Feed Availability, Conservation Practices and Utilization in Selected Milk-Shed Areas in the Central Highlands of Ethiopia

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Abstract

This study was conducted to assess feed availability, conservation practices and utilization of stored feeds for feeding dairy cattle in three milk-shed areas (Ejere, Sululta and G/Jarso) in the central highlands of Ethiopia. Data were collected from 147 dairy farmers using a structured questionnaire, observations, and sampling and measurements of pasture productivity from representative sites. Data was analyzed using SPSS and descriptive statistics. About 11 different feed types or categories were available in the study areas of which natural pasture hay followed by crop residues and pasture grazing constituted the dominant sources of basal feed to dairy cattle. Farmers produce hay on their own pasture land and/or by contracting standing hay on a total average area of 1.1ha with an estimated average production of 6.85 tons per household. Different crop residues dominantly of cereal straws were produced and used for feeding dairy cattle mainly in the peri-urban dairy production systems at Ejere and Sululta. Moreover, 36.7% of the sample households have adopted the production of improved fodder crops on an average area of 0.19ha for feeding dairy cattle. Farmers also use different agro-industrial and locally available by-products to supplement dairy cattle. Natural pasture hay was the dominant feed conserved followed by crop residues, while few farmers also make hay using oats/vetch mixture. Hay was stored in loose form and in open air by majority (≥70%) of the dairy farmers. Baling crop residues was totally uncommon in the study areas. However, crop residues were stored under shelter shade by 70% of the surveyed farmers. Farmers reported to feed dairy cattle with hay, crop residues and all stored feeds for 8, 5.8 and 10.4 months, respectively per annum. The study showed that both the form and method of feed storage practiced in the study areas were less efficient to ensure quality basal feed supply to dairy cattle. Therefore, regular trainings and other advisory services should be provided to farmers and development agents on efficient feed conservation and utilization to curb feed shortage. Moreover, introduction of baling machines and promotions of baling hay and crop residues are essential for efficient handling and utilization of available feeds. Baling will also allow mobilizations of seasonally excess feeds available in different areas for use in deficit areas.

***Key words**: - natural pasture hay, crop residues, storage method, dairy cattle, central highlands of Ethiopia*

Introduction

Ethiopia is known for its large cattle resource base and suitable climatic conditions for livestock production in general and dairy production in particular. However, milk production and the per capita consumption in the country has been one of the least in the world (Azage *et al.,* 2006; Staal *et al.,* 2008; FAOSTAT, 2010; LMP, 2014). Ethiopia is spending considerable amount of foreign currency for

importing dairy products mainly powder milk in order to augment the milk deficit. According to FAOSTAT (2015) the country has spent about 1.6 billion USD for the import of dairy products from 2002 to 2010.

Livestock production in general and dairy cattle productivity in particular has been mainly constrained by inadequate supply and poor quality of available feed resources in Ethiopia (EIAR, 2017). This could be further emphasized by the fact that feed accounts for 60-70% of the costs associated with livestock production. Dairy production is a function of genetics, feeding, health care and other management practices. Evidences indicate that genetic improvement will lead to an improvement in milk productivity of cattle in the range of 60 to 300% only if accompanied by better feeding regimes (McDermott *et al.*, 2010). As dairying is a routine venture which requires continuous and adequate supply of the required nutrients, no improvement in dairy production is possible without adequate understanding of the requirements and associated improvement in feed quantity and quality.

Natural pasture hay and crop residues which provide the bulk of livestock/dairy feed in Ethiopia are seasonally produced during particular periods of the year (October-January) following the main rainy season, and their extended use and quality will depend on proper harvesting, collection, storage, feeding and other management practices. Smallholder dairy producers in the central highlands of the country either partially or totally rely on conserved feed (hay and/or crop residues) for varying periods in a year. However, up-to-date information is lacking on production/availability and overall management practices such as forms and methods of storage, storage durations and utilizations of conserved feeds. Understanding these aspects would help to design appropriate interventions and extension guidelines for ensuring year round supply of better quality feed, and hence improve dairy production in potential milk shed areas. Therefore, the objective of this study was to assess feed availability, conservation practices and utilization of conserved feed for feeding dairy cattle in three selected milk shed areas in the central highlands of Ethiopia.

Materials and Methods

The study areas

The study was conducted in three selected milk-shed areas (Sululta and Girar Jarso from North Shewa zone, and Ejere from West Shewa zone) in the central highlands of Ethiopia. Girar Jarso is located between 9°38'47"N to 9°59'49"N and 38°34'17"E to 38°49'41"E and the zonal town Fiche, is situated 113 km northwest of Addis Ababa. Sululta is located between 9°4'30"N to 9°30'59"N and 38°31'26"E to

38°58'49"E and the woreda town Chancho, is situated 40 km northwest of Addis Ababa. Although it is geographically located in North Shewa zone of the Oromia Regional State, Sululta woreda has been administratively placed under the Oromia Special Zone Surrounding Finfinne since 2007. Ejere is located between 8°51'16"N to 9°14'53"N and 38°15'2"E to 38°28'45"E, about 40 km west of Addis Ababa. Both Sululta and Girar Jarso specifically the study sites are located at an altitude of above 2500 m above sea level (a.s.l), while Ejere is located at an altitude of 2400 m above sea level (a.s.l). Map of the study areas is shown in Figure 1.

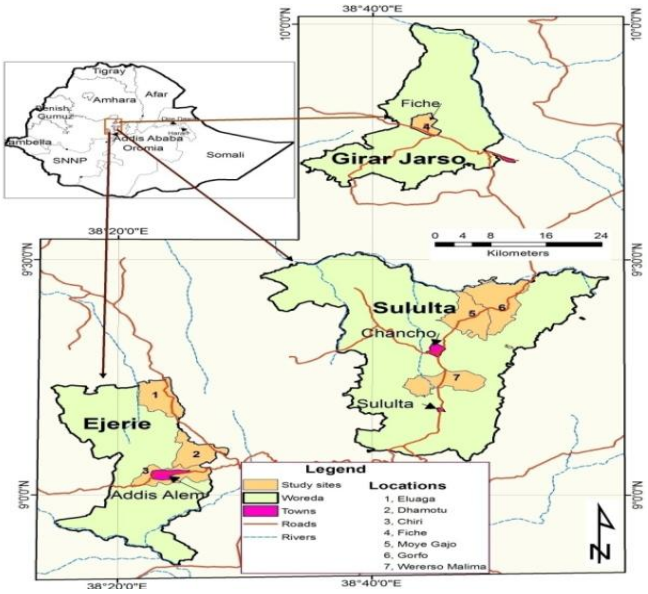

Figure 1. Map of the study areas

Girar Jarso (with Fiche town as focal study site) was selected to represent urban dairy production where dairying is practiced to support family income in addition to other off-farm activities. Dairy production in this system is relatively intensive and mainly based on stall-feeding using purchased feeds. Moreover, the exotic blood level in the herd could be high, but very few cows are kept per household.

Both Sululta and Ejere woredas represented peri-urban dairy production system where crop and livestock production are closely integrated, and agricultural activities other than milk production form additional source of income. The major difference between Sululta and Ejere is that in Sululta, cropping is mainly subsistent and livestock production particularly dairying is the major source of livelihood. Hence, it was selected to represent intensified dairy/crop livestock sub-system where some form of intensive dairy production is practiced and farmers had experiences with different dairy development projects which have influenced the production system (Azage *et al.,* 2005). Ejere is characterized by intensive cropping where both crops and livestock production have comparable contributions to livelihoods. Hence, it was selected to represent intensified crop/livestock (dairy) production sub-system where the cropping

system is more intensive. Therefore, the three woredas were assumed to represent three segments of market-oriented smallholder dairy production systems/sub-systems *viz.* urban (Girar Jarso-Fiche), peri-urban intensified dairy/crop-livestock sub-system (Sululta) and peri-urban intensified crop/crop livestock sub-system (Ejere).

Sampling procedures and data collection

First hand information was gathered on the overall picture of dairy production, feed resources and other related issues via a quick survey and discussions with agricultural extension offices and available dairy cooperatives/unions in the three woredas. The information was used to identify focal villages (Kebeles) and individual farmers using multi-stage purposive sampling technique. Two to three villages were selected from each woreda on the basis of dairy production potential, linkage to milk market, experience in feed production and conservation, and accessibility. Subsequently, a total of 147 dairy farmers (60 from Sululta, 39 from Girar Jarso and 48 from Ejere) were selected with the help of village development agents. A pre-tested questionnaire was used to collect data by interviewing the farmers at their farm gates. The questionnaire covered various topics including household characteristics, dairy cows herd size and composition, major types of available feed resources, land area used for hay and improved forage production, feed conservation practices and methods of conservation, and contribution of stored feeds for feeding dairy cattle in terms of the duration of feeding period in a year.

Estimation of hay production from natural pasture

Sampling for herbage yield determination was made during the peak hay harvesting period (mid – late October) in all the study areas. Three to five representative pasture fields were selected in each of the villages included in the study at Sululta and Ejere woredas. At Girar Jarso, sampling was made from pastures grown in government compounds like the military camp and Farmers` Training Centers (FTC`s) found around Fiche town as these compounds were reported to be major sources of hay for dairy farmers in Fiche town. Sampling was made by placing a $0.5m^2$ quadrate at five randomly selected plots within the pasture field. After measuring the fresh weight of the biomass harvested from the five $0.5m^2$ plots, a sample of 350 gram was taken using a sensitive field balance for further DM determination through oven drying (65°C for 72h). The quantity of hay produced per household was estimated by multiplying the average DM yield per hectare with the corresponding areas of pasture land reported to be used for hay production by the households.

Estimation of crop residue production

Crop residue yield was estimated from the corresponding grain yields of the crops reported to be grown by the surveyed farmers in the three woredas. Information on grain yields of the different crops grown on the respective areas (as reported by the farmers) was first collected by interviewing the farm households. The information was used for estimating average grain productivity of the respective crops per ha in the three woredas. Moreover, national, Oromia regional and zonal average grain yields of the different crops were collected from the reports of central statistical agency (CSA, 2012). Then, the average grain yields estimated using farmers` information and the CSA reports was considered for estimating crop residue yields from the different crops grown by the surveyed farmers. Crop residue produced by the surveyed households was estimated by multiplying grain yield data with conversion factors established for each crop (Kossila, 1984; FAO, 1987). A multiplier of 1.5 was used for wheat, barley and tef (*Eragrostis tef*); 1.7 for oats, 2.0 for maize and 1.2 for the different pulse crops. This estimation did not consider the amount of feed that could be obtained from crop aftermath, the inevitable field losses and other alternative uses which may account for about 30% of the total crop residues.

Data analysis

The three woredas (representing the three dairy production systems/sub-systems) were used as fixed factors for the various dependent variables assessed in the study. The survey data was coded and analyzed using the statistical package for social sciences (SPSS, 2007). Where applicable, the significance of differences in mean values of the quantitative variables between the woredas were tested using Duncan`s Multiple Range Test (Duncan, 1955) at a probability level of 0.05. Qualitative variables were also described using descriptive statistics.

Results and Discussion

Available feed resources

Table 1 indicates the different types of feeds available for feeding dairy cattle in the study areas. About 11 feed types or feed categories have been reported to be used for feeding dairy cattle in the areas. Grass hay was the dominant basal feed resource followed by crop residues and pasture grazing. Crop aftermath

(stubble) grazing was also reported as other important source of basal feed to dairy cattle in the peri-urban dairy production systems at Sululta and Ejere woredas. About 98.6% of all the sample households reported to use different agro-industrial by-products as supplementary feeds to dairy cattle. Considerable proportion of the sample households also reported to use local beverage residues, oats grain and/or hull and grain screenings to supplement dairy cattle. Improved fodder crops, tree leaves and weeds from crop fields were the other feed resources used for feeding dairy cattle in the study areas. The production and use of improved fodder crops for feeding dairy cattle was relatively better in Ejere as compared to the other two woredas. The tree leaves reported to be used as feed mainly belong to Tree lucerne *(Chamaecytisus palmensis)* and Sesbania *(Sesbania sesban)*, the promising fodder trees introduced to the study areas and established as live fences on the farmers backyards. The fodder trees remain green throughout the dry season and their leaves have been used for feeding dairy cattle in mixture with low quality roughages like crop residues.

The types and relative importance of the different feed resources reported in this study were in agreement with previous findings in various parts of Ethiopia (Agajie *et al*., 2002; Tessema *et al*., 2003; Yoseph *et al*., 2003; Zewdie, 2010). This suggests that these feed resources should be focused for targeted interventions to improve livestock feed supply in the country.

Table 1. Major types of feed resources available for feeding dairy cattle in the study areas

Type of feed resource	Proportion of respondents (%)			
	Sululta (n=60)	Girar Jarso (n=39)	Ejere (n=48)	Total (N=147)
Pasture grazing	98.3	5.1	95.8	72.8
Crop residues	100	64.1	97.9	89.8
Grass hay	100	100	100	100
Crop aftermath (stubble) grazing	96.7	2.6	93.8	70.8
Agro-industrial by-products	98.3	100	97.9	98.6
Improved fodder crops	30.0	30.8	68.8	42.9
Oats grain and/or hull	88.3	5.1	56.3	55.8
Grain screenings	55.0	7.7	47.9	40.1
Local beverage residue (`Attela`)	68.3	61.5	91.7	74.2
Tree leaves	15.0	-	47.9	21.8
Weeds from crop fields	38.3	-	12.5	19.7

Natural pasture hay production

Land area used for hay production, estimated pasture productivity and quantities of hay produced per household in the study areas are shown in Table 2. Dairy farmers produce hay on their own holding

and/or by contracting standing hay. The landless dairy farmers in Fiche town (G/Jaro) mainly produce hay by contracting standing hay grown within the government compounds such as the military camp located in the vicinity of the town. The overall average total area of pasture land used for hay production per household was 1.10 ha (1.15 ha in Sululta, 1.76 ha in G/Jarso and 0.83 ha in Ejere). The average pasture land areas used for hay production per household in this study were greater than the earlier figures reported at Selale (Kelay, 2002) and Debre Birhan area (Zewdie, 2010). In all the study areas, dairy farmers opt to produce more hay by contracting standing hay which implies the better access and well established culture of renting pasture land in the areas. Moreover, the higher cattle herd size with increased proportion of crossbred cows might have necessitated more hay production by contracting pasture land on top of own holding. Most dairy producers in G/Jarso have also reported to secure the roughage feed supply by purchasing readily available hay (heaps, bales, donkey loads, etc) from the surrounding areas.

Pasture productivity was significantly higher ($p<0.05$) in G/Jarso followed by Ejere and was lower in Sululta, with the overall average yield of 6.38 t DM/ha. Dairy farmers in G/Jarso (Fiche town) reported to make hay by contracting the pasture grown in the surrounding government compounds like the military camp and FTC`s which are well protected from livestock. This could be the reason for the higher productivity of pasture sampled from these areas. In Sululta, hay is mainly produced on waterlogged lands which may retard pasture growth resulting in low yield. On average, the quantity of hay estimated to be produced per household in a season was 6.85 tones (ranging from 0.76-31.88 tones) on dry matter basis (Table 2). Higher ($p<0.05$) amount of hay was estimated to be produced per household in G/Jarso, followed by Sululta and Ejere. This shows that the dairy producers in G/Jarso are striving to secure as much hay as possible to ensure adequate year round roughage feed supply as stall feeding is the sole feeding management of dairy cows in the urban setting.

Table 2. Estimated pasture productivity and quantity of hay produced per household in the study areas

District	Variable		
	Total land area used for hay (ha)*	Estimated pasture productivity (t DM/ha)	Estimated quantity of hay produced per HH (t DM)
Sululta (n=58)	1.15[b]	5.63[c]	6.48[b] (1.41-22.52)[@]
Girar Jarso (n=15)	1.76[a]	7.97[a]	14.01[a] (0.88-31.88)
Ejere (n=47)	0.83[b]	6.04[b]	5.01[b] (0.76-12.08)
Overall (N=120)	1.10	6.38	6.85 (0.76-31.88)

[a-c]Means with different superscripts within a row differ significantly (P<0.05)

**Includes both own holding and rented/contracted land*

[@]Figures in the brackets indicate ranges in the quantities of hay produced per household

Crop residue production

Table 3 shows the estimated quantities of different crop residues produced per household in a season. The types of crop residues produced by farmers were similar in Sululta and Ejere except maize stover which was produced by some households in Ejere. In Girar Jarso, only few households reported to produce some crop residues. The estimated total quantity of crop residues produced per household was higher ($p<0.05$) in Ejere (8.07 tones DM) followed by Sululta (5.28 tones DM), and was lower in Girar Jarso (3.04 tones DM). This could be attributed to differences in the intensities of cropping which in turn determines the availability of crop residues for feeding dairy cattle in the study areas. Higher quantities of barley and tef straws were produced per household in Sululta and Ejere, respectively. Although the quantity of tef straw produced per household was higher than wheat and oats straws in Sululta, its actual availability for feeding was reported to be lower than the other cereal straws due to its various alternative uses. At Ejere, the availabilities of both wheat and tef straws for dairy cattle feeding were comparable, while the availabilities of both barley and oats straws were comparatively lower. Among the pulses, higher amounts of faba bean and grass pea straws were respectively produced at Sululta and Ejere.

The quantities of crop residues produced by farm households depend on the land area allocated to each crops, grain productivities and harvest indexes of the different crops. In this study, cereals account for the major share in terms of both land allocation and crop residue production. This was in line with the national scenario in which cereals account for 79.34% of the total cropped land and about 86.06% of the total grain production in the country (CSA, 2012).

Table 3. Quantities of different crop residues produced per household in the study areas (t DM)

Type of crop residue	Sululta	Girar Jarso	Ejere
Barley straw	1.96 (0.57-5.68)*	1.42 (0.57-2.28)	1.36 (0.33-2.62)
Teff straw	1.87 (0.83-3.33)	1.97 (0.84-2.53)	3.88 (0.94-11.25)
Wheat straw	1.76 (0.48-10.53)	0.49	2.94 (0.59-7.03)
Oats straw	1.07 (0.48-2.40)	0.46	0.89 (0.28-2.31)
Maize stover	-	-	1.08 (0.61-1.21)
Faba bean straw	0.60 (0.16-1.33)	0.66 (0.33-1.00)	0.49 (0.22-1.10)
Field pea straw	0.47 (0.13-1.06)	-	0.41 (0.31-0.62)
Chick pea straw	0.42 (0.16-1.25)	-	0.40
Grass pea straw	0.48 (0.32-0.64)	0.65	0.62 (0.03-1.23)
Total	5.28^{ab} (0.79-15.89)	3.04^{b} (2.24-4.64)	8.07^{a} (0.66-23.45)

[a-b]Means with different superscripts within a row differ significantly (P<0.05)

**Figures in the brackets indicate ranges of the different crop residues produced on the farm*

Improved forage production

The status of improved forage production in the study areas is shown in Table 4. Overall, 36.7% of the sample households reported to produce improved fodder crops. About 70.8 and 33.3% of the respondents in Ejere and Sululta, respectively, have reported to produce improved forages, while all the sample households in Girar Jarso (urban setting) had no experience in improved fodder production due to lack of access to farm land. The proximity of Ejere to Holetta Agricultural Research Center and the better access to improved forage technologies coupled with better extension efforts could be the major reason for the better adoption of improved forages in the area. A recent study has shown that adoption rate of improved forage crops in Oromia Region was 10% with comparatively higher adoption rates in North Shewa (23%) followed by Southwest Shewa (16%), Arsi (14%) and West Shewa (10%) (Agajie, *et al.*, 2016).

Table 4. Status of improved forage production in the study areas

Variable	Status	Sululta (n=60)		Girar Jarso (n=39)		Ejere (n=48)		Overall (N=147)	
		n	%	n	%	n	%	n	%
Production of improved forage crops	Yes	20	33.3	-	-	34	70.8	54	36.7
	No	40	66.7	39	100	14	29.2	93	63.3
Types of forage crops produced									
Napier grass (*Pennisetum purpureum*)		6	30.0	-	-	28	82.4	34	63.0
Treelucerne (*Chamaecytisus palmensis*)		13	65.0	-	-	24	70.6	38	70.4
Sesbania (*Sesbania sesban*)		3	15.0	-	-	14	41.2	18	33.3
Oats/vetch mixture		18	90.0	-	-	29	85.3	47	87.0
Fodder beet (*Beta vulgaris*)		4	20.0	-	-	1	2.9	5	9.3
Land area allocated for improved forage (ha)									
0.01 – 0.08		5	25.0	-	-	12	35.5	17	31.5
0.10 – 0.50		13	65.0	-	-	19	55.9	32	59.3
>0.50		2	10.0	-	-	3	8.8	5	9.3
Total		20	100	-	-	34	100	54	100
Mean±SE		0.16±0.03[b] (0.01–0.75)*				0.21±0.04[a] (0.01–1.13)		0.19±0.03 (0.01–1.13)	

[a-b] Means with different superscript letters within a row are significantly different (P<0.05)
**Indicate total range of land area covered by fodder crops in the three woredas*

The proportion of improved fodder producing farmers observed in this study was higher than the figures reported for crop-livestock mixed farms in different parts of Ethiopia *viz.*, Debre Birhan, Sebeta, Ziway and Jimma (Zewdie, 2010); in Benishangul-Gumuz (Beyene, *et al*., 2011); in Alaba area (Yeshitila, 2008); in Wolayta Soddo (Irvin, 2000) and in north-western Ethiopia (Yitaye, 2008). This may be attributed to the better exposure and access by farmers in the study areas to improved fodder production and utilization technologies than smallholder farmers in the other areas. The major types of improved fodder species produced in the study areas were Napier grass (*Pennisetum purpureum*), Tree lucerne

(*Chamaecytisus palmensis)*, Sesbania (*Sesbania sesban*), Oats/vetch mixture and Fodder beet (*Beta vulgaris*). Among the improved forage producing households, the majority (87%) have reported to adopt oats/vetch mixture followed by Tree lucerne (70.4%), Napier grass (63%), Sesbania (33.3%) and Fodder beet (9.3%). In Ejere, oats/vetch mixture and Napier grass were equally adopted followed by Tree lucerne, whereas in Sululta, Tree lucerne was the second important fodder produced after oats/vetch. This could be due to the difference in climatic conditions and soil types of the areas. Sululta is characterized by seasonal frost, waterlogged and poorly fertile soils which may limit the production of Napier grass which is highly susceptible to frost and low soil fertility than the other fodder crops.

The average area of land used for improved fodder production per household was 0.16 ha at Sululta and 0.21 ha at Ejere, with an overall average of 0.19 ha (Table 4). Majority of the improved fodder producing farmers (65% in Sululta, 55.9% in Ejere and 59.3% of the respondents) allocated 0.10-0.50 ha land for fodder production. Whereas, 25% in Sululta, 35.3% in Ejere, and 31.5% of the total fodder producing farmers reported to allocate only 0.01-0.08 ha land for fodder production. Small proportion (10% in Sululta, 8.8% in Ejere, and 9.3% of the total fodder producing farmers) reported to allocate more than 0.50 ha land for fodder production. The result showed that the average land area used for improved fodder production was estimated to account only for 5.9% of the total land owned by a household in the study areas. This is in line with the national scenario in which smallholder farmers are usually reluctant to take land away from food crop production and use for fodder production. Getnet *et al*., (2002) indicated that farmers are mainly willing to allocate their arable land for fodder production provided that they own crossbred dairy cows, and if the income from milk and milk products would be more rewarding than crop production.

Supplementary feed resources

The different types of supplementary feeds available for feeding dairy cattle in the study areas are presented in Table 5. Ten different concentrates and feed ingredients are used for feeding dairy cattle; the majority of which are agro-industrial by-products, while oats grain/hull and grass pea hull are locally produced. The majority of the dairy farmers reported to use wheat bran followed by noug (*Guizotia abyssinica)* seed cake and oats grain to supplement dairy cattle. Considerable proportion of the sample households also reported to supplement dairy cattle with molasses, compound dairy ration and brewery residues. Linseed and cotton seed cakes were mostly used for fattening and less commonly used for dairy cows except in Ejere where about 45.8% of the respondents reported to supplement dairy cattle with linseed cake especially when the animals lose condition.

The types of concentrate feeds/ingredients used to supplement dairy cattle were similar across the study areas except the variations in the degree of utilization of some ingredients like oats grain, grass pea hull and brewery residues. Oats grain was reported to be used to supplement dairy cattle by 85 and 37.5% of the sample households at Sululta and Ejere, respectively. About 45.8% of the sample households in Ejere also reported to use grass pea hull, which is commonly available in the area. Similarly, 58.3% of the sample households in Sululta reported to supplement dairy cattle with brewery residue (industrial), while it was uncommon in Ejere. However, local brewery residues were reported to be commonly used to supplement dairy cows in all the study areas.

Table 5. Types of supplementary feeds used for feeding dairy cattle in the study areas (% of respondents)

Type of supplementary feed	Sululta (n=60)	Girar Jarso (n=39)	Ejere (n=48)	Total (N=147)
Wheat bran	96.7	100	81.3	92.5
Wheat middling	30.0	15.4	14.6	21.1
Noug cake (*Guizotia abyssinica)*	75.0	82.1	77.1	77.6
Linseed cake	5.0	-	45.8	17.1
Cotton seed cake	3.3	2.6	-	2.1
Molasses	50.0	12.8	50.0	40.1
Brewery residues (industrial)	58.3	2.6	-	24.5
Compound dairy ration	18.3	33.3	31.3	26.5
Oats grain and/or hull	85.0	2.6	37.5	47.6
Grass pea hull	-	-	45.8	15.0

Feed conservation practices and utilization

Table 6 indicates the major types of conserved feeds in the study areas. Natural pasture hay was the dominant feed conserved followed by crop residues. Oats/vetch mixture hay was also reported to be conserved by some dairy farmers. Although oats is widely produced in Sululta than in Ejere, it is mainly used as a food grain than for hay production and this was the reason why oats/vetch hay conservation was reported by small proportion of farmers in Sululta than in Ejere. In both Sululta and Girar Jarso, natural pasture hay was ranked first as conserved feed followed by crop residues, whereas in Ejere, crop residues were the dominant conserved feeds. This is due to the better cropping intensity and higher crop residue production in Ejere than in the other two sites. Overall, natural pasture hay was ranked first as conserved feed for feeding dairy cattle. This shows that native hay is the major source of roughage feed for dairy cattle in the study areas and an improvement in feed supply for dairy cattle will depend on improvement in both productivity and quality of the available pasture lands. Moreover, development of oats/vetch mixture and conservation as hay can contribute to improve feed supply in the areas.

Table 6. Types of feeds conserved for feeding dairy cattle in the study areas

District	Type of feed conserved	% of respondents	Priority (1=highest; 3=lowest)			Rank
			1	2	3	
Sululta (n=60)	Natural pasture hay	100	90.0	10.0	-	1
	Crop residues	98.3	10.2	89.8	-	2
	Improved fodder hay	11.7	-	-	100	3
Girar Jarso (n=39)	Natural pasture hay	100	97.4	2.6	-	1
	Crop residues	64.1	4.0	96.0	-	2
	Improved fodder hay	2.6	-	-	100	3
Ejere (n=48)	Crop residues	100	78.7	19.2	2.1	1
	Natural pasture hay	97.9	20.8	72.9	6.3	2
	Improved fodder hay	25.0	8.3	25.0	66.7	3
Overall (N=147)	Natural pasture hay	99.3	69.4	28.6	2.0	1
	Crop residues	89.1	33.6	65.7	0.8	2
	Improved fodder hay	13.6	5.0	15.0	80.0	3

The forms and methods of storage of hay and crop residues practiced in the study areas are shown in Table 7. The majority of the sample households reported to store loose hay. Baling hay was totally uncommon in Ejere, while 31.7% and 35.9% of the respondents reported to make baled hay at Suluta and Girar Jarso, respectively. The sources of baler were private owners and the average baling costs ranged from 3.00-5.00 Birr/bale during this study (2012). Based on this, a farmer has to pay at least 1500 Birr for baling hay produced on 1 ha of land. Such a high baling cost was the major reason why most farmers store loose hay. Baled hay is advantageous over loose hay in terms of reducing field losses and facilitating the overall management practices such as collection, transportation, storage and feeding. Therefore, dairy development projects and government extension programs should consider introduction of balers to organized groups of farmers in potential hay producing areas.

About 57.8% of the sample households store hay in open air, 29.3% under shelter shade (corrugated iron roofed or grass thatched roof), and 12.9% using plastic covering on the hay stored outside (Table 7). It can be deduced that about 70% of the sample households store hay in open air as the protection provided by plastic sheets is only partial and does not equate to shelter shades. Most farmers believe that hay quality can be deteriorated when stored outside than under shade, and mentioned lack of resource capacity as the major limitation to construct shades. According to the farmers, mold growth, change in colour (black or brown-reddish), bad smell, low animal preference and high refusal are some indicators of spoiled hay. On the other hand, about 30% of the respondents perceived that hay can be stored outside without any problem if well thatched and piled properly.

A study at Holetta showed that CP content of natural pasture hay was reduced by 23.3 and 36.7% between the pre-storage period and eight months after storage when stored under shelter shade and in open air, respectively (Fekede *et al.*, 2014). This shows that storing hay outside for a long period will result in substantial loss in feed quality to the level detrimental to the nutrition of dairy cattle. Exposure to

adverse weather conditions is the major factor responsible for the loss in hay quality when stored outside. Hay that is stored outside and subjected to wetting and drying cycles will develop a fibrous, weathered layer and this process is referred as "weathering". Weathering in hay refers to the wet, discolored, and moldy layer on the exterior and bottom surfaces of baled and/or loose hay (Lemus, 2009). The process will decrease digestibility, increases fiber concentration and reduces the overall hay quality. The highest nutrient loss in hay due to weathering is caused by leaching which refers to the dissolving and removal of nutrients by the passage of rain water over the surface of the hay. In this process, the more soluble nutrients (carbohydrates, lipids, fatty acids, etc) are washed out of the forage. The loss of nutrients in this way causes the fiber component to represent a larger proportion of the dry matter with the consequent reduction in total digestible nutrients. Hence, there is a likelihood of substantial loss in hay quality when stored in open air as practiced by majority of the respondents in this study.

The forms and methods of storage of crop residues practiced by farmers in the study areas are also shown in Table 7. Baling crop residues was uncommon in the study areas and only 5.1% of the households in Sululta reported to have ever used baled crop residues by purchasing from the local market as it was brought from other areas like Bishoftu. Farmers usually store mixtures of different crop residues together and some of them also practice re-threshing crop residues both to reduce the fiber length and thoroughly mixing the different straws prior to storage. The major reasons for storing mixtures of crop residues were to save storage space, to improve animal intake of the less preferred crop residues such as wheat straw by mixing it with the most preferred ones like barley and oats straws, and to improve the nutritive value of straws by mixing pulse straws with cereal straws. On the other hand, the farmers reported that tef (*Eragrostis tef*) straw, which has various alternative uses other than feed is usually stored in pure form in order to ease its management and utilization for the different purposes.

About 69.5% of the sample households store crop residues under shelter shade, 27.5% in open air, and the rest (3%) use plastic covering (Table 7). This was in contrary to the storage method practiced for natural pasture hay. According to the farmers, crop residues except tef straw are thick stemmed and less suitable for firm piling in a way to protect percolation of rain into the inside of the heap and the consequent spoilage. Moreover, farmers reported that crop residues are mainly fed during the rainy season in combination with some green feeds, as it is perceived that feeding crop residues alone during the dry season could lead to loss in animal condition and reduced milk production. In views of these, crop residues are stored for a long period necessitating storage under shelter shade to avoid spoilage resulting from exposure to rain.

In a study conducted to assess the effects of storage method and storage duration on the dynamics in nutritional qualities of tef and wheat straws sampled from Ejere area, the CP, IVOMD and ME contents showed consistently decreasing trends with prolonged storage durations, with higher nutrient losses in

straws stored in open air than those stored under shelter (Fekede *et al.,* 2015). The result showed that the estimated losses in CP contents during the six months storage period when stored under shelter and in open air, respectively, were 30.2 and 41% in tef straw; and 22.3 and 46.9% in wheat straw. Similarly, IVOMD was reduced by 35.8 and 41.1% in tef straw and by 33.3 and 42.6% in wheat straw when stored under shelter and in open air, respectively, during the six months storage period. This shows that storing crop residues under shelter would help to maintain better nutritional quality in the straws.

The contribution of crop residues as livestock feed depends on proper collection, handling, processing, and storage. There was a well established practice of crop residue conservation for livestock/dairy cattle feeding in the study areas. However, baling crop residues was totally unknown and stacking loose straws into heaps was the sole traditionally adopted handling and storage of the crop residues to extend their use as feed. Such a practice may lead to losses in both biomass and nutritional quality during collection, transportation, storage and feeding. Moreover, it is difficult to handle and transport loose crop residues over long distances due to bulkiness. These factors could result in inefficient management and utilization of crop residues, not only in the study areas, but also throughout the country. For instance, there are many areas in the country where ample quantities of cereal straws are produced and left in the field for in situ feeding instead of being collected and conserved for long term feeding. When left on the field, the residues rapidly deteriorate, and the considerable proportion is usually trampled upon and wasted, while there is critical feed shortage especially in the urban and peri-urban dairy production systems in the highlands of Ethiopia. There could be a possibility of using the potentially wasted crop residues in excess producing areas by transporting into the feed deficit areas provided that they are properly collected and baled. Baling crop residues is not only convenient and reduces cost of transportation, but also helps to reduce the space required for storage and facilitates feed budgeting as compared to the traditional handling of crop residues in loose form (Massawe and Mruttu, 2001). Hence, possible introduction of balers and crop residues baling technologies in potential grain producing areas not only helps to tackle feed shortage via efficient utilization of crop residues, but also enables farmers to generate substantial income by selling crop residues.

The duration of feeding stored feeds to dairy cattle in the study areas is shown in Table 8. Stored hay is used to feed dairy cattle for about 8 months (range, 2-12 months) per year. The duration of hay feeding period was significantly ($p<0.05$) longer in Girar Jarso (10.5 months) followed by Sululta (8.5 months), and was shorter at Ejere (5.4 months). Most dairy farmers in Girar Jarso and Sululta use hay as a major source of basal diet to dairy cattle for 8 months or more per year. On the other hand, over 80% of the respondents in Ejere use hay for 2-7 months per year. Overall, 42.9% of the sample households feed dairy cattle with hay for 2-7 months per year, while the rest (57.1%) use hay for 8 months or more per year. Moreover, 46.1 and 25% of the respondents in Girar Jarso and Sululta, respectively, reported to feed hay

for more than 10 months per year. Hay is considered as better quality roughage by the dairy farmers and is preferably fed to lactating cows, while the other groups of cattle are fed with crop residues especially in Ejere where the supply of hay is very limited as compared to the other two sites.

Table 7. Form of storage and method of storage of hay and crop residues in the study areas (% of respondents)

Feed type	Form and method of storage		Sululta (n=60)	Girar Jarso (n=39)	Ejere (n=48)	Overall (N=147)
Hay	Form of storage	Loose hay	68.3	64.1	100	77.5
		Baled hay	31.7	35.9	-	22.5
		Total	***100***	***100***	***100***	***100***
	Method of storage	Under shelter shade	38.3	25.6	20.8	29.3
		In open air	55.0	61.5	58.3	57.8
		Using plastic cover	6.7	12.8	20.8	12.9
		Total	***100***	***100***	***100***	***100***
Crop residues	Form of storage	Loose hay	94.9	100	100	97.7
		Baled hay	5.1	-	-	2.3
		Total	***100***	***100***	***100***	***100***
	Method of storage	Under shelter shade	71.2	60.0	72.3	69.5
		In open air	25.4	32.0	27.7	27.5
		Using plastic cover	3.4	8.0	-	3.0
		Total	***100***	***100***	***100***	***100***

The overall average duration of feeding crop residues to dairy cattle in the study areas was 5.8 months (range, 1 to 12 months) per year (Table 8). Crop residues were fed to dairy cattle for a longer ($p<0.05$) duration in Ejere (7.5 months) followed by Sululta (5.4 months), and the shortest at Girar Jarso (3.5 months). About 61.7% of the sample households in Ejere reported to use crop residues as a major source of basal feed to dairy cattle for 7 months or more per year. On the other hand, majority of the dairy farmers in Sululta and Girar Jarso use crop residues as basal feed to dairy cattle for 1-6 months per year. Overall, 67.2% of the total respondents in the study areas feed crop residues to dairy cattle for a period of 1-6 months, 23.7% for 7-9 months, and the rest 9.2% for more than 9 months per year. The study showed that the major share of annual basal feed supply to dairy cattle was obtained from crop residues in Ejere, and from natural pasture hay in Sululta and Girar Jarso. This implies that both technological and development interventions to improve basal livestock feed supply should mainly target crop residues in Ejere, and hay in Sululta and Girar Jarso.

As shown in Table 8, the overall average duration of feeding all stored feeds (natural pasture hay plus crop residues) to dairy cattle in the study areas was 10.4 months (range, 5-12 months) per year. Basal feed supply to dairy cattle was contributed by stored feeds the whole year in Girar Jarso (urban setting), for 10 months in Sululta, and for 9.7 months at Ejere. Dairy cattle were maintained on stored feeds for about 8-10 months per year according to 51.7% of the sample households in Sululta, 50% in Ejere and

37.4% of the total respondents. The remaining (55.1%)sample households (40% in Sululta, 100% in Girar Jarso and 37.5% in Ejere) also reported to maintain dairy cattle on stored feeds for 11-12 months per year. The findings showed that peri-urban dairy farmers in Sululta and Ejere areas maintain their cows on other feed resources mainly on grazing for about 2 months (range, 1-7 months) per year. On the other hand, in the urban production system at Girar Jarso, dairy cattle are totally confined and maintained on stored feeds the year round.

Table 8. Duration of feeding stored feeds to dairy cattle in a year (% of respondents)

Type of feed	Feeding period (months)	Sululta (n=60)	Girar Jarso (n=39)	Ejere (n=48)	Overall (N=147)
Hay	2 – 4	3.3	-	39.6	14.3
	5 – 7	33.3	2.6	43.7	28.6
	8 – 10	38.3	51.3	14.6	34.0
	>10	25.0	46.1	2.1	23.1
	Total	100	100	100	100
	Mean (months)	8.5^{b} (3-12)*	10.5^{a} (5-12)	5.4^{c} (2-12)	8.0 (2-12)
Crop residues	1 – 3	11.9	60.0	-	16.8
	4 – 6	67.8	32.0	38.3	50.4
	7 – 9	15.2	8.0	42.5	23.7
	>9	5.2	-	19.2	9.2
	Total	100	100	100	100
	Mean (months)	5.4^{b} (2-12)	3.5^{c} (1-8)	7.5^{a} (4-12)	5.8 (1-12)
All stored feed	5 – 7	8.3	-	12.5	7.5
	8 – 10	51.7	-	50.0	37.4
	11 – 12	40.0	100	37.5	55.1
	Total	100	100	100	100
	Mean (months)	10.0^{b} (6-12)	11.9^{c} (11-12)	9.7^{b} (5-12)	10.4 (5-12)

$^{a-c}$ Means with different superscripts within a row differ significantly (P<0.05)
**Figures in the brackets indicate total range in the duration of feeding period of stored feeds*

Conclusion

Natural pasture hay followed by crop residues and grazing constituted the dominant sources of basal feed used for feeding dairy cattle in the study areas. Dairy farmers produce hay on their own pasture land and/or by contracting standing hay. Very small percentage of farmers also make oats/vetch mixed hay. Different crop residues are used for feeding dairy cattle mainly in the peri-urban dairy production systems at Ejere and Sululta. About 36.7% of the farmers included in the study have adopted the production of improved fodder crops on an average land area of 0.19ha. Different agro-industrial and locally available by-products are also used to supplement dairy cattle.

Most farmers tore hay in loose form and in open air. Although baling crop residues is uncommon, about 70% of the dairy farmers store the crop residues under shelter. Dairy cattle are maintained on a

basal diet of hay, crop residues and all stored feeds, respectively for 8, 5.8 and 10.4 months per annum. The study revealed that both the form and method of feed storage practiced by farmers were less efficient to ensure adequate supply of better quality basal feed to dairy cattle. Hence, frequent trainings and advisory services should be provided to farmers and development agents on efficient feed conservation and utilization. Moreover, introduction of baling machines and promotions of baling bulky feeds are essential for efficient handling and utilization of available feeds. Baling will also helps to facilitate mobilizations of seasonally excess feeds available in some areas for use in deficit areas.

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