{a}	56.18^{bc}	57.32^{ab}	*	0.353
REA (cm^2)	8.49^{c}	10.53^{b}	12.18^{a}	10.08^{b}	10.67^{b}	***	0.254
TEOC (kg)	4.71^{b}	4.39^{b}	5.08^{a}	4.03^{c}	4.91^{b}	***	0.078
TNEOC (kg)	12.02^{b}	12.34^{b}	13.01^{a}	12.89^{b}	13.41^{a}	***	0.108

*a-d, means with different superscripts in a row are significantly different; ***= (P<0.001); *= (p<0.05); SW: slaughter weight; HCW: hot carcass weight; EBW: empty body weight; DP: dressing percentages; DP1: HCW/SW; DP2: HCW/EBW; REA: rib-eye muscle area; PSE: pooled standard error of mean; SL: level of significance; TEOC: total edible offal component; TNEOC: total non-edible offal component; T1: received 300 g cowpea hay; T2: received 225 g cowpea hay + 75 g wheat bran; T3: received 150 g cowpea hay + 150 g wheat bran; T4: received 75 g cowpea hay + 225 g wheat bran; T5: received 300 g wheat bran*

3.2 Feed Intake

Variations in hay DM, total DM, NDF, ADF (p<0.001), OM and CP intake (p<0.01) were observed among treatment groups (Table 3). Hay and total DM intake were greater (P<0.001) for T3 and no difference (p>0.001) among T1, T2 and T5. Total DM intake as metabolic body weight was higher (P<0.01) for T1 compared to T4 and T2, but no difference (P>0.01) among T1, T3 and T5. NDF and CP intake were higher for T3 compared to T4 and T5, but same among T1, T2 and T3. However, T4 had the least OM, CP, NDF and ADF intake.

3.3 Growth Performance

As presented in Table (4) T3 had higher body weight gain and average daily weight gain (ADG) (p<0.001) compared with other treatment groups but, same with T2 on final body weight and T4 on FCE. There was no difference among T2, T4 and T5 on final body weight (p>0.01), body weight gain, ADG and FCE (p>0.001). Lower body weight gain, ADG and FCE (p<0.001) were recorded in T1.

3.4 Carcass Traits

Significant difference on slaughter weight, hot carcass weight (HCW), rib-eye muscle area (REA) (p<0.001), empty body weight (EBW) and dressing percentages (DP) (p<0.05) on SW and EBW basis was observed among treatment groups (Table 5). Higher values on SW and HCW were recorded by T3, T2 and T5. T1 and T4 had similar SW, HCW, EBW and DP on slaughter and empty body weight basis. T3 had higher dressing percentages on SW and EBW basis in comparison with T1 and T4, but same with T2 and T5. Similarly, T3 had higher REA and TEOC compared to the other treatment groups.

4. DISCUSSION

4.1 Chemical Composition of Experimental Feeds

The crude protein (CP) content of grass hay was lower than the values obtained before [24,25,26, 27], but it was higher than the value (3.6%) that obtained by Bishaw and Melaku [28]. It was, however, comparable with that of Abraham [29]. The difference in CP content among the studies might be due to difference in species or variety, soil, climate, grazing, plant fraction and stage of maturity at sampling [30]. Moreover, the CP content of grass hay was below the maintenance requirements of the animals, 7% [31] and lower compared with 11% noted for good quality hay [32]. The low CP content of grass hay was due to the over the maturity of the grass at the time of harvest since the stage of maturity has a direct relationship with cell wall constituent and inversely related with the percentage of CP [32].

Moreover, the CP content of cowpea hay was in line with the previous reports that noted by [33, 19,34) and above recommended minimum requirements for lactation (120 g/kg DM) and growth (113 g/kg DM) in ruminants [35]. The difference in CP content among the studies might be due to variation in cowpea variety, soil fertility, climate and stage of maturity at harvest. Higher neutral detergent fibre (NDF) and acid detergent fibre (ADF) obtained in the present study could be due to the variety and environment where this variety was produced. Likewise, the CP content of wheat bran was comparable with the previous reports [36,37,25,38,39], but lower than that of [16] and [18]. The difference in CP content of wheat bran among the studies could be attributed to differences in the variety of the original wheat grain as well as the method of wheat flour processing employed [32]. Overall, the chemical composition of the supplements justifies their use as a supplement in hay-based feeding of sheep.

4.2 Feed Intake

Higher dry matter intake as metabolic body weight in T1 was in an attempt to meet their energy requirements. High total DM intake in T3 might be due to higher CP, OM and ADF digestibility. Basal diet and total DM intake were comparable with that of Koralagama, et al. [19]. The total DM intake was lower compared with the previous studies [28,40,27]. The low total DM intake obtained was due to high ADL and NDF content of grass hay and high NDF and ADF content of cowpea hay. The difference in DM intake among the studies could be due to differences in the chemical composition of the experimental diets. The higher the CP content, the higher the intake and the higher the growth rate [41].

The higher and lower CP intake in T3 and T4, respectively were in part due to greater and lower DM intake. The CP intake was within the range of previous studies [42,26], but below that of Bishaw [28,25,39,43]. The difference in CP intake among the studies might be due to difference in CP content of the experimental diets. The CP intake as a per cent of total DM intake (11.86-12.55%) was above 8%, this indicates that all treatment groups have no negative impact on overall feed intake [44]. Except for lambs in T1, which received metabolizable energy (ME) below their requirements, all lambs received above their CP and ME requirements ($55.0gd^{-1}$ and $7.0\ MJd^{-1}$) according to the recommendations of (ARC) [45]. Moreover, the positive body weight gain was an indicator of getting nutrients above their maintenance requirements.

4.3 Growth Performance

Higher average daily body weight gain (ADG) obtained from T3 could be due to greater DM and CP intake and feed conversion efficiency (FCE). According to Warmington and Kirton [46], increased growth was largely attributable to higher intakes of higher protein diets. On the contrary, lower values on final body weight ($p<0.01$), ADG and FCE ($p<0.001$) observed in T1 were due to low ME intake. The low ADG in T1 as compared with T5 could be due to the relatively lower ME intake. A similar result was found by Sayed [47] who observed lambs received highest energy level diet had a higher ($P < 0.05$) average daily body weight gain than that received low energy diets. There were also similarities among T2, T4 and T5 on final body weight ($p>0.01$), body weight gain, ADG and FCE ($p>0.001$), which reflected that the supplements were comparable in their potential to supply nutrients to improve weight gains of Begait lambs. The variation on ADG could be attributed to variation in nutrient supply from the diets [48].

The ADG obtained was lower compared with that of Koralagama, et al. [19] for Ethiopian Highland (Arsi) sheep and [43] and [34] for the same breed of sheep. Breed difference and having higher NDF, ADF and ADL contents of cowpea hay (CPH) used in this study could be the possible reasons with Koralagama, et al. [19]. Similarly, low ADG in T5 as compared with that noted by Bishaw and Melaku [28] might be due to the difference in the quality of basal diet and wheat variety from which the wheat bran was prepared. Generally, the low ADG obtained could be due to the low DM intake, which could be due to low CP content of grass hay and high NDF and ADF content of cowpea hay. Regardless of this, an increase in weight indicated that nutrients in the diets were adequate for growth performance.

Except for T4, the FCE value followed the trends of ADG. Higher FCE observed in T3 implies that lambs in this treatment group consumed lower feed per unit of gain than in T1, T2 and T5. Low FCE in T1 was supported by Sayed [47] who reported lower FCE in lambs group fed on low energy diet; here the decrease in growth rate and live weight attained could be the reason. Similarly, [49] observed an improvement in FCE with energy density. In this study, up to 50% replacement of cowpea hay to wheat bran (WB) appeared to impart positive response in animal performance.

4.4 Carcass Traits

Carcasses were evaluated based upon dressing percentage (DP), carcass weight (HCW), rib-eye-muscle area (REA) and internal fat deposits. Higher dressing percentage obtained from T3 could be attributed to higher CP intake leading to better tissue deposition and better growth performance. On the contrary, the relatively low slaughter body weight, HCW and DP on empty body weight basis observed in T1 could be due to low growth performance and agrees with that found by Yagoub and Babiker [50]. Differences in HCW and REA, which are indicators of carcass leanness, observed among treatment groups were partly similar to growth performance.

The value for dressing percentage on dressing percentages that expressed as HCW / SW was within the range of the previous studies [19,42, 26]. It was, however; lower than the values noted by Sefa [27] and [16], the difference in the breed of sheep could be the possible reason. Moreover, it was lower than that of Michaele [34] for the same breed of sheep, which could be due to the difference in the nutrient composition of the experimental diets. The observed lower value of dressing percentages that expressed as HCW / SW could be due to higher gut fill. On the other hand, the value for dressing percentages that expressed as HCW / EBW was comparable and higher than that of Tsegay, et al. [16] and [42], respectively. Moreover, [41] reported 41.77-46.24 and 51.85-55.31% of DP on slaughter and empty body weight basis, respectively, which was comparable with the current finding. Dressing percentage is the proportion of body weight considered to be edible and is an important trait in carcass merit consideration.

Dressing percentage on slaughter body weight basis is smaller than that of on an empty body weight basis, this implies the influence of digesta (gut fill). It’s more meaningful to express DP as the proportion of empty body weight than slaughter body weight base. Gut contents contribute 4-14% of fasted live weight in sheep and goats fasted for about 24 hours before slaughter. Dressing percentage of sheep is generally between 40-50% (on empty body weight base) but depends very much on what parts of the carcass are sold as meat [31] and vary widely due to breed, levels of fatness, sex and animal husbandry system [51]. According to [51], in heavy muscled and fatter sheep, dressing percentage can extend up to 54-55% depending on weighing condition. Thus, the difference in carcass characteristics among the studies could be due to a difference in the breed of sheep, slaughter weight and age and level of nutrition.

The value for REA was higher than that of Hirut Yirga, et al. [37] and [27], which could be due to the difference in breed of sheep and age of the experimental animals; since the lambs used in this study were too young (5-6 months of age) and it's already known that fat and age are positively correlated. This is the reason why it's recommended to slaughter animals at a younger age. But, it was in line with that of Abebe Hailu, et al [52]). Rib-eye-muscle area is an indicator of the amount of lean muscle associated with a carcass since these two parameters are positively correlated [37]. As the REA increases, the amount of muscle in a carcass increases and yield grade tends to improve [53]. Rib-eye muscle area is frequently used as a measure of carcass lean or an expression of carcass desirability.

Moreover, carcass offal components were categorized in to edible and non-edible based on the eating habit of the people in the study area. The high and low total edible offal components

(TEOC) ($p<0.001$) in T3 and T4, respectively indicated that live weight affects the production efficiency of the offal. The difference in the alimentary tract was attributed with the daily feed intake. Nutritional status of the animals and body weight affect the production efficiency of the offal [54], which was comparable with T3 and T4 of the current study.

The function of the spleen is to store blood for release under stressful conditions, therefore, the smaller spleen size might have been related to a concomitant reduction in blood weight [27], which is in agreement with T1. Lower skin and spleen weight observed in T1 might be due to lower SW since SW has a positive relationship with skin [55] and spleen weight. Higher gut fill in T4 and T5 might be due to the inadequate supply of nutrients (energy and protein) and was not in agreement with that of Mahgoub, et al. [56] and [50] who observed gut fill significantly increased with the decrease of dietary energy level.

5. CONCLUSION

This study indicated that diet influenced growth performance and carcass traits. Among the diets evaluated, the treatment group with 150 g of cowpea hay and 150 g of wheat bran had better growth performance and carcass traits. The study also ensured that Begait lambs fed on 150 g of cowpea hay and 150 g of wheat bran had the highest meat value with desirable fat as compared to other treatments set-up. However, Begait lambs fed on 300 g cowpea hay didn't improve body weight gain and carcass yield. Therefore, the study suggested that feeding mixture of 150 g of cowpea hay and 150 g of wheat bran improved sheep performance.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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