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Cajanus cajan and *Lablab purpureus leaf meal-potential supplements* over conventional protein sources for yearling Horro sheep fed a basal diet of fodder oat (*Avena sativa*) hay

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ABSTRACT

A 90-day feeding trial with 25 yearling Horro lambs (22.6 ± 1.8 kg) was conducted from November 2022 to January 2023. The trial was designed to see how supplementing forage varieties of *Cajanus cajan* (Degagsa and Belabas) and *Lablab purpureus* (Beresa-55 and Gebis-17) affected the growth performance, feed intake and digestibility of Horro lambs fed a basal diet of fodder oat hay compared to conventional protein supplements. Five experimental sheep per treatment were arranged in a Randomized Complete Blocked Design to receive dietary treatments formulated on an iso-nitrogenous basis which was targeted to provide crude protein (CP) of 64.37 g/h/day. Data were taken on weight gain, feed conversion ratio, feed intake and refusal, and in-vivo digestibility features. All lambs were fed *ad-libitum* fodder oat hay containing 91.5 % Dry matter, 7.8 % ash, 6.4 % crude protein, 60 % neutral detergent fiber, 42.8 % acid detergent fiber, 13.4 % acid detergent lignin and 65 % in-vitro organic matter digestibility. The dietary treatments were fodder oat hay plus 280.8 g Gebis-17 variety (T1), 274.4 g Beresa-55 variety (T2), 320.9 g Belabas variety (T3), 329.3 g Degagsa variety (T4) and 300 g concentrate mixture (T5). The total dry matter intake (DMI) was higher in T3 and T4 than in the other treatment groups. Except for CP, nutritional consumption differed significantly across treatments. T3 and T4 had higher fiber intakes than the other treatments, while T2 had higher ash intakes and T5 had higher metabolizable energy intakes. Even though there was no significant variation in final body weight, lambs in T5 and T1 showed the greatest weight change and average daily gain. Although the diet in T5 induced the lamb performance in a manner comparable to that of the other dietary supplements, its inaccessibility and high cost would limit the use of such supplements by smallholder farmers. Thus, depending on their availability, either *Lablab purpurues* or *Cajanus cajan* varieties could be employed as feed supplements in the lambs` diet.

1. Introduction

Ethiopia has a large and diversified indigenous sheep population, producing some of the nation's most valuable meats. Based on Galal (1983) report, the country is home to fourteen traditional sheep populations, which can be divided into four main categories according to the type of tail they have: short, long, thin, and fat-rumped. Furthermore, Ayele and Urge (2019) reported that 75 % of Ethiopia's sheep population is raised in mixed crop-livestock systems, with the remaining 25 % retained in pastoral and agro-pastoral systems. Gizaw et al. (2013) stated that sheep are especially valuable to farmers in the subalpine highlands where crop production is unpredictable, as well as to pastoralists and agro-pastoralists. Farmers always strive to raise sheep that can supply the highest amount of lean meat in the shortest amount of time because raising sheep in most production methods produces meat quickly (Gizaw et al., 2013).

Horro sheep, one of the indigenous breeds, primarily inhabit the mixed crop-livestock systems of western Ethiopia. These sheep have been adapted from cool, wet highland (2991 m) to humid mid-highlands (1600 m). Zewdu (2008) highlights the breed`s unique traits, including a rapid growth rate, good mature ability, a higher percentage of twinning, and early lambing. These characteristics set the stage for the research on feed supplementation. The widely available feed resources such as natural pasture and crop residue could not allow this sheep breed to fully express their genetic potential (Tolera, 2012). Poor quality feed prevents animals from consuming enough feed to gain weight, causing them to

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age before they reach the ideal live weight for sale (MacDonald et al., 2010). This implies the need to look for alternative quality feed supplements for optimal use of the feed resources and consequent improvement of sheep production. Supplementation with nutrient-rich feed resources, mainly agro-industrial by-products has been used in many developed countries for improving locally available poor quality feed resources (Xianjun et al., 2012). Under smallholder livestock production systems, however, the use of such supplements is usually limited due to their inaccessibility to farmers and unaffordable cost.

The use of leguminous forage crops as an alternative supplemental diet is more promising because, in addition to being more affordable and easily produced locally, they also have low fiber content and high crude protein and mineral, making them a good option during the dry season when pasture is scarce or of poor quality (Hailecherkos et al., 2020; Makuriaw and Asmare, 2018). The supplementary value of leguminous fodder crops on production (Abera et al., 2021; Dida et al., 2023; Shibeshi et al., 2022; Tulu et al., 2018a) and reproduction (Tulu et al., 2023) performance of ruminant animal have been widely explored and published in various literatures. Those findings confirmed that production of forage legumes could provide useful nutrients in areas where agro-industrial by-products are not readily available (Tolera et al., 2012).

Cajanus cajan and *Lablab purpureus* are leguminous forage crops widely adapted to the agroecology of the current study area. Tulu et al. (2021) who evaluated ten pigeon pea genotypes under the agroecology of the present study area reported that the forage yield ranged from 3.16-7.22 t/ha, with the mean crude protein (CP) and neutral detergent fiber (NDF) content of 201 and 532.5 g/kg DM, respectively. On the other hand, a study conducted by Tulu et al. (2018b) using ten *Lablab purpureus* genotype revealed that, Lablab could produce herbage dry matter yield ranging from 2.4-8.5 t/ha, with the mean CP and NDF content of 167.8 and 553.4 g/kg DM, respectively. Although two improved leguminous forage varieties of *Lablab purpureus* (Gebisa-17 and Beresa-55) and *Cajanus cajan* (Belabas and Degagsa) were released as a variety and documented along with their nutrient profile, data on their feeding value have not been studied yet. Therefore, there was a strong need to further evaluate these promising tropical forage crops in terms of their role in animal response. Therefore, the objective of this study was to evaluate the growth, feed intake, and digestibility of Horro sheep given fodder oats as a basal diet when supplemented with *Lablab purpureus* and *Cajanus cajan* varieties over conventional protein supplements.

2. Materials and methods

2.1. Study area

The study was carried out at Bako Agricultural Research Centre. The site depicts the mid-altitude, sub-humid maize growing agro-ecology of Western Oromia, Ethiopia. The center is located at 9°06′N and 37°09′E, and it is 1650 m above sea level, with a mean monthly minimum and maximum temperatures of 11.23 and 31.74 °C, respectively. During the study period, the area received an annual rainfall of approximately 1316.7 mm.

2.2. Ethical statement for the experimental animal care

The experiment protocol utilized in this study was based on the Ethiopian Animal Experiments Inspectorate's institutional guidelines for animal experiments, which are part of Ethiopia's ministry of livestock and fisheries. The experiment was carried out following the regulations for the management of experimental animal care.

2.3. Feed preparation

The released fodder oat variety (Bate) was used as a basal diet, with two varieties of *Lablab purpureus* (Beresa-55 and Gebisa-17) and *Cajanus cajun* (Belabas and Degagsa) serving as supplements. The experimental forage were established at the Bako Agricultural Research Center in the early June 2019 cropping season. During plantation, all prescribed agronomic practices for both forage legumes and fodder oats were properly followed. During haymaking, both legume forage types and fodder oats were harvested after they reached approximately 30-40 % flowering stage, field-cured for 2–3 days depending on weather conditions, baled, and stored in a roofed hay barn. The legume forages were then chopped into 3–5 cm lengths to make them more homogeneous for sampling and accessible to the animal. Wheat bran and Noug seed cake were purchased from nearby wheat and oil processing companies.

2.4. Experimental animals and their management

Twenty five yearling Horro lambs (22.6 ± 1.8 kg) were bought from the local market. All lambs were isolated for fifteen days before being assigned to the various dietary treatments. Lambs were ear-tagged for easy identification, dewormed with anti-helminthic to control internal parasites, and sprayed with acaricides for exterior parasite management as directed by the manufacturer prior to the start of the experiment at the center. At the end of the quarantine period, all lambs were tied into their individual pens and fed the experimental diet for 15 days to acclimate them to the experimental feeds before beginning the 90-day feeding study.

2.5. Experimental design, treatments and feeding

The study employed a Randomized Complete Block Design wherein the experimental lambs were divided into five groups, each comprising five lambs. Lambs were grouped into blocks according to their initial live weight, which was measured in the morning before they were fed and watered. All experimental lambs were fed the basal diet ad libitum, with a 20 % refusal rate modified weekly. Forage legume (*Lablab purpureus* and *Cajanus cajan*) hay and a concentrate mixture were supplemented on an isonitrogenous basis. A mixture of concentrate composed of Noug seed cake and wheat bran mixed at the proportion of 33 %:67 % was formulated and provided as a supplement to one of the treatment groups assigned as a positive control.

The amount of concentrate mixed supplement was established at 300 gm/head/day which would result in good performance in growing indigenous sheep breeds (Fentie, 2007; Bekele et al., 2013). As a result, the daily amount of the legume supplements were estimated using their crude protein (CP) content to ensure that they were iso-nitrogenous with the control group (concentrate mixture). Thus, the daily allowance of legume supplements was calculated to supply 64.37 g CP, which fits between the 60 to 65 g CP/head/day recommended by ARC (1980) for growing sheep weighing 20–30 kg and gaining 100 g/head/day. As a result, all of the lambs received free access to fodder oat hay along with the following supplemental feeds: 280.8 g Gebis-17 (T1), 274.4 g Beresa-55 (T2), 320.9 g Belabas (T3), 329.3 g Degagsa (T4), and 300 g concentrate mixture (T5).

The actual feeding trial began by providing the experimental feed for 90 days. The experimental lambs were given free access to clean water and common salt blocks until the completion of the trial. To calculate daily feed intake as the difference between feed offered and refused during the trial period, the amount of feed offered to each experimental lamb and the associated refusals were noted on daily basis. At the end of the experiment, feed samples that were offered and refused were combined for each treatment, well mixed, and subsampled for chemical analysis. The daily DM intake expressed as a percent of the body weight of lambs was calculated by employing the following formula:

$$\text{Total DM intake}(\text{percent body weight}) = \frac{\text{Total DM intake}(\text{gm/d})}{\text{Final Body weight (kg)}} \times 100$$

2.6. Body weight change and feed conversion efficiency

Lambs in all groups were weighed on the first day of the actual feeding trail to determine their initial body weight. Following that, a weight record was taken at every fifteen days interval in the morning before the morning feeding and watering. The feeding trial began in November 2022 and ran for ninety consecutive days, ending in January 2023. The average daily weight gain and feed conversion efficiency (FCE) for each lamb were calculated using the equation below (Brown et al., 2001; Gulten et al., 2000).

$$\text{Average daily weight gain} = \frac{\text{Final body weight} - \text{Initial body weight}}{\text{Number of feeding days}}$$

$$\text{FCE} = \frac{\text{Body weight gain}(g/d)}{\text{DM intake}(g/d)}$$

2.7. Digestibility trial

Before the actual digestibility study, lambs in all groups were fitted with fecal collection bags and allowed to adapt for three days. Then, the real data collection was continued for another 7 days. During these days, voided feces were collected, weighed, recorded, and thoroughly mixed from each lamb separately. Twenty percent of each lamb's daily fecal output was sub-sampled, pooled in plastic bags, and deep-frozen at -20 °C. At the end of the digestibility trial, the daily collected sub-samples were thoroughly mixed and pooled for each individual lamb, pending chemical analysis. The following formula (McDonald et al., 2002) was used to determine apparent digestibility coefficients of nutrients:

$$\text{Apparent Digestibility Coefficient}(\%) = \frac{(\text{Nutrient in feed} - \text{Nutrient in feces})}{\text{Nutrient in feeds}} \times 100$$

Metabolizable energy intakes were also estimated using the formula: ME (MJ Kg^{-1} DM) = DOMD X 0.016: Where DOMD; is gram-digestible organic matter per kilogram of dry matter. The digestible organic matter contents of treatment feeds were estimated by multiplying the OM content of the feed by its digestibility coefficient.

2.8. Chemical analysis

Dry matter, N (crude protein = N*6.25) and Ash were analyzed according to AOAC (2005) procedure. Organic matter content was estimated by deducing the value of ash from 100 as OM = 100-ash. Neutral detergent fiber, acid detergent fiber, and acid detergent lignin were analyzed using the procedure of Van Soest et al. (1991). In-vitro organic matter digestibility was estimated using the procedure of Tilley and Terry (1963).

2.9. Statistical analysis

Data on feed intake, weight gain and nutrient digestibility were subjected to the mixed model procedure of SAS (SAS, 2002, version 9) by fitting dietary treatment as a single fixed factor, while experimental animals are considered as a random effect in the model. The measured dependent variables were first checked for normality and homoscedasticity of variance, and transformation was conducted for the required parameters. Significantly different means were separated by using Fisher`s least significant difference test at a 5 % level of significance. The block effect and random effects of experimental lambs were initially included in the model, but both were excluded from the final analysis because their impact was not significant ($P > 0.05$), as seen in the model: $Yi = \mu + Ti + ei$; Where; Yi = response variable; μ = overall mean of the response variable; Ti = the fixed effect of the i^{th} dietary treatment (j = 1, 2,3,4 and 5) and ei = random error.

3. Results and discussion

3.1. Feed chemical composition

Table 1 displays the chemical composition of the experimental diets utilized in the present study. The experimental diets had comparable dry matter contents, but fiber and non-fiber nutrients contents differed. The ash content of Gebis-17 and Beresa-55 was higher, but wheat bran had a lower content; the other diets displayed an intermediate value for this parameter. The crude protein content varied, ranging from a greater value of 31.43 % (Noug seed cake) to a lower value of 6.43 % from the fodder oats (Bate variety), which also contained more fiber than the other experimental diets. The organic matter content of wheat bran was higher but lower for the two *Lablab purpureus* varieties (Beresa-55 and Gebis-17). The concentrate mixture showed higher in-vitro organic matter digestibility than the rest of the dietary feeds. The fiber and non-fiber nutrient features discovered in this study were consistent with earlier findings (Diribsa et al., 2016; Sisay et al., 2023; Tulu et al., 2018a; Tulu et al., 2023).

3.2. Dry matter and nutrient intake

Table 2 displayed the daily dry matter and nutrient intake of the experimental lambs. Dietary treatments showed significant differences in total DMI ($P < 0.01$), but not in basal hay or intake on percent body weight basis ($P > 0.05$). The hay intake in the current study was lower than that reported by Tassew et al. (2022) who investigated the effects of vetch hay supplementation on Arsi-Bale sheep fed a basal diet of fodder oat, but higher than that reported by Tulu et al. (2018a). This discrepancy could be attributed to the difference in nutritional characteristics of the dietary feeds and the breed used in the study. During the trial period, all lambs consumed the supplements without showing any refusal. The primary reason for the difference in daily provision of supplemental diets among the treatment groups appears to be the diet adjustment designed to obtain an iso-nitrogenous level of supplements.

The total DMI of lambs in T3 and T4 was comparable and considerably greater than lambs in T1, T2, and T5, while lambs in T5 had a higher intake than lambs in T1 and T2. Even though the dietary groups consumed nearly the same amount of basal hay, the observed variation in total DMI could be attributed to daily variations in the supplemental feed given. The total DMI of the current study (923.75–978.63 g/d) were consistent with the value ranging from 768.4–954.9 g/d reported for the same sheep breed (Gemechu et al., 2020), but higher than the value reported by Sisay et al. (2023) for Blackhead (557.5 -869.9 g/d) sheep. The DMI on a percent body weight basis recorded in the current study varied from 3.32 to 3.65 %, which was consistent with the value reported by Devendra and Burns (1983) for several breeds of sheep and goats in the tropics (2.5 to 3.9 %).

Except for crude protein ($P > 0.05$), significant variation ($P <$

Table 1
Chemical composition of experimental feeds.

Feed sample	DM %	Nutrient composition (%DM)						
		Ash	CP	NDF	ADF	ADL	OM	IVOMD
Beresa-55	91.9	13.5	23.5	43.9	25.34	5.64	86.5	63.9
Gebis-17	91.8	10.1	22.9	44.6	26.9	5.6	89.9	62.3
Degagsa	91.0	7.0	19.6	44.3	30.3	9.7	93.0	53.1
Belabas	90.9	7.1	20.1	48.3	32.8	10.6	92.9	53.43
WB	91.9	3.8	16.5	39.1	7.9	1.0	96.2	75.3
NSC	92.3	7.0	31.4	34.6	19.2	7.2	92.9	71.0
Fodder oat (Bate)	91.5	7.8	6.4	60.0	42.8	13.4	92.2	65

Note: DM = dry matter' CP = crude protein; NDF = neutral detergent fiber; ADF = acid detergent fiber; ADL = acid detergent lignin; OM = organic matter; IVOMD = in-vitro organic matter digestibility; WB = wheat bran; NSC = noug seed cake

Table 2
Dry matter and nutrient intake of Horro lambs fed a basal diet of fodder oat hay and supplemented with *Cajanus cajan* and *Lablab purpureus* varieties, and concentrate mixture.

Intake (g/day)	Treatments					SEM	*P-value*
	T1	T2	T3	T4	T5		
Dry matter							
Basal hay	651.8	649.3	654.6	649.3	650.2	3.67	0.8252
Supplements	280.8[d]	274.4[e]	320.9[b]	329.3[a]	300.0[c]	0.00	<0.0001
Total Intake	932.6[c]	923.7[c]	975.5[a]	978.6[a]	950.2[b]	3.67	<0.0001
Intake (% BW)	3.4	3.4	3.6	3.6	3.3	0.11	0.1662
Total nutrient intake							
NDF	592.2[b]	576.3[c]	601.5[a]	599.3[ab]	568.1[d]	2.57	<0.0001
ADF	426.2[bc]	425.9[c]	431.9[ab]	436.1[a]	378.2[d]	1.94	<0.0001
ADL	37.6[c]	37.4[c]	56.2[a]	53.9[ab]	31.1[d]	0.12	<0.0001
Ash	79.1[b]	87.6[a]	73.8[c]	73.6[c]	65.3[d]	0.29	<0.0001
OM	853.4[c]	836.2[d]	901.7[a]	905.1[a]	884.8[b]	3.39	<0.0001
CP	106.3	106.1	106.5	106.1	106.2	0.24	0.8299
ME (MJ/day)	9.58[b]	9.56[b]	9.55[b]	9.55[b]	10.31[a]	0.04	<0.0001
Digestible nutrient intake							
DM	429.7	505.6	462.9	450.9	470.4	56.75	0.9087
CP	61.0	72.7	59.9	52.2	67.9	4.88	0.0893
NDF	241.3	306.3	222.7	236.8	240.2	30.82	0.3916
ADF	169.7	214.5	187.9	155.7	184.2	23.95	0.5233
OM	403.9	465.8	442.9	432.4	464.8	51.09	0.9027

[a,b,c,d]Means within a row with different superscripts differ significantly ($P < 0.05$); SEM (Mean + SE) = standard error of means; T1 to T5 = treatments; BW = body weight; DM = dry matter; CP = crude protein; OM = organic matter; NDF = neutral detergent fiber; ADF = acid detergent fiber; ADL = acid detergent lignin; ME = metabolizable energy.

0.0001) for total NDF, ADF, ADL, ash and ME intake were observed among the dietary treatments. NDF, ADF and ADL intake were higher for Lambs in T3 and T4 fed Belabas and Degagsa variety, respectively but the least one was observed from lambs fed concentrate mixed diet (T5). The likely reason for the higher NDF, ADF and ADL intake observed in T3 and T4 could be related to the higher cell wall contents in Belabas and Degagsa varieties as compared to the rest of the dietary treatments. The total ash intake was also higher for lambs fed diets in T2 followed by those in T1, while the least intake was seen from lambs fed concentrate mixed diet (T5). The variability in ash content among the experimental feeds might be the major factor contributing to the observed difference where the Beresa-55 variety contained the higher value while the mixed concentrates (wheat bran and noug seed cake) demonstrated the lower value. Total organic matter intake was higher in lambs fed diets in T3 and T4, followed by those in T5, than in the other dietary groups. The observed variation may have resulted from reduced ash consumption (Table 2) or lower ash content of the diets supplied to the lambs in those treatment groups (Table 1).

Despite the non-significant variation in CP intake among the dietary treatments, the result obtained in the current study (106.13–106.47 g/d) was comparable to the value reported in the literature. Hunegnaw and Berhan (2016) who supplemented Wollo sheep with pigeon pea, cowpea and Lablab reported CP intake ranging from 100.88–105.61 g/d for the supplemented groups. Similarly, CP intake ranging from 100.26–102.77 g/d was also reported by Dida et al. (2023) for Gummuz sheep supplemented with *Azadirachita indica* leaves, stylosanthes fruicosa and dolichose lablab as a substitute for concentrate mixed diet. Diribsa et al. (2016) who evaluated the performance of Horro sheep, however, reported CP intake which ranged from 93.9–145.1 g/d which was by far higher than the value obtained in the current study. Despite similar breeds used in these studies, this disparity might be caused as a result of the additional wheat bran supplemented across the treatment groups which is not in the case of the current study. According to ARC (1980), the CP requirement for growth of a 20 kg sheep gaining 50–100 g daily is reported to be in the range of 40–55 CP g/d and that of 30 kg sheep is 55–65 CP g/d. Hence, CP intake in the current study was above the satisfactory CP requirement for growth (33.34–81.39 g/day) of Horro sheep fed hays from *Lablab purpureus* and *Cajanus cajan* varieties, and concentrate mixture.

Intake of ME was also significantly varied ($P < 0.0001$) among the dietary treatments, where significantly higher ($P < 0.001$) value was recorded for lambs fed diet in T5 (10.31 MJ/d) as compared to the rest of the treatment groups. The observed ME intake in the current study was comparable with the values reported by Gezahegn et al. (2020) for Bonga (8.3–10.2 MJ/kg DM) sheep, but higher than reported by Gebrekidan et al. (2019) for Begait (6.74–8.17 MJ/kg DM) sheep. According to ARC (1980), the ME requirement for growth of a 20 kg sheep gaining 50–100 g daily is reported to be in the range of 5.1–6.2 MJ/kg DM and that of 30 kg sheep be 7–8.5 MJ/kg DM. Thus, the ME intake observed in the present study (9.55–10.31 MJ/kg DM) meets the energy requirements for maintenance and growth (33.34–81.39 g/day) of Horro sheep.

In the current study, there was no significant variation ($P > 0.05$) in the intakes of any of the digestible nutrients across the dietary regimens. This could be associated with the lack of considerable variation in the digestibility coefficients of the respective nutrients (Table 3). Gebregiorgis et al. (2012) found no change in the digestible nutrient intake of DM, OM, NDF, and ADF in Adilo sheep, which was consistent with the current study. The digestible nutrient intake for DM, NDF, and ADF noted in this study was comparable to what Diribsa et al. (2016) reported for the same sheep breed fed natural grass supplemented with pigeon pea and lablab fodder varieties while the digestible CP and OM intake in this study, was lower than what the author indicated. This variation may have resulted from the different basal feed used in those studies, which in this case was fodder oats. The DM, OM, ADF and NDF

Table 3
Digestibility coefficient (%) in Horro lambs fed a basal diet of fodder oat hay and supplemented with *Cajanus cajan* and *Lablab purpureus* varieties, and concentrate mixture.

Parameters	Treatments					SEM	*P*-values
	T1	T2	T3	T4	T5		
DM	60.2	69.2	61.6	60.2	62.9	5.88	0.8061
CP	58.8	68.9	57.5	50.3	64.8	4.57	0.0840
OM	61.3	67.9	63.2	61.8	65.8	5.76	0.8178
NDF	54.1	66.7	50.1	52.6	54.7	5.25	0.2647
ADF	51.1	62.8	47.7	48.7	49.4	4.83	0.2242

SEM: (Mean + SE)= standard error of means; T1 to T5 = treatments; DM = dry matter; CP = crude protein; OM = organic matter; NDF = neutral detergent fiber; ADF = acid detergent fiber.

digestible intake reported by Shitaneh et al. (2021) for Gumuz sheep supplemented with cowpea hay as a replacement for Noug seed cake was lower than the result found in the present study. However, the author reported a higher CP digestible intake value than the current study. This difference might be caused by variation in sheep breed and the quality of the supplemental and basal feed used for the experiments.

3.3. Dry matter and nutrient digestibility

The apparent DM, CP, OM, NDF and ADF digestibility coefficient of diets used in the present study (Table 3) did not show significant variation ($P > 0.05$). This could be due to the provision of higher and similar CP, and lower fiber contents of the dietary supplements which might have enhanced the supply of nutrients to ruminal microbes with resultant improvement in total digestibility of dietary nutrients (McDonald et al, 2010). While the concentrate mixture had lower fiber contents than the leguminous forage (*Cajanus cajan* and *Lablab purpureus*), the lack of significant variation in digestibility coefficients among dietary treatments may be explained by the presence of nitrogen in forage legumes, which promotes roughage feed fermentation in ruminants (Shitaneh et al., 2021). This, in turn, increases the forage legumes' rumen degradability and passage rate through rumen (MacDonald et al., 2010). McDonald et al. (2002) remarked that concentrate feed rich in protein promotes a high microbial population which in turn facilitates rumen fermentation. Interestingly, the lack of significant difference in the apparent digestibility of the dietary nutrient in this study signifies that leguminous forage crops (*Cajanus cajan* and *Lablab purpureus*) evaluated along with the conventional protein source could equally supply the required CP for effective rumen function.

The percentage digestible DM of feeds lower than 55 % is reported to be classified as poor quality (David, 2007), and thus values recorded in this study all exceeded the specified critical level suggesting that all the dietary supplements could be used as sources of quality feed supplements for animals. In line with the present finding, no significant variation in the digestibility coefficient for CP, OM, NDF and ADF was observed for yearling Abergell sheep (Gebru et al., 2017). Except for CP, lack of significant variation in digestibility coefficient for dietary DM, OM, NDF and ADF was noted for yearling highland (Tesfay and Tesfay, 2013) and Black Ogaden (Birhanu et al., 2013) sheep breeds. Contrary to this, Diribsa et al. (2016) and Gemechu et al. (2020) reported significant variations in the digestibility coefficient of dietary nutrients for the same breed. Variations in the type, quality, and amount of the basal diet, as well as the supplement, growth stage of the lambs, and other similar factors, may contribute to differences in the nutrient digestibility coefficient observed in the current and previous studies.

Table 4
Body weight gain and feed conversion efficiency of Horro lambs fed a basal diet of fodder oat hay and supplemented with *Cajanus cajan* and *Lablab purpureus* varieties, and concentrate mixture.

Parameters	Treatments					SEM	*P-value*
	T1	T2	T3	T4	T5		
Initial body weight (kg)	22.6	22.4	22.7	22.9	22.6	0.5	0.9620
Final body weight (kg)	28.8	27.9	27.9	27.9	29.9	0.87	0.4601
Body weight change (kg)	6.2[ab]	5.6[b]	5.3[b]	5.1[b]	7.3[a]	0.49	0.0409
Average daily gain (g/day)	68.6[ab]	62.2[b]	58.6[b]	56.1[b]	81.4[a]	5.4	0.0409
Feed conversion efficiency	0.08	0.07	0.06	0.06	0.08	0.01	0.0804

[a,b,c]Means within a row with different superscripts differ significantly ($P < 0.05$); SEM (Mean + SE) = standard error of means; T1 to T5 = treatments.

3.4. Body weight change and feed conversion efficiency

Table 4 displayed the feeding value of *Cajanus cajan* and *Lablab purpureus* varieties over the conventional concentrate supplements on the performance of Horro lamb. Supplementation significantly affected the weight change ($P < 0.05$) and average daily gain ($P < 0.05$) than the final body weight and feed conversion efficiency features ($P > 0.05$). The lambs fed diet in T5 and T1 demonstrated higher and comparable performance in weight change and mean daily weight gain attributes, while the rest of the dietary treatments had an intermediate value. The absence of statistical variation in final body weight observed across the dietary treatments in general, and comparable average daily gain among lambs fed diet in T1 (Gebis variety) and T5 (concentrate mixture) in particular reflected that the supplements were comparable in their potential to supply nutrients for improving the performance of the growing Horro lambs.

The insignificant result in the final body weight recorded was consistent with the finding reported by Dida et al. (2023) for Gumuz sheep supplemented with *Azadirachita indica* leaves, Stylosanthes fruticose and Dolichose lablab as a substitute for conventional concentrate mixture. Similarly, Dida et al. (2019) found that feeding intact yearling Gumuz goats with varying proportions of pigeon pea (*Cajanus cajan*) and neem (*Azadirachta indica*) leaves instead of a concentrate mixture had no significant effect on their final weight. Moreover, there was no significant difference in the final body weight for Washera sheep-fed tree Lucerne (*Chamaecytisus palmensis*) as a substitute for the concentrate mix reported by Hailecherkos et al. (2020). Malisetty et al. (2013) came to the same conclusion as the current study: stating that maize silage can be supplemented either with Lucerne hay, groundnut haulums (to meet 25 % DM requirement) or concentrate at 1.5 % of body weight depending on the availability for optimum growth rate and feed efficiency in growing Nellore ram lambs. The final body weight observed in the current study was higher than the values which ranged from 21.24–25.4 kg (Tulu et al., 2018a) and 23.5–28.04 kg (Gemechu et al., 2020) reported in the literature for the same breed used in the present study. Similarly, the final body weight ranging from 19.23–23.16 kg recorded for Wollo sheep (Hunegnaw and Berhan, 2016) supplemented with pigeon pea, Lablab and cowpea hay was significantly lower than the result of the current study.

In general, the trend of body weight change (kg) across the feeding days (Fig. 1) showed that the growth performances of sheep were positively increased. From the current study, it can be generalized that, all dietary treatments positively promoted the growth performance of the lambs which suggests the comparative nutritional values of the leguminous forage supplements (*Lablab purpureus* and *Cajanus cajan*) relative to the conventional concentrate mixed feeds used in the current study.

The mean daily gain observed in the current study was comparable with reports of Hailecherkos et al. (2020) for Washera (51.1–82.2 g/d) sheep, but higher than the finding reported by Hunegnaw and Berhan (2016) for Wollo (3.1–49.36 g/d) sheep breeds. This variation in final body weight and daily gain might be attributed to the difference in the breed used, and the type and nutrient content of the dietary supplements, as well as basal feed used for the respective studies. The feed conversion efficiency in the present study was also consistent with earlier studies reported for different indigenous sheep breeds, such as Arsi-Bale (Wegi et al., 2018; 0.06–0.09), Abergele (Gebru et al., 2017; 0.066–0.073) and Gumuz (Shitaneh et al., 2021; 0.058–0.086) breeds.

4. Conclusion

The current study revealed that the inclusion of hay from *Cajanus cajan* and *Lablab purpureus* varieties in a fodder oat hay-based diet helped to meet the crude protein requirement for maintenance and growth of Horro lambs as compared to conventional concentrate mixed diet, indicating the comparative feeding value of the leguminous forage crop

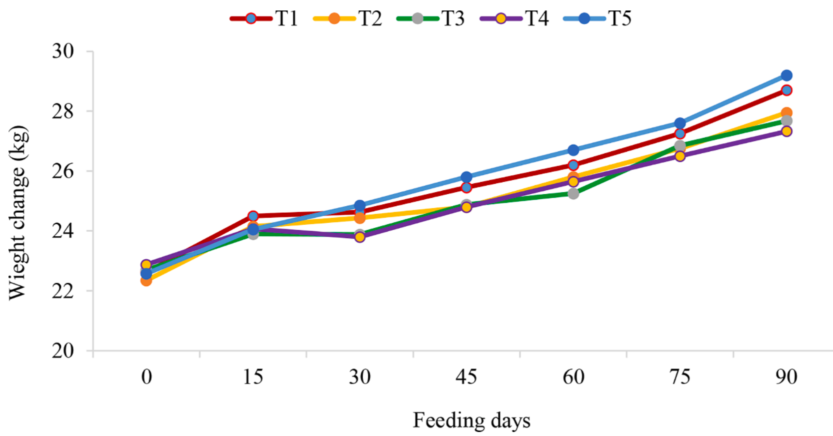

Fig. 1. Body weight change trend of Horro lambs fed basal diet of fodder oat hay and supplemented with *Lablab purpureus* and *Cajanaus cajan* varieties, and concentrate mixture.

as a protein-source feed for better animal performance. Total DMI showed significant variation among the dietary groups and was in the order of T3 (975.5) = T4 (978.6) > T5 (950.2) > T1 (932.6) = T2 (923.7 g/d/head). Total CP intake, however, was not varied among the dietary treatments ($P > 0.05$) and were 106.3, 106.1, 106.5, 106.1, 106.2 for T1, T2, T3, T4 and T5, respectively. Similarly, dry matter and nutrient digestibility coefficients did not reveal significant variation ($P > 0.05$) among the dietary groups. Even though a diet in T5 (concentrate mixture) improved the lamb performance in the same way that the rest of the dietary supplements (leguminous forage crops) did, the use of such supplements is usually limited due to their high cost and inaccessibility to smallholder farmers. This emphasizes how crucial it is to take advantage of the opportunity to switch from expensive, conventional protein sources to inexpensive, farm-grown, improved fodder crops. Thus, depending on their availability, supplementation of lambs with either *Lablab purpurues* (Gebis-17 and Beresa-55) or *Cajanus cajan* (Degagsa and Belabas) varieties could be employed as an alternative protein-source feed supplement in the diet for lambs. To validate the viability of the findings and effectively utilize the current findings, an on-farm experiment under the farmer's management condition is essential. Moreover, investigating optimal feeding strategies, assessing the economic feasibility at different scales of production, and evaluating environmental benefits should be the priority area in the future.

Ethical statement for the experimental animal care

The experiment protocol utilized in this study was based on the Ethiopian Animal Experiments Inspectorate's institutional guidelines for animal experiments, which are part of Ethiopia's ministry of livestock and fisheries. The experiment was carried out following the regulations for the management of experimental animal care.

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CRediT authorship contribution statement

Abuye Tulu: Writing – original draft, Formal analysis, Data curation, Conceptualization. **Worku Temesgen:** Supervision, Methodology, Data curation. **Tusa Gemechu:** Writing – review & editing, Validation, Supervision. **Birmeduma Gadisa:** Writing – review & editing, Software, Project administration. **Mekonnen Diribsa:** Validation, Supervision, Software, Methodology, Data curation.

Declaration of competing interest

There are no conflicting financial interests or personal relationships that could have influenced the research presented in this study.

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