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EVALUATION OF NUTRITIONAL COMPOSITION OF MAJOR AVAILABLE FEED RESOURCES FOR BACKYARD SHEEP FATTENING IN SOUTHERN ETHIOPIA

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ABSTRACT: The study was conducted in the Bule district of Gedeo zone in southern Ethiopia to assess the available feed resources for sheep fattening and their chemical composition in backyard sheep fattening operations. A reconnaissance study identified the main sources of feed, followed by a multi-stage sampling procedure to select kebeles and households involved in sheep fattening. Six kebeles were specifically selected based on sheep population, experienced fatteners and accessibility. A total of 126 households were randomly selected for the study. The main food sources included natural pasture, stubble pasture, forage, bamboo leaves, enset (*Ensete ventricosum*), crop residues, desho grass (*Pennisetum pedicellatum*), tree alfalfa, kitchen residues and mill products. Feed samples were taken for laboratory analysis, and the average values for dry matter (88.3%), ash (10.71%), organic matter (77.25%), crude protein (11.21%), neutral detergent fibers (60.2%), and acidic detergent fibers yielded (39.42%) and acidic detergent lignin (10.22%). Tree alfalfa (26.06%), mill products (16.11%), green fodder (13.88%), and bamboo leaf (12.45%) had the highest crude protein content. Bamboo leaves (21.15%), forage (15.17%), and stubble pasture (12.36%) provided suitable ash levels for mineral intake. However, concerns arise regarding fiber content in crop residues, grazing practices, and bamboo leaf quality, affecting feed intake, digestibility, and absorption. Promising feeds such as alfalfa, mill products, and forage boost high protein content, but better fiber management is essential for feeds with excessive fiber. Tailored feeding strategies, enhanced feed conversion, and thorough training for sheep fatteners are pivotal to address these challenges.

Keywords: Bamboo leaf, Desho grass, *Ensete ventricosum*, Fattening, Feed Resource, Sheep.

INTRODUCTION

Sheep fattening is widely practiced across the country of Ethiopia, through the scale and resources used vary significantly. It is particularly suited for smallholder farms, requiring minimal capital, have shorter production cycles, and have better environmental adaptation ability than large ruminants (Sejian et al., 2021). However, the status of sheep productivity is generally hampered by numerous factors, such as insufficient energy at breeding when in poor body condition, early embryonic death, predators, and feed shortage (Bachano and Etefa, 2022) Among the problems feed shortages with quantity and quality and the escalation of feed prices, which hampering sheep production and productivity in the country (Ayele et al., 2021).

In many regions, sheep graze on permanent grazing areas, fallow land, and post-harvest cropland, relying primarily on natural pasture and crop residues, which fail to meet their nutritional needs (Belay and Negesse, 2019). The practice of sheep fatting in various parts of the country is predominantly limited to two fattening cycles (Belachew, 2019). As a result, producers are not getting the expected benefit from it (Shimelis, 2018). It is required to assess an optional way of solving the problem in line with analyzing available feed sources. Hence, different previous studies have been done on sheep-fattening areas to overcome such challenges. However, aside from listing many kinds of feed available in that vicinity, the majority of them have no documentation about feed nutrient composition related to sheep fattening at farmer levels (Gufa et al., 2017) except for the research done by Jarso et al. (2023) which focused on only natural pasture and barely crop residues. Bule district is among the possible locations with a favorable environment for sheep production in the Gedeo Zone of Ethiopia, is known for its favorable environment for sheep production and a long-standing tradition of backyard fattening (Tezera and Engidashet, 2022). It also has a large sheep population and active livestock marketing. Despite these advantages, modern sheep fattening practices are lacking, and no comprehensive study has been conducted on the area's feed resources and their nutritional composition, except for commercial feeds. This study aims to assess the available feed resources and evaluate their nutritional chemical composition for sheep fattening in the area.

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MATERIALS AND METHODS

Description of study area

The study was carried out in chosen kebeles of Bule District which is located in the Gedeo zone in Southern Ethiopia. The district lies between latitudes 6°04'16" and 6°23'50" N, and longitudes 38°18'00" and 38°30'00" E, approximately 386 km from Addis Ababa, 117 km from Hawassa, and 27 km from Dilla, the zone's capital. Bule District is bordered by Oromiya Region to the south, east, and west, and Sidama Zone to the north. Covering 27,300 hectares, it ranges from 2,001 to 3,000 meters above sea level. The district includes 15 rural and 3 peri-urban kebeles, with a total area of 11,546.2 hectares and a population of about 95,436. About 70% of the district is highland agro-ecology, while 30% is mid-altitude. The average annual rainfall is 1,600 mm, with temperatures ranging from 12.6°C to 20°C. Farming in the area follows a mixed crop-livestock system, with land primarily used for annual crops and perennial plants (CSA, 2021).

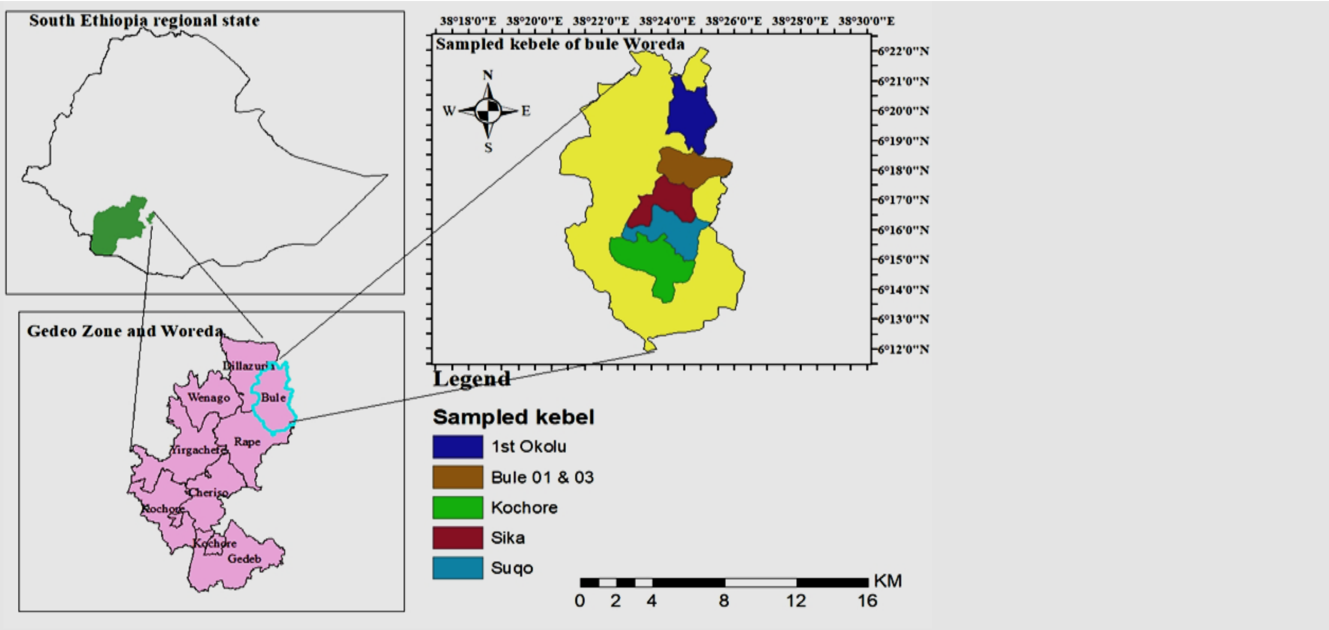

Figure 1 - Location of study area.

Sampling method

Before selecting a representative sample, a reconnaissance survey and consultations were conducted with district agricultural experts. Based on this information, six Kebeles were purposively chosen for their sheep resources, farmers' experience in sheep fattening, and accessibility. From each selected kebele, households engaged in sheep fattening were randomly chosen based on their number of fattening sheep, experience, and willingness to participate. According to the district's livestock resources department, 328 households in the study area were involved in sheep fattening.

Sample size determination

The sampling frame consists of farmers who raise sheep for fattening and are willing to participate in the study. According to the district agricultural office's livestock data, the total number of sheep fattening households in the study kebeles is 126. To meet the study's requirement for a representative sample within the constraints of time and budget, all 126 households across the six sampled kebeles were selected using systematic random sampling for interviews and data collection. The sample size for each kebele was determined using Yamane (1973) formula with a 0.07 standard error and 95% confidence level, resulting in 21 households per kebele.

$$n = \frac{N}{1+N(e2)}$$

Where: n= sample size required; N = number of people in the population; e = allowable error (%)

Therefore, the total of 126 households (38.4% of 328) were randomly selected from the six Kebeles, with 21 households from each kebele. A semi-structured questionnaire was used for interviews. Additionally, an introductory meeting was held at the village level in each kebele to brief farmers on the study's objectives.

Collection of feed sample

Ten feed samples were collected from 60 randomly selected fatteners (10 from each kebele). The fresh samples were spread on plastic sheets and air-dried in the shade for 3-5 days before being placed in an oven. After drying, the samples were mixed thoroughly, sub-sampled to 500g for each feed type, packed in airtight polythene bags, labeled, and transported to the lab for analysis. A 500g portion from each sample was weighed using a sensitive balance and taken to the Dilla University animal nutrition laboratory, where it was dried at 65°C for 72 hours, ground through a 1 mm sieve in a Willey mill, equilibrated at room temperature for 24 hours, and stored in airtight containers for chemical analysis (AOAC, 1995).

Laboratory analysis

Feed samples collected from the study area were processed and analyzed for chemical composition at Dilla and Hawass University's Animal Nutrition Laboratory. To ensure consistent weight, samples were dried for 72 hours at 65°C in a forced-air oven. Each dried sample was then ground and sieved through a 1 mm mesh. The ground samples were stored in airtight plastic bags for analysis. Chemical composition was determined following AOAC (1995) procedures, with analyses for dry matter (DM), organic matter (OM), crude protein (CP), acid detergent fiber (ADF), acid detergent lignin (ADL), and ash content. Neutral detergent fiber (NDF) was measured according to Van Soest (1982). Crude protein content was calculated using the Kjeldahl method, with the nitrogen concentration multiplied by 6.25

Statistical data analysis

Data were checked, corrected, and coded using SPSS version 20 for analysis. Descriptive statistics, including mean, percentage, and standard deviation, were used to present the findings. ANOVA, performed with SAS, tested differences in the chemical composition of major feedstuffs, with mean separation via the Tukey test at P<0.05.

RESULTS AND DISCUSSION

Status of backyard sheep fattening

As described in Tables 1 and 2, sheep fattening was the common practice in the study area, with 94.4% of households engaging in tethering and free-grazing systems. Traditional fattening systems prevailed, that the mean sheep fattened per household (1.97±0.08) for 2–6 months and 1.59±0.059 sheep fattened per year. Rams were the most commonly fattened (72.2%), followed by both rams and ewes (17.5%), and only 10.3% of households fattened ewes. In contrast, Mohammed (2020) found that 55.7% of farmers in Fogera District did not engage in sheep fattening. However, the current study aligns with Assefa and Ayza (2020), who reported an average fattening period of 3–4 months in southern Ethiopia. The mean sheep fattened per household (1.97±0.08) in this study was lower than Shewangzaw et al. (2018), who found 2.86 sheep fattened per period in Amhara. This discrepancy may be due to differences in resources (e.g., feed, land) and inputs available for fattening.

Available feed resources for fatteners and utilization

The major feed resources for fattening sheep in the study area, ranked in order of availability, are listed in Table 2. These include natural pasture (1st), green fodders (3rd), kitchen leftovers (5th), enset (6th), crop residues (4th), cultivated forage (7th), stubble grazing (8th), salt (5th), bole (9th), mill products (11th), and bamboo leaves (9th). This ranking aligns with Belay and Negesse (2019), who identified similar primary feed sources such as crop residues, natural pasture, stubble grazing, agro-industrial by-products, and improved forages in the Chalia districts of the West Shoa Zone.

Natural pasture, enset, and green fodder (fresh grass and bamboo leaf) were identified as the top three feed sources in the study area for fattening sheep. This reflects that natural pasture was the primary source, followed by green fodder and enset. Similar findings were reported by Mekuria et al. (2018) in the Amahara region, where natural pasture was also the predominant feed source for fattening small ruminants. Crop residues were ranked fourth, while home leftovers with salt and stubble grazing followed closely with index values (Table 3). Crop residues and stubble grazing were mainly available during dry seasons after crop harvest. Additionally, cultivated forage, bole and bamboo leaf alone, salt with bole, and mil1 products were identified as other important feed sources, with rank indexes of 0.059, 0.021, 0.0056, and 0.006, respectively.

On the other hand, fatteners and group discussants responded that the availability of such feed resources was limited by the seasons. Accordingly, natural pasture, forage (other than fresh grass) and enset were available over the years, but crop residues and forage resources were available for stubble grazing during the harvest season. In addition, the information received from the fattener and panelist shows that the use of available feed resources is also seasonally limited. Mainly crop residues and stubble pastures served as fodder along with other and supplementary fodder during the rainy season deficiency (Table 6). This suggested that if sufficient and protein-rich supplementary feed was not provided to fattening sheep during periods of rain deficiency, this could be influenced by nutritional deficiencies and a long period of time to reach the optimal marketing weight due to low CP % and poor quality could be forage species in the study area. Consistent with the current study, it was indicated that stubble pasture is available immediately after harvest in Tigray (Gizaw et al., 2017). It was also noted that the proportion of crop residues during the dry season is high and can be up to 80% (Schillinger and Wuest, 2021). Likewise, crop residues play a particularly important role during the dry season when there is a critical feed shortage (Duguma and Janssens, 2021). Also, Belay and Negesse (2019) reported a similar result, where crop residues and crop stubble grazing are important sources of forage during the dry season.

This study also determined the utilization status of these feed resources in the feed lots of the study area (Table 3). Accordingly, the combination of different available feed sources was a common usage trend throughout the study area. The combination of available feed resources most commonly used by fatteners in the study area were natural pasture, green fodder, crop residues, and stubble pasture (19.8%), followed by natural pasture, crop residues, green fodder, and enset (18.3%), natural pasture, crop residues and enset (16.7%), forage (fresh grass and bamboo leaves) and crop residues with stubble pasture (12.7%) and natural pasture, enset and cultivated fodder (desho and alfalfa) (11.9%). At certain fattening farms (4.8%), only natural pasture, crop residues and cultivated fodder (desho and alfalfa) were available as feed for fattening sheep in the region (Table 4). This shows that the availability of feed resources varied from farmer to farmer depending on the type of use and most feeders in the study area had a combination of natural pasture, forage, crop residues and stubble pasture (19.8%). The main reason why fatteners rely on such combined feed resources may be that the region has conditions for high crop production and mixed agriculture. In addition, it was pointed out that the most commonly used feed source combinations in the study area had low quality in terms of NDF, ADF, ADL and CP%, with the exception of forage. Similarly, Feyisa et al. (2022) stated that fodder is considered low grade if the crude protein content is less than 8 %, acid detergent fiber is more than 45 %, and neutral detergent fiber content is more than 65%.

Table 1 - Overall backyard sheep fattening status in the area

Variables		Kebeles						Total N=126	P-value
		Bule 01	Bule 03	Sika	Suqo	Kochore	1g na okolu		
FS	M ±SE	5.62±0.71	5.10±0.46[b]	5.43±0.50	5.14±0.46[c]	7.14±0.43[a]	7.43±0.62[a]	5.98±0.23	0.004
	Minimum	0	3	2	2	4	3	0	
	Maximum	14	10	12	10	10	13	14	
Age	Me ±SE	36.24±2.8[b]	37.33±1.6	45.90±3.3	40.05±1.6	42.00±1.8	46.76±2.6[a]	41.38±1.0	0.007
	Mi	19	24	26	25	28	29	19	
	Ma	72	46	83	56	56	81	83	
TLHg (ha)	M ±SE	0.70±0.07	0.69±0.06	0.67±0.05	0.851±0.09	0.76±0.10	0.90±0.06	0.76±0.04	0.094
	Mi	0.23	0.25	0.25	0.25	0.25	0.35	0.023	
	Ma	1.65	1	1.03	1.70	1.25	1.67	1.70	
MS (%)	Married	14.3	16.7	14.3	15.9	15.9	15.9	92.9	0.6
	Single	0.8	0	1.6	0	0	0	2.4	
	Widowed	1.8	0	0.8	0.8	0.8	0.8	4.8	

	Participation status in sheep fattening	Frequency	%	X²	P-value
Do you participate in sheep fattening?	Yes	119	94.4	18.05	0.001
	No	7	5.6	1	

Preferred type of sheep for fattening activities

	Type	Frequency	%
Type of sheep used for fattening	Ram	91	72.2
	Ewe	13	10.3
	Both	22	17.5
	Total	126	100.0

FS= family size; TLHg= total land holding per hectar; MS= marital status; SEM =standard error of means

Table 2 - Provided feed and feeding/fattening system in study area

Description	Sheep fattening/Feeding system	Free grazing with cut and carry system	Tethering with stall feeding system	semi-grazing with stall feeding system	Total	X²	p-value
Mostly provide feed for sheep during stall-feeding	Bamboo leaf and home leftover	2.4(1.0)	20.6(3.8)	6.3(0.9)	29.4(5.3)	7.78	0.4
	Green fresh grass	4.8(1.3)	23.8(4.3)	6.3(0.9)	34.9(6.2)		
	Cultivated forage	4.0(1.3)	10.3(2.4)	2.4(0.3)	16.7(3.3)		
	Enset (*Ensete ventricosum*)	0	10.3(3.6)	3.2(0.4)	13.5(4.0)		
	Crop residues with Bole	0	3.2(0.2)	2.4(0.2)	5.6(1.4)		
Total		11.1(5.0)	68.3(11.2)	20.6(4.8)	100.0(17.2)		

The parenthesis value in the table is SEM (standard error of means)

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Table 3 - Ranking of available feed resources in study area

No	Available feed resources categories	Frequency of rank given by respondents											
		1st	2nd	3rd	4th	5th	6th	7th	8th	Sum	Weight	Index	Rank
1	Natural pasture	42	39	15	4	5	3	1	0	109	750	0.18	1
2	Crop residues	0	10	25	28	23	13	7	2	108	507	0.12	4
3	Cultivated forage	11	7	7	8	4	3			40	244	0.06	7
4	Stubble grazing	14	13	16	7	0	1			51	337	0.08	8
5	Green fodder (fresh grass and bambo leaf)	39	27	17	5	1	1			90	635	0.15	3
6	kitchen left over	0	10	14	23	21	9	5	1	83	391	0.09	5
7	Enset	20	18	28	25	12	4	1	1	109	642	0.16	2
8	Salt and *bole*				3	2				5	23	0.01	11
9	Salt			2	10	41	43	21	4	121	401	0.09	5
10	*Bole*			1	2	4	5	7	1	20	62	0.02	9
11	Mill product			1	2	2	1			6	27	0.01	11
12	Bamboo leaf alone		2	1	9	2	1	1		16	78	0.02	9

Index = [(8 × number of responses for 1st rank + 7 × number of responses for 2nd rank + 6 × number of responses for 3rd rank + 5 × number of responses for 4th rank +4 × number of responses for 5th rank+3 × number of responses for 6th rank+2 × number of responses for 7th rank+1 × number of responses for 8th rank)] divided by (8 × total responses for 1st rank + 7 × total responses for 2nd rank + 6 × total responses for 3rd rank + 5× total responses for 4th rank + 4×total responses for 5th rank+3 × total responses for 6th rank+2 × total responses for 7th rank+1 × total.

Table 4 - Available feed resources utilized by sheep breeders

No	Fatteners used available feed resources	F	%
1	Natural pasture(grazing), crop residues and enset	21	16.7
2	Natural pasture(grazing), crop residues, green fodder and enset	23	18.3
3	Natural pasture and green fodders (fresh grass and bamboo leaf)	12	9.5
4	Natural pasture, green fodder, crop residues and Stubble grazing	25	19.8
5	Natural pasture, crop residues and cultivated forage (desho and treelucern)	6	4.8
6	Green fodders (fresh grass and bamboo leaf) and crop residual with stubble grazing	16	12.7
7	Natural pasture, enset and cultivated forage (desho and treelucern)	15	11.9
8	Natural pasture, green fodder, enset, crop residues and Stubble grazing	8	6.3
	Total	126	100.0

F= frequency

Major supplementary feed resources for fattening sheep's

Providing supplementary feed for their fattening sheep was a common practice in the fattening farms in the study area. All fatteners in the study area used locally available feed sources as a supplement to sheep fattening and thus achieved the required body weight change and minimized fattening time, which these trends were common practice in most countries as a common fattening method (Mengistu et al., 2020; Wamatu et al., 2021; Alimi et al., 2024).

As shown in Figure 1, Salt, kitchen leftover (sorting out grains from cereals, coffee residues (*ashara*), and enset (18.3%) were mostly used as supplementary feed combinations, followed by the uniform provision of Salt, bole, and home leftover (15.1%), and Enset with salt (11.1%). obtained from cereal crops was mostly available at harvest time and used mainly after mixing with coffee residues and salt or mineral soil (named local *bole*). According to report of Nurlign (2020) most households provided their fattening sheep with leftover feed and screening. The current result was also consistent with Bekele et al. (2019), as about 100% of the respondents in the highlands have the experience of feeding mineral soil/salt to their sheep in the Arba Minch *Zuria* District. There was leftover for the fatting sheep (6.3%) other additional feed sources and feeding practices among the fattener's response in the study area. According to the fattener's response and field observation data, feeding green fodder such as locally available fresh grass and bamboo leaves has practiced when after the animals have passed some limited grazing conditions. Accordingly, freshly cut and carried locally available fresh grass and bamboo leaves are used when after air drying to enhance their palatability by animals. Moreover, respondents informed us that green fodders were preferred and that they commonly provided feed to animals with salt or kitchen leftovers rather than cultivated forage in the area. In support of the current finding, previous various researchers also reported similar findings. According to Schillinger and Wuest (2021) native grasses are better if timely cut and proper handling and storage measures are applied. Many farmers currently practice an intermediate system, where sheep have limited grazing but are also fed additional 'cut-and-carried' fodder (Duguma and Janssens, 2021). Coffee residues are used as supplementary feed in Daramillo Woreda of Gamo Gofa Zone (Gufa et al., 2017). In the Arba Minch Zuria District of Gamo Zone, common supplements offered to sheep are Green fodders, Food leftovers, and Bole provided in the afternoon when the animals return home (Guyo, 2016).

On the other hand, about 0.8% of fatteners used both enset and mill products with salt for their fattened sheep as a supplementary feed for their fattening sheep, and 4.8% of them utilized salt alone. The variation was due to the difference in the availability access of feed types among households in the study area. Respondents responded that the combined utilization of all available feeds was carried out based on their availability in the study area. However, provision of crop residues for fattening animals can be taken placed with combined supplementary feeds such as kitchen leftovers including screening from cereals and coffee residues/*ashara*; and salt and enset when after animals brought from stubble semi-grazing area. This indicated that fatteners have knowledge or information about crop residues that do have not enough nutrition if provided alone to fattening sheep. A similar finding was reported by different previous researchers. According to Byaruhanga et al. (2015), crop residues do not fulfill the nutritional requirements of animals, particularly in the dry season due to poor management and poor quality. Thus, the provision of supplementary feeds to increase the productivity of livestock is essential (Belay and Negesse, 2019).

Seasonal Feed shortage for sheep fattening

The main seasons for feed shortage and reasons in the study area are summarized in Table 5. The majority of respondents (44.2%) identified the dry seasons as the most critical period for facing feed shortages, compared to the short rain season (38.3%) and long rain seasons (11.7%) alone. These findings are consistent with earlier reports (Mengistu et al., 2017) which highlighted seasonal variations, particularly dry seasons, as contributing to feed shortages in Ethiopia. The primary reasons identified for feed shortage across the study area were unproductive land (soil acidity) (35%), followed by land scarcity (30%), and both lack of improved forage and land (26.7%). This underscores that factors contributing to feed shortages are closely linked to seasonal variations and highlight limited access to feed as a common issue in the study area.

Fattening animals were most unproductive during the short rainy season (dry season) (Table 5), primarily due to land constraints ($P<0.05$). Field observations and discussions indicated that frequent tethering with other livestock contributed significantly to feed shortages in the study area. Consequently, cultivated crops, including forage, took longer to grow and were less productive. Consistent with these findings, Samuel (2016) noted that feed accessibility in the lowlands of the Amhara Region was predominantly hindered by low land productivity. Addressing this issue requires enhancing farmers' skills to implement soil fertility rehabilitation strategies such as rotational grazing, resting land through crop rotation, and planting improved forage materials. Additionally, utilizing local waste materials for composting could further benefit the study area. Teague and Barnes (2017) suggested that collective management of grazing lands can enhance resource utilization effectively.

Likewise, fatteners faced higher land shortages ($P<0.05$) in both dry and rainy seasons due to their cultivated lands being occupied by seasonal crops after harvest. According to respondents, 46.6% of existing lands were occupied by seasonal crops, while land fragmentation (34.2% per household member) and unproductive grazing land (19.2%) were major factors limiting productive land availability in the study area (Table 4). This indicates that land occupied by seasonal crops is a primary cause of land shortage, leading to limited availability of feed resources. Therefore, promoting and adopting feed conservation practices is essential to mitigate feed shortages resulting from land competition, through increased awareness among farmers in the study area.

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Land fragmentation due to household expansion was the second most significant factor limiting land availability, leading to feed shortages in the study area. Wassie (2020) similarly noted that land scarcity is likely to worsen with the ongoing population growth in Alaba Woreda. Hence, the study's findings underscore the constraints in implementing alternative forage development strategies that could efficiently utilize the available land for fattening sheep in the study area.

Furthermore, respondents cited a higher prevalence ($P<0.05$) of improved forage shortage during both seasons compared to the dry and rainy seasons alone (Table 5). Inadequate availability of improved forage also hinders sheep fattening practices, affecting adherence to recommended criteria such as fattening duration, feeding systems, and overall management across the study area. A majority (68.3%) of sheep fatteners in all study kebeles do not cultivate forage in their home yards. Only 31.8% of households grow cultivated forage, predominantly desho grass (30%) and tree lucerne (25%), which are most common in the area. The current proportion of forage-cultivating farmers in the study area is lower than reported figures from Damote Gale District (Shimelis, 2018), where 99% and 82.5% of farmers in intervention and non-intervention sites, respectively, practiced forage cultivation. However, Assefa and Ayza (2020) reported a lower percentage of sheep fatteners using improved forage in Duna Woreda. Major reasons cited for the shortage of improved forage include land scarcity (52.38%), lack of attention (30.95%), soil acidity/unproductivity (14.29%), and lack of awareness (2.38%) (Figure 2). This suggests that limited land access may contribute to the higher prevalence of improved forage shortage among households in the study area. Similar constraints of land scarcity and lack of awareness were noted in Damote Gale District (Shimelis, 2018).

Seasonal feed shortage and feed management

As shown in Figure 3, fatteners in the study area were examined for various options. Accordingly, about 48.33% of sheep farmers have tied their animals in enset farms to graze available green fresh feed material such as grass, enset leaves and herbs; and then provided kitchen scraps, while households representing 39.17% and another 12.50% of households could have the option of doing nothing but feeding available feed sources and selling fattening sheep, respectively, until these seasonal conditions cut off are. This indicated that almost half of the beneficial opportunities implied by fattening to also use these food materials left over from the kitchen as a supplement to solve such problems in the study areas. Guyo (2016) noted that using homemade concentrates could also help overcome periods of feed shortage. In addition, the current study results also suggest that the presence of fatteners who do not take measurable measures, as such a condition, also represent factors for the lengthening of the fattening period per cycle and the presence of constraints on available feed management in the region. Tegegne and Feye (2020) pointed out that feed management systems such as storing and purchasing sufficient feed during times of abundance from feeders have been cited as strategies to overcome seasonal feed shortages in Ethiopia.

Feed shortage consequences and measurements

The different available feed resources in Ethiopia have different palatability and nutritional status. In addition, however, availability in sufficient quantity and quality is questionable in all parts of the country, resulting in farmers facing varying feed restrictions (Shapiro et al., 2015). As a result, these farmers adopted different mechanisms to deal with such problems in the country. In this study, similar conditions were also found in the sheep fattening households in the study area. Accordingly, the lack of feed had serious consequences in the study area. According to surveyed households, weight loss of fattening sheep (47.6%), shortened fattening cycle per year (42.9%) and increased mortality of fattening sheep due to vulnerability to harsh conditions (9.5%) were the major consequences of feed shortages in sheep fatteners (Table 7). Under such conditions, farmers in the study area proposed various measurable measures, such as purchasing fodder or renting pasture land (42.9%), using available crop residues (9.5%), and excluding pasture land from stocks (47 .6%). Guyo (2016) reported a similar finding and found that in Bonke Woreda in Gamo-Gofa Zone, most highland households (62.5%) use agricultural residues, while about 37.5% of mid-altitude producers rely on purchased feed to overcome problems associated with feed shortages. However, this finding is greater than the current study result of crop residue users and feed purchasing households in the region.

The purchase of various feedstuffs such as enset and its residues as well as crop residues and the rental of pasture land for all stocks and especially for fattening animals from the neighboring general were measures taken before and during the above-mentioned consequences in the region. This demonstrated that certain farmers are knowledgeable and competent in predicting threats related to feed shortages and protecting them by applying necessary measurements in the study area. Furthermore, it was predicted that such events also represent an opportunity for the expansion of improved forage production. In conclusion, the fatteners explained that after the development of another way of fattening sheep, the available family land was protected from encroachment on the stock for a certain period of time until pasture grass developed to take measures to some extent and deal with the consequences of the feed shortage. About 47.6% of surveyed households followed such measurements to prevent weight loss and mortality of their fattening animals and to lengthen the fattening cycle per year (Table 6).

Table 5 - Reasons for shortage of land in study area.

Description		Reasons for seasonal shortage of feedstuffs				Total	X²	P-value
		Unprod. L.	Shor. L	Shor. I. F.	Shor. L. & I.F.			
Reasons for shortage of land (%)	Existed lands are occupied by seasonal crop	0	21.9	1.4	23.3	46.6	12.38	0.017
	Grazing land become unproductive due the tethering other livestock	2.7	4.1	1.4	11.0	19.2		
	Fragmentation of land	0	23.3	1.4	9.6	34.2		
Total		2.7	49.3	4.1	43.8	100		

Unprod. L=Unproductivity of land due to soil acidity; Shor. L= shortage of land; Shor. I. F= shortage of improved forage; Shor. L. & I.F.= shortage of land and improved forage.

Table 6 - Reasons and seasons of feed shortage occurred at study area

Description		Seasons of feed shortage occurred			Total	X²	P-value
		Short rainy season (dry season) %	Long rainy season %	Both seasons %			
Reasons for seasonal shortage of feedstuffs	Unproductivity of land (soil acidity)	24.2	5.8	5.0	35.0	37.03	0.0001
	Shortage of land	5.8	2.5	21.7	30.0		
	Shortage of improved forage	1.7	0.8	5.8	8.3		
	Shortage of land and improved forage	6.7	8.3	11.7	26.7		
Total		38.3	17.5	44.2	100.0		

Table 7 - Consequences, techniques and measurement taken to alleviate feed shortage problems

Variables		Frequency	%
Consequences of the feed shortage	Weight loss of fattening sheep	60	47.6
	Reduced fattening cycle/ year	54	42.9
	Increased mortality of fattening sheep due to harsh condition	12	9.5
Fatteners applied techniques to improve intake and nutrient status of available feed	Chopping	42	33.3
	Mix with Bole	30	23.8
	Salting	54	42.9
Measurement taken to alleviate feed shortage related problems	Purchase forage (rent grazing land)	54	42.9
	Use crop residues	12	9.5
	Excluded areas from stock	60	47.6

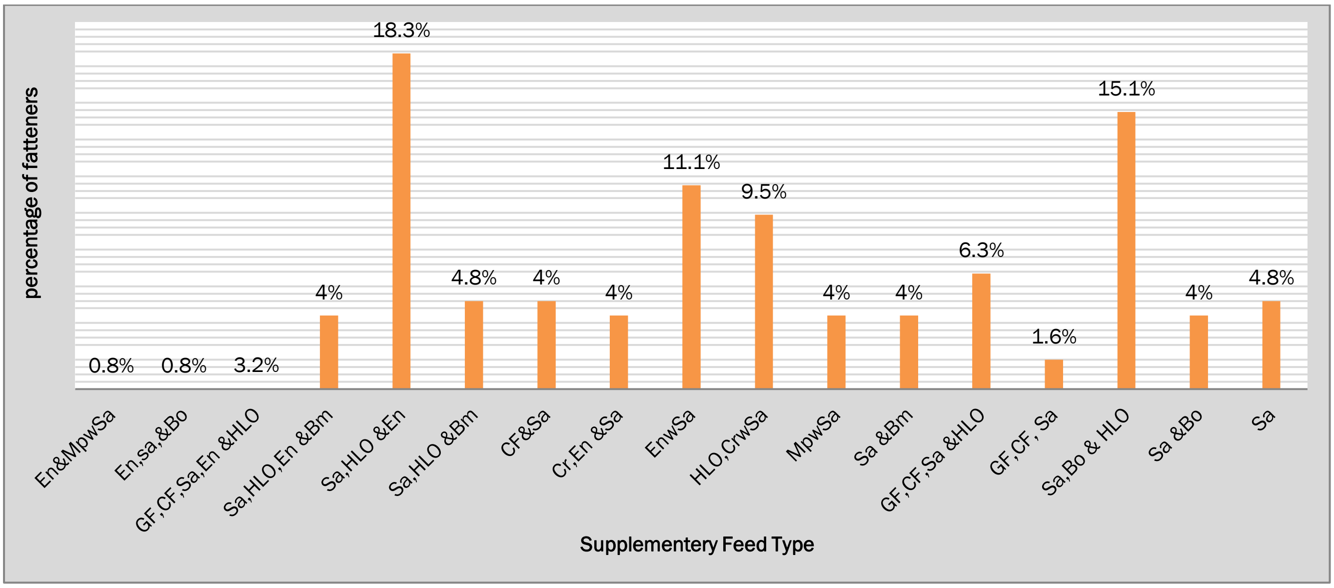

Figure 1 - Status of utilization and type of available supplementary feed. En=enset; MpwSa=mill product with salt; Sa=salt; Bo=bole; GF=green fodder; CF=cultivated forage; HLO= homeleftover;Bm=bamboo leaf; EnwSa=enset with salt; CrwSa= crop residues with salt.

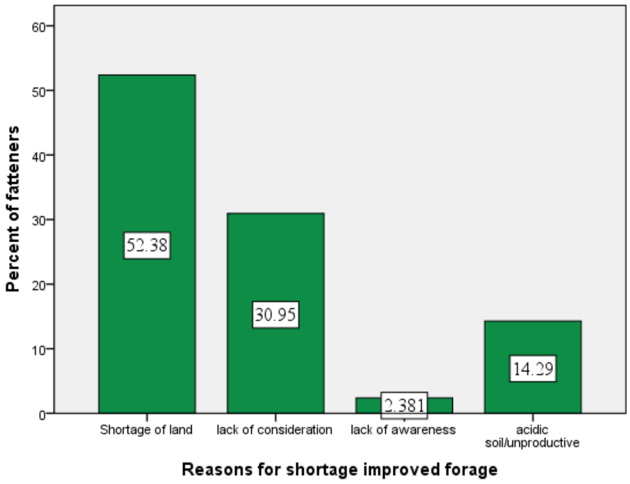

Figure 2 - Reasons for shortage of improved forage across study kebeles.

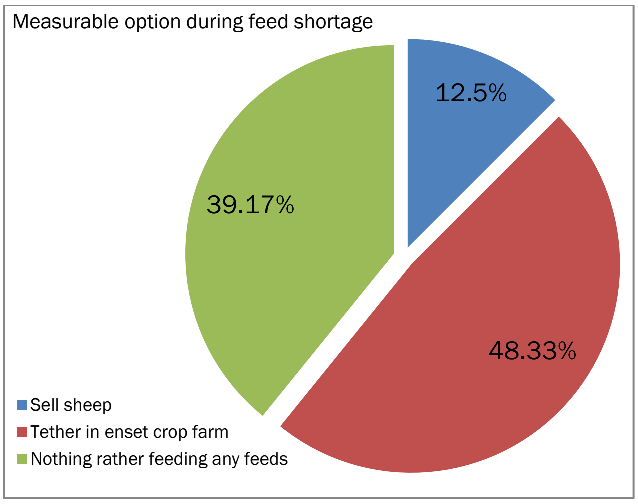

Figure 3 - Practiced option to overcoming seasonal feed shortage in study area.

Table 8 - Chemical composition of available feed types in study area.

No.	Feed Types	DM%	Ash%	OM%	NDF%	ADF%	ADL%	CP%
1	Natural pasture grass	90.82bac	9.39cd	81.43ba	64.42b	40.85dc	7.91c	7.4d
2	Crop residue	92.87a	8.36cd	84.54a	73.33a	57.050a	12.06b	3.15e
3	Stubble grazing	92.02ba	12.36cb	79.66ba	57.21c	46bc	8.30c	2.9e
4	Green fodders (fresh grass)	85.98ef	15.17b	70.80dc	52.78d	29.71e	4.78d	13.08c
5	*Desho* grass	89.37bdc	13.64b	75.73bc	71.05a	42.86c	6.04dc	7.43d
6	Tree lucerne	85.72ef	5.68ed	80.04ba	51.47d	31.49de	11.33b	26.06a
7	Bamboo leaf	85.76ef	21.15a	64.61d	71.96a	54.6ba	12.95b	12.45c
8	*Enset*	88.47edc	8.61cd	79.86ba	62.28b	36.81dce	7.81c	11.52c
9	Mill products	84.5f	3.69e	80.81ba	48.26d	16.86f	4.82d	16.11b
10	Home left overs	87.58ed	9.10cd	74.98bc	49.27d	38.61dce	26.19a	11.98c
Overall mean		88.31	10.71	77.25	60.20	39.48	10.22	11.21
P-value		0.0004	0.0001	0.0012	0.0001	0.0001	0.0001	0.0001

Chemical composition of available feedstuffs

The chemical compositions of the available forage species in the study area are shown in Table 8. The main feed resources studied include natural pasture grass, stubble pastures, crop residues, forage (fresh grass), desho grass, tree alfalfa, bamboo leaves and enset, mill products and household residues such as coffee residues and crop sieves. The current study examined the nutritional properties of ten different feed samples used by sheep farmers in the study area

There is a significant variation (P<0.05) in the chemical composition of major feed resources within the different species (Table 8). The DM content of mill products and crop residues ranged from 84.5 to 92.87%, while the OM content varied between 64.61% bamboo leaves and 84.54% crop residues. The ash content varied from 3.69% mill product to 21.15% bamboo leaf. Crude protein (CP) content ranged from 2.9% for stubble pasture to 26.06% for tree alfalfa. Fiber content was also significantly different between species (P<0.05). The NDF content ranged from 48.26% for mill products to 73.33% for crop residues. The ADF content ranged from 16.86% to 57.05% for mill products and crop residues, respectively.

Furthermore, ADL content varied from 4.82% for mill products to 26.19% for leftover houses across the study area. This study result revealed that there are significant differences in the chemical composition of available feeds, which may be due to the variation of forage plant species, cultivar, maturity level, soil type and fertility status, plant environment temperature and general management status of such feed resources. The current study results confirmed the idea expressed by previous researchers that the stage of forage crop maturity, the plant species; Plant variety, plant fraction, crop management and environmental factors such as soil type and fertility as well as temperature during plant growth are factors that influence feed quality (Tikabo and Belay, 2021; Feyissa et al., 2022).

The DM content (90.82%) of natural pasture obtained in the current study is higher than that of Tamene et al. (2022), who reported that 89.64% of the DM from natural pasture grass from low agroecological areas The focus was on the Haru district. The current DM content of crop residues (92.87%) is comparable to the results of previous studies, which reported

DM content of crop residues between 89.86 and 93.6%. This variation may be due to differences in source (plant species), soil fertility status, and general handling of crop residues and their source from cultivation to harvest or storage. In support of this finding, Tamene et al. (2022) listed management practices, soil fertility, crop species and diversity as factors that vary the DM content of crop residues from area to area. The DM content of the milled product (84.5%) in the current study is lower than the report of Fekadu et al. (2020) who reported the DM content of the milled product of 91.36% in Homa district of West Wollega.

Furthermore, the current DM value of forage (fresh grass) was over 30.49% as reported by Tikabo and Belay (2021) from central Tigray in northern Ethiopia. Finally, the overall average of all available DM contents in the feed in the study area resulted in a value of over 85%, which represents an advanced value for the extraction of essential nutrients for fattening sheep. In line with this, Fekadu et al. (2020) stated that feed dry matter content is important as it contains the essential nutrients in a particular feed ingredient or feed.

This result showed that tree alfalfa (CP=26.06%) has higher and more beneficial protein value, followed by mill products, green fodder and bamboo leaves. Therefore, tree alfalfa could be categorized as high-quality feed, while mill products, green fodder and bamboo leaves could be classified as mediocre and all remaining forages could be divided into intermediates based on the classification with low quality of their protein content (Lonsdale, 1989), the feeds with CP values of less than 12%, between 12 and 20%, and more than 20% are categorized into low, medium, and high protein sources, in that order.

The current CP content of tree alfalfa is comparable to the results of study conducted by Gebrehiwot et al. (2017) which reported a CP content of tree alfalfa of 27.8%, but higher than the report of Meron (2016) stated that the CP value of tree alfalfa is 8.9 -20.9% or 16.6%. The higher CP content of tree alfalfa species in the current study area could make them a potential source of strategic supplements to poor quality forages such as crop residues, natural pastures, stubble pastures and desho grass. The present results on crude protein content of bamboo leaves were not as high as the results published by Desalegne et al. (2019), which indicated that the crude protein content of bamboo leaves introduced in Ethiopia ranged from 15.17% to 37.92%. However, the current CP content of bamboo was found to be higher than the minimum threshing value of 8% CP required for optimal rumen function and feed intake in ruminants (McDonald et al., 2002) and therefore can be used as a commodity Source of protein to supplement low-quality staple foods. As shown in Figure 1, the fatteners in the study area additionally fed their sheep bamboo leaves, which was an indicator that they provided them with a good source of protein. This is consistent with the findings of Desalegne et al. (2019), who found that bamboo leaves reduced the protein requirements of small ruminants (sheep and goats) by 14%.

In the current study, the Enset CP content (11.52%) was found to be lower than the values of 14.9% and 16.5% reported by Geremew et al. (2017). However, the current CP value is above the threshold and is intended to promote microbial development in the rumen and thus improve fermentation. This variation could be due to differences in soil fertility and type, species diversity, seasons and agroecology. The current CP content of Desho grass is lower than the value of the previous result of 10% CP reported by Bezabih et al. (2023), while it is higher than that of Genet et al. (2017) reported value of 3.97% Somewhat similar to the CP value of 6.93% reported by Asmare et al. (2017) for planted desho grass in another region of Ethiopia. The growing conditions of the feed, the variety and quality of the raw materials, and the processing methods used during the extraction, drying, milling, and storage processes could all be factors that contribute to the differences between the current result and previous research. Similar arguments were made by Hailecherkos et al. (2021), who pointed to differences in drying, extraction, milling and storage processes, as well as maturation stages and variability

Lastly, the study area's feeds from stubble grazing and crop residues have excessively low crude protein (CP <7%), which limits the amount of dry matter that sheep can consume overall and makes farmers less profitable by extending the fattening cycle and decreasing the number of sheep. It suggests that to produce sheep fattening in the studied locations suitably, protein source feed must be supplemented, and the nutritional content of this type of feed must be enhanced through physical, biological, and chemical processes.

The current OM content of crop residues (84.54%) is lower than the results (Degefa and Tamirat, 2022) recorded for barley crop residues (88.82%) and wheat crop residues (91.48%). Likewise, higher organic matter (OM) content values were reported from previous findings for desho grass (86.3%) and tree alfalfa species (95.6%) by Shewaye et al. (2021). The differences in OM value between such feeds could be related to the proportion of ash content in the dry matter of these feeds. Accordingly, (Al-Arif et al., 2017) stated that organic matter consisted of all nutrients except ash.

This study result revealed that bamboo leaves provide a larger amount of intermediate storage ash and advanced sources for meeting the mineral requirements of fattening sheep in the study area compared to other types of feedstuffs. A supported finding was reported by José et al. (2019), who described that the ash content in a particular animal feed is considered a good criterion for the total mineral content of the plant material and when its value is above 10%, it becomes acceptable. The ash content of the mill products used in this study was above 4.45% as reported by Degefa and Tamirat (2022) but below 18.78% as reported by Debeko et al. (2023) from Sidama highland in Ethiopia. This could be due to the amount of sampled and composite crop species in the mill products. Furthermore, the ash content of crop residues in the present study (8.36%) was higher than the ash content (4.7%) of barley crop residues in the three agroecologies in East Gojjam zone as reported in Desta (2023). This discrepancy could be due to the different seasons of the forage samples collected as well as the contamination level of this forage type with the soil and dry matter content. This is consistent with other researchers' findings that the ash content of a particular forage in a particular region can be influenced by seasonal variations as well as soil and other habitat factors that need to be studied by forage crops (Kafeel et al., 2013).

In the current study, the ADF content *of desho* grass (42.86%) and tree lucerne (31.49%) was lower than 48.4% and 35.4%, respectively, whereas the ADF content of mill product (28.5%) was higher than 14.4 % reported by Al-Arif et al. (2017). Furthermore, the ADF of natural pasture (40.85%) and crop residues (57.05%) of the current finding are higher than the results of Aruwayo (2018) who reported 36.35% of ADF to natural pasture and 51.71% ADF to crop residue, respectively. On the contrary, however, the current result of ADF was lower than the values reported by Desta (2023) for barley crop residues at 63.0 % and by Tamene et al. (2022) ranging 47.47%–50.51% for natural pastures. This may be associated with variations in sources, variety, soil types, and climate and crop management between previous studies conducted and in the current study area. Similarly, Tamene et al. (2022) explained that species, soil, temperature, amount, and intensity of rainfall could make the variation between ADF values of different feed types from place to place. On other hand, a previous work scientific findings indicated that a feed type with acid detergent fiber is more than 45 % be considered a low-grade feed source (Feyisa et al., 2022). Based on this conclusion, mill products (16.86%), green fodders (29.71%), tree lucerne (31.49%), enset (36.81%), home leftovers (38.61%), and natural pasture (40.85%) presented less than 45 % of ADF content and were considered a good fodder.

This study result revealed that bamboo leaves provide a larger amount of intermediate storage ash and advanced sources for meeting the mineral requirements of fattening sheep in the study area compared to other types of feedstuffs. A supported finding was reported by José et al. (2019), who described that the ash content in a particular animal feed is considered a good criterion for the total mineral content of the plant material and when its value is above 10%, it becomes acceptable. The ash content of the mill products used in this study was above 4.45% as reported by Degefa and Tamirat (2022). This could be due to the amount of sampled and composite crop species in the mill products. Furthermore, the ash content of crop residues in the present study (8.36%) was higher than the ash content (4.7%) of barley crop residues in the three agroecologies in East Gojjam zone as reported in (Desta, 2023). This discrepancy could be due to the different seasons of the forage samples collected as well as the contamination level of this forage type with the soil and dry matter content. This is consistent with other researchers' findings that the ash content of a particular forage in a particular region can be influenced by seasonal variations as well as soil and other habitat factors that need to be studied by forage crops (Kafeel et al., 2013)

The ADL concentration of sampled feeds varies depending on the type and species of feed available in the study area. According to the results of the present study in Table 8, the lignin content of forage (fresh grass), mill products and desho grass were comparable and below the critical lignin value (7%) (Degefa and Tamirat, 2022). The result showed that these animal feed species have good fiber digestibility and intake by sheep due to their low ADL value and are classified as medium quality feedstuffs among the available feedstuffs in the study area. This result is consistent with the finding of (Degefa and Tamirat, 2022), who found that feeds with a lignin content above the maximum lignin content (7%) had limited intake and were classified in a low-quality group, while feeds with a with a lower lignin content and good intake were considered to be medium quality feed sources.

The current ADL study result of various grass feeds such as natural pasture grass (7.91%), forage (4.78%) and desho grass (6.04%) was below 14.4% and 6.7% (Mohammed, 2020; Shewaye, 2021) each for different grass species. This suggested that the fiber of this forage species of the current study area is more digestible than that of the grass species reported in previous work because ADL is less bound to their fiber. This was supported by Aruwayo (2018), who found that the digestibility of plant cell wall material is mainly influenced by lignin, which is the non-carbohydrate of the cell wall of feed and has been shown to limit fiber digestion. More lignin generally results in higher levels of ADF and NDF and lower animal performance, intake and digestibility. Therefore, fatteners in the current study area have the opportunity to improve their fattening activities by improving this grass species with nutritional supplements while offering it to animals.

CONCLUSION AND RECOMMENDATION

The aim of this study was to examine the nutritional quality of available feed at the level of backyard sheep farms in Bule district. The result obtained through the collection and analysis of data based on the objectives showed that a combination of locally available feed sources was a commonly practiced feed conversion method for sheep fattening, with a large number of households using natural pasture, forage, crop residues, etc. and stubble grazing in such a system in the study area. In addition, fatteners are engaged in the use of high fiber and low crude protein (CP) feed sources, with the exception of forages. In addition, it was pointed out that fattening sheep fed on such a combination suffer from the influence of nutrient deficiencies due to the low digestibility and absorption properties of such feed sources. Regarding forage quality, this study concluded that the CP content of crop residues, stubble pastures, relatively dry grass and natural pasture was below the minimum threshing value (8%) required for maintenance, optimal rumen function and forage intake. Likewise, the structural components (NDF, ADF and ADL) of stubble willows and bamboo leaves were optimal and could be classified as mediocre. On the other hand, green fodder, alfalfa, mill products and household residues were identified as quality feed in terms of their structural components (NDF, ADF and ADL) and their crude protein. In addition, the study results revealed that bamboo leaves, green fodder and desho grass have beneficial ash levels. Therefore, the study could conclude that unless feed quality is improved through quality-improving mechanisms such as crushing, mixing with salt, treating with urea and combining with high-quality sources, those sources whose CP content is below 8% should be fed and which have a high structure ingredient had a greater impact on the productivity of fattening sheep in the study area. However, they suffered more from access to important nutrients when only single food sources were available to them, rather than combinations of different sources.

Therefore, based on these study results, the following recommendations are made to improve fattening activities: Feed sources vary in quality within similar parameters. To maximize feed intake, it is important to design through improving feed conservation and treating way and, choose appropriate sources based on quality and provide them to sheep in the study area.

• To improve the productivity of fattening sheep in the study area, a combination of forage, alfalfa, mill products and household residues is beneficial and recommended for their diet.

• It is recommended to train the fatteners in the area of use of improved feed development of feed on available piece of land to address the seasonal fodder shortage and the associated consequences

DECLARATIONS

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Ethical consideration

Present study is based on *in vitro* evaluations and it’s according to nutritional laboratory guidelines for each essay, and there is no any *in vivo* experiment in present research work.

Data availability

The data that support the study findings are available from the corresponding author upon request.

Author contribution

T. Udesa: designed the study, performed the experiment and collect the data, and discussed the results to the final manuscript;

W. Bekele: Proposal design, supervision; validation; visualization; writing-review and editing;

Consent to publish: Both researchers have consented to the submission of the research article to the journal.

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Competing interests

The authors declare no competing interests in this research and publication.

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