AVAILABILITY, UTILIZATION, AND CHEMICAL COMPOSITION OF BARLEY (*Hordeum vulgar* L.) STRAW IN KOFELE DISTRICT, ETHIOPIA

M.Sc. THESIS

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Availability, Utilization, and Chemical Composition of Barley (*Hordeum vulgar* L.) Straw in Kofele District, Ethiopia

By Refissa Bekele Moti

M.Sc. Thesis

Submitted to the School of Graduate Studies of Jimma University, College of Agriculture and Veterinary Medicine, Department of Animal Sciences in Partial Fulfillment of the Requirements for the Degree of Master of Science in Animal Production

Major Advisor: Taye Tolemariam Ejeta (Prof.)
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We, the thesis advisers have evaluated the content of this thesis and found to be satisfactory, executed according to the approved proposal, written according to the standard and format of the University and ready to be submitted. Hence, we recommend the thesis to be submitted.

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DEDICATION

This work is dedicated to my relatives Wondimu Mihrete and Emebet Tadele.

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BIOGRAPHICAL SKETCH

Refissa Bekele was born in 1992 from his mother Medekse Waktola and his father Bekele Moti in Sibu sire woreda East Wollega Zone, Oromia Region. He started his education in Bujura elementary and junior school and completed his senior secondary and preparatory School Education at Sibu sire secondary and Preparatory School.

Upon successful completion of his high school and Preparatory school studies, he joined Jimma University, College of Agriculture and Veterinary Medicine in Animal Science in September, 2006. Later he graduated with diploma in General Agriculture from Israel and B.Sc. in Animal Science from Jimma University College of Agriculture and Veterinary Medicine, and then he immediately joined Animal production for Msc program.

STATEMENT OF THE AUTHOR

I declare that the thesis hereby submitted for the MSc degree at the Jimma University College of Agriculture and Veterinary Medicine is my own work and has not been previously submitted at any other university or institution for any degree or diploma. I concede copyright of the thesis in favour of the Jimma University, College of Agriculture and Veterinary Medicine.

Name: Refissa Bekele Moti

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LIST OF ABBREVIATIONS

ADF	Acid Detergent Fiber
AOAC	Association of Official Analytical Chemists
CF	Crude Fiber
CGL	Communal Grazing Land
CP	Crude Protein
CSA	Central Statistical Agency
DCP	Digestible Crude Protein
DM	Dry Matter
DMI	Dry Matter Intake
ELDMPS	Ethiopian Livestock Development Master Plan Study
FAO	Food and Agriculture Organization,United Nations
g	Gram
IVDMD	In Vitro Dry Matter Digestibility
kg	Kilogram
km	Kilometer
LFDO	Livestock and Fisheries Development Office
m	Meter
m.a.s.l	Meter above Sea Level
ME	Metabolizable Energy
ml	Milliliter
MoA	Ministry of Agriculture
N	Nitrogen
Na2SO3	Sodium sulphate
NDF	Neutral Detergent Fiber
NRC	National Research Council,USA
PLG	Private grazing Land
SAS	Statistical Analysis of System
SPSS	Statistical Package for the Social Sciences
T/ha	Tone per hectare
TLU	Tropical Livestock Unit
WANRO	Woreda Agricultural and Natural resource Office

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ABSTRACT

This study was carried out to identify available feed resources, with particular focus on barley straw, in Kofele district of West Arsi Zone in Oromia Regional State, southeastern Ethiopia. Information on utilization, feeding practices of barley straw and constraints limiting its use in two kebeles, namely Geremama and Guchi was assessed by interviewing 180 households based on accessibility and straw yields. In evaluating the nutritional values of barley straw, samples of five barley varieties, namely, Ebon, Traveler, Kulumsa, Excel, and Grace were considered. The annual estimated barley straw yield was 11.92 and 9.41 tons/ha in Germama and Guchi respectively. The amount used as animal feeds at Guchi kebele was about (83.48%)of the barley straw produced that was higher than that of Germama kebele 78.75%. Higher proportion of farmers from Guchi kebele utilized barley straw for economical purposes such as feed, as mulch and as the source of income more than that of Germama.Farmers at the study area had an average of 14.97 years of barley growing practices. The firest preference of households in study area to feed their livestock was barley staw compared with available straws of wheat and pulse with the index of 0.94 at Germama and 0.93 at Guchi kebele.The most use of barley straw was to Cattle feed. The most barley straw quality affecting factor at Germama kebele was rain during storage at the index of 0.85 and at Guchi was mold at the index of 0.75. Lack of awareness was the major constraint by all respondents in Germama and Guchi for the use of barley straw as animal feed. The dry matter (DM) contents of all barley straws were above 90%. Traveller variety of barley straw had the highest crude protein content (5.54%). Mean neutral detergent fiber (NDF) of all the varities was (73.19 %) and there was no significant diference(p=0.57) between varities.Mean In–vitro, organic matter digestibility (IVOMD) of barley straw varities was(47.59%) and there was no significant diference between varitiea(p=0.69). In general,between barley straws used in the current study there was significant diference in CP ,Ash and ADL containts. Therefore, efficient utilization of barley straw in the study area necessitates for designing appropriate strategies to enhance the feeding value of the straw, along with awareness creation about the availability of the resource as feed.

Key Words: Barley Straw, Collection and Storage, Constraints, Feeding System and Utilization

1. INTRODUCTION

Sufficient and quality feed resource availability is some major determinants of livestock productivity (Eba *et al.,* 2013). Seasonality in feed availability and lack of knowledge on feed conservation has created feed shortage both in the highland and lowland ecology of Ethiopia (Tesfaye *et al*., 2010). Furthermore, the population pressure and expansion of cropland call for alternative ways of feed production, conservation, and utilization. However, the seasonally surplus total dry matter biomass could be effectively utilized to support market-oriented ruminant production (Tesfaye *et al.,* 2010). Feed supply was erratic and seasonal. There was a severe shortage during the dry season from January to the beginning of the small rain (ESAP, 2009).

Various studies and reviews (Alemayehu, 2006; Yayneshet, 2010; Adugna, 2012; Diriba *et al.,* 2013) underscored that inadequate feed supply is the major obstacle hampering livestock productivity in Ethiopia. A feed is the major production input and the major cost item in any livestock production activity accounting for about 60-70% of the total cost of production (Adugna, 2012). Inadequacy of feed in terms of quality and quantity is considered to be critical among the constraints of livestock in the country and this is exacerbated by the expansion of cropping land, urbanization and industrial development, all of which result in a proportional decrease in grazing land (Alemayehu, 2006).

Animal agriculture is an integral component of almost all farming systems in Ethiopia. In the highlands, livestock serve as sources of food, employment opportunity; income, draft power and fertilizer, while in the lowlands livestock form the basis of the livelihood for the pastoralist community. These various linkages form the economic and social basis of agriculture and thus have contributed to poverty alleviation and food security. The major feed source, mainly during the dry season, has been residues from different crops. Annually available crops residues in Ethiopia have so far been estimated based on harvest indices of source crops. Actual figure based on farmers circumstances are lacking. Crop residue productivity and its quality has been affected by a number of factors, which include species of the crop, variety, the production location and prevailing climatic condition in the growing area, different agronomic practices, post-harvest management and storage practices.

The contribution of native pasture is declining from time to time due to poor management systems and continued advance of crop farming into grazing lands (Adugna., 1999; Diriba *et al.*, 2013). The continued expansion of crop farming is resulting in the increasing share of crop residues as livestock feed resources. For example in Ethiopian highlands, crop residues provide on average about 50% of the total feed source for ruminant livestock and the contributions of crop residues reach up to 80% during the dry seasons of the year in densely populated and intensively cultivated parts of the country (Adugna, 2007; Kassahun et al., 2015) which further increases as more and more of the native grasslands are cultivated to satisfy the grain needs of the rapidly increasing human population (Ahmed *et al.*, 2010).

Crop residue is one of the main feed in animal production in Ethiopia, especially those areas which practice livestock and crop production. Apart from being a source of animal feed, residues are also used as fuel, sold as an income source and are also used for house construction, particularly for plastering of walls and thatching of roofs. Some farmers also use crop residues for mulching purposes to enhance the fertility of the soil (Dereje *et al*., 2014). In the mixed cereal livestock farming systems of the Ethiopian highlands, crop residues (wheat, teff, millet, maize, and sorghum) provide on average about 50% of the total feed source for ruminant livestock. The contributions of crop residues reach up to 80% during the dry seasons of the year (Adugna, 2007). (Yeshitila 2008) confirmed that more than 65% of the feed resources are obtained from crop residues. Cereal crop residues are fed to livestock during the dry season when the quantity and quality of available fodder from natural pasture decline drastically (Getachew, 2002). Crop residues are abundantly available at the beginning of the dry season following the harvest and threshing of cereal and pulse crops. The low protein content (3.1-6.7%) and poor digestibility (40.7-54.1%) of these kinds of stuff make them feeds of low nutritional value (Malede and Takele, 2014; AACCSA, 2006).

Crop residues which constitute another major feed resource are produced in large amounts on farm, but only a small fraction of the amount available is used strategically. A large quantity of cereal straws is left on the field for in situ grazing, instead of being harvested, treated and stored for long term feeding. When left on the field, the residues rapidly deteriorate, and a large amount is usually trampled upon and wasted. In addition, the nutrient imbalance which

characterizes these fibrous residues is not corrected by appropriate supplementation (Olanrewaju, 1993).

Barley was mainly cultivated and used for human food supply in the last century but nowadays it is significantly grown as animal feed, malt products, and human food respectively. Barley (Hordeum vulgare L.) is an annual cereal crop, which belongs to the tribe Triticeae of family Poaceae (Martin *et al.*, 2006). Barley holds a unique place in farming in Ethiopia, and various sources agree that it has been in cultivation for at least the past 5000 years in the country. The first Ethiopians to have ever cultivated barley are believed to be the Agew people; in about 3000 BC (reviewed by Zemede, 1996). According to Birhanu et al. (2005) barley is used in diversity of recipes and deep rooted in the culture of people's diets. Besides its grain value, barley straw is an indispensable component of animal feed especially during the dry season in the highland where feed shortage is prevalent (Girma et al., 1996). Barley straw is also used in the construction of traditional huts and grain stores as thatching or as a mud plaster, as well as for use as bedding in the rural area (Zemede, 2000). The major barley growing areas in Ethiopia are located in the Southeastern highlands. Quite substantial amount of by-products of barley are annually produced in Ethiopia and have provided a major feed resource in the mixed crop livestock system of the highlands. Better utilization can be realized through innovations in the crop residue delivery system, which involves efforts by the research and extension systems and by farmers. But, little is known about the extent of production of barley straw, the level of use, feeding system and methods that could be used to improve the value of the straw as livestock feed. With the increasing need to explore alternative and cost_ effective feedstuffs, research into effective and efficient use of barley straw as livestock feed will have an important implication for livestock production in an era where population pressure is seriously reducing grazing lands that used to provide most of the livestock feed in Ethiopia.

Knowledge of the potential feed resources availability and utilization practices would be necessary in order to make judicious and effective use of available feed resources for enhancing livestock productivity. In this respect, there is scanty of information about the availability, production and utilization practices of barley straw in Kofele district. The progressive expansion of barley-based mono-cropping in Arsi highlands has raised the

importance of barley straw and stubble as animal feed by replacing natural grazing areas, which were encroached for the cultivation of cereal crops. Thus, it is of paramount significance to gather data on the types and volume of barley straw biomass production, chemical composition, and farmers' management and utilization system of the straw in the district.

1.1 Statement of the Problem

Despite the importance of livestock production in Ethiopia, animal productivity is low. The problem is feeding scarcity and fluctuation in quality and quantity within seasons and between years. As more and more land is put under crop production, livestock feed becomes scarce and crop residues, particularly cereal straw, remain the major feed source for the animals during the dry period of the year (which spans November through to May). They are produced on the farm and therefore widely spread geographically. On small farms in developing countries, they form the principal feed of ruminant livestock during the dry seasons.

The shortage of feed and low quality of the available feeds are among the major constraints affecting livestock productivity in the study area. The major feed resource used for livestock is crop residues such as barley straw which have low nutrient contents, especially protein. Identifying the locally available dietary resources which deserve better attention is one of the bases of the principles underlying the development of livestock feeding systems in developing countries, especially those in the tropics based on the available resources which are mainly crop residues, dry and/or mature pastures and agro -industrial by-products (Preston et al., 2007). The agricultural office of the area practiced very few types of improved barley development strategies. However, there has been no study on barley straw and its nutritive value for livestock feeds and the availability and utilization efficiency as well. So, this study aims to evaluate chemical composition of different varieties of barley straw and assess their potential as animal feed.

1.2 Research Questions

1. How much is the availability and Utilization of barley straw as livestock feed in Kofele area of Arsi zone, Ethiopia?

2 .What are the influencing factors for farmers' decisions on barley utilization and conservation?

1.3 The Objective of the Study

- The general objective of the study was to generate base-line information on availability and utilization of barley straw, and to evaluate the chemical composition of the available straw as feed for livestock at Kofele district of West Arsi zone, Ethiopia.

Specific Objectives

- ✓ To assess the availability of barley straw in terms of type and volume of production
- ✓ To determine the barley straw utilization method in the study area
- ✓ To determine the chemical composition and in vitro digestibility of the major available barley straw in the study area.

2. LITRATURE REVIEW

2.1.Available feed resources in Ethiopia

Livestock in the Sub-Saharan Africa are dependent primarily on native grasslands and crop residues (Ibrahim, 1999).The major available feed resources in Ethiopia are natural pasture, crop residues, aftermath grazing, and agro-industrial by-products (Adugna, 2007; Firew and Getnet, 2010; Yaynshet, 2010). The feeding systems include communal or private natural grazing and browsing, cut and carry feeding, hay and crop residues. The availability and quality of forage are not favorable year round.

At present, in the country stock are fed almost entirely on natural pasture and crop residues. The current report of (CSA, 2015) revealed that 56, 30 and 1.2% of the total livestock feed supply of the country is derived from grazing on natural pasture, crop residues and agro industrial byproducts respectively. (Shitahun,2009; Assefa *et al.*, 2013 and Gebremichael,2014) reported that natural pasture, weeds, aftermath grazing, crop residues and maize thinning in wet season and crop residues , aftermath grazing, hay and supplements were the major feed resources in dry season. Their contribution to the total feed resource base varies from area to area based on cropping intensity (Seyoum *et al.*2001). At present, livestock are fed almost entirely on natural pasture and crop-residues. Using of improved forages and agro-industrial by products is minimal and most of agro industrial by-products are concentrated in urban and peri-urban areas (Alemayehu, 2005). Though increased utilization of agro-industrial by-products has been reported (Benin *et al*., 2004), they are not available, affordable or feasible for most of the farmers in the highlands of Ethiopia. Depending on agro-ecology, different feeds are available at different season of the year. In the low altitude area of rangeland areas, grazing/browsing serves as the main source of feed available for most part of the year while in the mid-altitude and highland areas crop residues, stubble grazing, harvested hay, grazing/browsing, and to limited extent improved forages constitute the major feeds for livestock (Yayneshet, 2010).

2.1.1. Natural Pastures

Natural pasture refers to naturally occurring grasses, legumes, forbs, shrubs, and tree foliages used as livestock feed (Fekede *et.al,* 2011). The availability and quality of natural pastures

vary with altitude, rainfall, soil type and cropping intensity (Adugna, 2008). In Ethiopia the feed from natural pastures is estimated to covers 80-90% of the livestock feed (Alemayehu, 2006). In fact this figure varies between the lowland and highland parts of Ethiopia. Despite the continued expansion of croplands into the grasslands and the resultant decline in the size of grazing areas, native pastures remain the major contributors of livestock feed in the densely populated highlands of Ethiopia (Lemma *et al.*, 2002). Grazing lands still play a significant role in livestock feeding and support a diverse range of grasses, legumes, shrubs and trees (FAO, 2001). In the highlands of Ethiopia, seasonal fluctuation in the availability and quality of natural pasture is a common phenomenon which results in serious feed shortage thereby affecting livestock production and productivity (Solomon, 2004). Grazing of pasture and rangelands is an integral component of livestock production systems in many countries (Johansson *et al*., 1996).

Livestock grazing stimulates nutrient mobilization and uptake through consumption of vegetation; in that mobilization of nutrients to the growing points is enhanced by frequent defoliation (Mohamed, 1998). Natural grassland consists of the main highlands pastures of Ethiopia and the grassland of Ethiopia accounts for about 30.5% of the area of the country (Alemayehu, 2004). The size of the grazing land is decreasing over time with the expansion in farmland size, which is a result of the increase in human population. The size of the grazing land has declined after the land redistribution because of the decrease in the size of land holdings. Accordingly, the feed obtained from grazing lands is inadequate both in terms of quantity and quality throughout the year (Hassen et al., 2010).Natural pasture grazing lands are divided into private and communal grazing lands. Grazing on either private grazing land (PGL) or communal grazing land (CGL) is a common practice following the onset of rain in most parts the country (Hassen *et al.*, 2010). The use of communal grazing lands, private pastures and forest areas as feed resources have declined while the use of crop residues and purchased feed have generally increased (Benin *et al*., 2003).

2.1.2. Agro-industrial By-products

The supplementation with energy and protein-rich concentrates of forages which are likely to be of low nutritional value, can be expected to improve dry matter intake, milk yield, milk

solids content, body condition, nutrient utilization efficiency of livestock and most probably will result in a favorable benefit-cost ratio (Rehrahe et al., 2003; Tadesse et al., 2003 and Meeske et al., 2006).Supplemental feeds such as the by-products of grain and oil seed mills are fed to livestock especially when there is shortage of feed. Farmers in high altitude zone, especially those around the peri-urban areas, utilize by-products of grain for lactating crossbred cows. By- products of oil seeds secured through purchase from the local market are mixed with straw and other local supplements such as the spent brewer's grains from the local manufacture of "atela" to feed livestock especially cross-bred dairy cows (Hassen et al., 2010).

Agro-industrial by-products have special value in feeding livestock mainly in urban and Peri-urban livestock production system, as well as in situations where the productive Potential of the animals is relatively high and require high nutrient supply. The major agro-industrial by-products commonly used are obtained from milling industries, edible oil extracting by-products, brewery, and sugar producing industries (Adugna, 2007 and Birhanu et al., 2009). Though increased utilization of agro-industrial by-products has been reported (Benin et al., 2004), they are not available, affordable or feasible for most of the farmers in the highlands of Ethiopia. Under smallholder livestock production system, animals are dependent on a variety of feed resources which vary both in quantity and quality.

The various milling by-products obtained through processing wheat bran, corn and barley are of great interest as livestock feed for state farms, city dairy holders and to a lesser extent for some dairy co-operatives. Wheat grain is processed in big mills, whereas in the case of teff, barley, maize and sorghum the whole grains are processed and used for food (Yayneshet, 2010).

Oil cakes are an excellent concentrate feed for ruminant livestock in Ethiopia which grows most of the temperate and sub-tropical oilseed plants such as linseed, groundnuts, rape, sesame, sunflower, cotton seed and noug cake. The processing factory of oilseeds is widely practiced on a family basis or in small village mills. Brewer's grains are traditionally valued for lactating cows because of their palatability and milk-producing property. In addition to commercial beer production at the more than nine breweries are practiced in the country (Yayneshet, 2010).

2.1.3. Fodder Trees and Cultivated Forages

Fodder trees are the leaves, pods of trees and shrubs and twigs growing shrubs, woody vines and trees available for animal consumption (Alemayehu, 2006). Foliage of trees such as different acacia species and *Banalities aegyptiaca* as well as the pods and fruits of trees/shrubs can be used as substitute for concentrate supplement. Fodder trees and shrubs are important animal feeds in Ethiopia especially in arid, semi-arid and mountains zones, where large number of the country`s livestock is found (Alemayehu, 2004). Babayemi and (Bamikole, 2006) opined that fodder and shrubs are important components of ruminant diet and they have been found to play important roles in the nutrition of grazing animals in areas where few or no alternatives are available. Browses have multiple roles in farming systems such as feed, fuel wood and as human and veterinary medicines (Luseba and Van der Merwe, 2006). Their importance increases in arid areas (Getachew, 2002). The importance and availability of trees and shrubs in tropical Africa are influenced by the distribution, type and importance of livestock, their integration and role within the farming systems and availability of alternative sources of feed (Getachew, 2002).

The potential available resources of fodder trees and shrubs in different areas reported by the number of authors (Aynalem and Taye, 2008; Mekoya *et al*,2008; Belete *et al*.,2012; Diriba *et al.*,2013; Mulugeta and Kindu,2013 and Takele *et al*., 2014). The common browse species indentified in Ethiopia are: *Acacia ask, Acacia lahai, Acacia oerfeta, Acacia Senegal, Acacia tortilis, Albizia amera, Balanites aegyptiaca, Boswellia papyrifera, Ficus glumosa, Ziziphus spina-christi, Acalypha fruticosa, Xanthum spinosa, Ziziphis Mauritania* (Teferi, 2006 and Adugna *et al*., 2007).

Production of cultivated forage and pastures depends on availability of species that are adapted to the climatic, edaphic and biotic factors prevailing in the environment in which they are to be utilized. Suitability of a forage species to a given area is judged based on dry matter yield potential, persistence, adequate feed quality, compatibility with other species and ease of propagation and establishment. Cultivated forage and pasture crops are mainly important as cut and-carry sources of feed and as a supplement to crop residues and natural pastures. The type of cultivated forage crop produced is variable from place to place depending upon the prevailing climatic and edaphic factors.

2.1.4. Crop Residues

Livestock in Sub-Saharan Africa is dependent primarily on native grasslands and crop residues (Ibrahim, 1999). According to (Alemayehu 2003), Ethiopia's Livestock feed resources are mainly natural grazing and browse, crop residues, improved pasture, and agro-industrial by-products. The feeding systems in clued communal or private natural grazing and browsing cut and carry feeding, hay and crop residues. At present, in the country stock is fed almost entirely on natural pasture and crop residues. The availability and quality of forage are not favorable year_ round. As a result, the gains made in the wet season are totally or partially lost in the dry season (Alemayehu, 2003). Inadequate feed during the dry season is a major that causes a decline in the productivity of ruminants in the study area. In Ethiopia particularly in the West Arsi zone of Kofele district, the human population is increasing rapidly, forcing farmers to use grazing areas for arable farming. As a result, the smallholder farmers in this part of Ethiopia have integrated their livestock into their cropping systems and used barley straw as a main livestock feed resources.

2.1.5. Barley straws

Barley (Hordeum vulgare L.) is an annual cereal crop, which belongs to the tribe Triticeae of family Poaceae (Martin *et al.,* 2006). It is a diploid (2n=14) plant with high degree of self-fertilization. Barley is the most widely grown crop over broad environmental conditions. It has persisted as a major cereal crop through many centuries and it is the world's fourth important cereal crop after wheat maize and rice (Martin *et al.,* 2006). Barley has a long history of cultivation in Ethiopia and it is reported to have coincided with the beginning of plow culture (Zemede, 2000). It is the most important crop with total area coverage of 1,129,112 hectares and total annual production of about 1.7 million tons in main season (CSA, 2010). Ethiopia is the second in the Africa in terms of barley production and produced only 1.7million tons of barley during the year 2011(Verm .V *et al,.* 1996).

Barley is also a principal Belg season crop second to maize in area coverage and production (Birhanu *et al*., 2005; CSA, 2008). In the highland of the country barley can be grown in Oromia, Amhara, Tigray Regional States and part of SNNP in the altitude range of 1500 and 3500 m, but it is predominantly cultivated between 2000 and 3000 masl (Berhane *et al.,*

1996). Under extreme marginal conditions of drought, frost and poor soil fertility, barely is the most dependable cereal and is cultivated on highly degraded mountain slopes better than other cereal crops in the highland of Ethiopia (Ceccarelli *et al*., 1999). As barley is early harvested crop, it is popular hunger breaker or relief crop during season of food shortage in some parts of the country (Baye and Berhane, 2006). In Ethiopia, barley types are predominantly categorized as food and malting barley based on their uses while the highest proportion of barley production area is allocated for food barley. Food barley is principally cultivated in the highland where the highest consumption in the form of various traditional foods and local beverages from different barley types (Zemede, 2000). Ceccarelli et al. (1999) also indicated that barley grain accounts for over 60% of food for the highland in Ethiopia, for which it is the main source of calories. According to (Birhanu *et al.* 2005) barley is used in diversity of recipes and deep rooted in the culture of people's diets.

Besides its grain value, barley straw is an indispensable component of animal feed especially during the dry season in the highland where feed shortage is prevalent (Girma *et al*., 1996). Barley straw is also used in the construction of traditional huts and grain stores as thatching or as a mud plaster, as well as for use as bedding in the rural area (Zemede, 2000). Barley straw is commonly used as animal feed in many developing countries and, is one of the main feed in animal production in Ethiopia, West Arsi Zone of Kofele district, which practice livestock and crop production. Apart from being a source of animal feed, straws are also used as fuel, sold as an income source and are also used for house construction, particularly for plastering of walls and thatching of roofs. Some farmers also use crop residues for mulching purposes to enhance the fertility of the soil (Dereje *et al.,* 2014). In the mixed cereal livestock farming systems of the Ethiopian highlands, crop residues (barley, wheat, teff, millet, maize, and sorghum) provide on average about 50% of the total feed source for ruminant livestock. The contributions of crop residues reach up to 80% during the dry seasons of the year (Adugna, 2007). Yeshitila (2008) confirmed that more than 65% of the feed resources are obtained from crop residues. Cereal crop residues are fed to livestock during the dry season when the quantity and quality of available fodder from natural pasture decline drastically (Getachew, 2002). Crop residues are abundantly available at the beginning of the dry season following the harvest and threshing of cereal and pulse crops. The low protein content (3.1-6.7%) and poor

digestibility (40.7-54.1%) of these stuffs make them feeds of low nutritional value (Malede and Takele, 2014; AACCSA, 2006).

Barley straw which constitutes another major feed resource is produced in large amounts on the farm, but only a small fraction of the amount available is used strategically. A large quantity of cereal straws is left on the field for in situ grazing's, instead of being harvested, treated and stored for long term feeding. When left on the field, the residues rapidly deteriorate, and a large amount is usually trampled upon and wasted. In addition, the nutrient imbalance which characterizes these fibrous residues is not corrected by appropriate supplementation (Olanrewaju, 1993).

2.1.6. Other feed resources

Livestock feed resources are classified as conventional and non-conventional (Alemayehu, 2003), where the non-conventional ones vary according to the feeding habit of the community and others, e.g. vegetable refusals, sugar cane leaves, Enset leaves, fish offal and etc are nonconventional feed types. (Yeshitila 2008) also identified non conventional feeds and it includes like residues of local drinks coffee, atela, chat left over called geraba, fruits and vegetables reject. (Endale 2015) reported utilization of non-conventional feeds other than local alcohol waste (Atella) was very low.

2.1.7. Barley Straw Utilization and Management

In Ethiopia survey indicates that not all CRs produced is used as animal feed. In some parts of the country, households sell teff straw for wall plastering. Sorghum Stover is mainly used for fencing and firewood. Bean straws are not commonly used as animal feed. Maize Stover is harvested and piled for feeding during periods of feed shortage, but most of it is left in the field for stubble grazing. Barley straw is kept outside with little protection and in many parts of the country improper stacking and extended storage for up to 3–5 months exposed the straws to termite damage, wastage and nutrient leakage. Poor storage facility and effect of termites are the most serious problems related to crop residue utilization. Improvement of barley straw (e.g. urea treatment and ensiling of crop residues) is rarely practiced except spraying salt solution to improve palatability by some farmers. Generally, the availability of green fodder during most part of the year reduces the importance and proper utilization of

crop residues as livestock feed. The management of crop residue reflects the way smallholder farmers collect, transport, store, and feed to their livestock, and attempt to improve its nutritional quality using proven practices.

Although crop residue or barley straw is one of the available feed resources commonly used in the study area, the majority of the people do not practice appropriate handling of it. Both crop residue and barley straw will be utilized untreated by majority of the farmers begging from the time of harvest. Similarly, Mohammed et al. (2016) reported as stubbles of crops like maize, sorghum and teff were allowed to be grazed by livestock from October to December in Kersa, Omo Nada and Tiro Afeta; Jimma zone of administration. No chemical crop residue treatment was reported (100%) but (40.1%) of the respondents stated as they practice moistening and salting during feeding for collected and managed crop residues.

Seasonal variations and inadequate supply of quantity and quality feed are the major technical factors limiting the productivity of the livestock in Ethiopia. Feed, usually based on fodder and grass is not available in sufficient quantities due to fluctuating weather conditions (Ahmed et al., 2003).Natural pasture supply the bulk of livestock feed which is composed of indigenous forage species and is subjected to overgrazing. The fibrous agricultural residues contribute a major part of livestock feed especially in the populated countries where land is prioritized for crop cultivation. (Adugna, 2012) reported that crop residues contribute to about 50% of the total feed supply in Ethiopia.

The available quantity of each type of crop residues varied from place to place and between species. (Solomon *et al*. 2008) reported the annually available crop residue per household 9 tones in Sinana area and (Abdinasir 2000) reported 9.35 tons of straw per household in the highlands of Arsi in Ethiopia. (Shitahun,2009) reported the total utilizable DM production from cropping system per household significantly varied between the agro-ecologies that accounted for 8.05 TDM and 16.36 TDM in mid altitude and low altitude agro_ ecologies, respectively.

Information on management (Collection, storage and processing) and feeding of crop residues or barley straws, and constraints to undertake such practices was obtained from primary sources using a structured questionnaire.

Table 1 Problems related to the utilization of crop residues.

Collection and transportation	Storage problem	Feeding problem	Improvement
Labor shortage, lack of proper collection; transport and road problem	Stack outside, spoilage with urine, manure and rain	Treating feeds, use of proper feeding places and feeding troughs not widely used	Feeding with atela and salt concentrate and legume supplementation very limited
Lack of awareness, high cost, little practice of collection	Lack of knowledge and capacity to properly store	Improving but wastage is there, resistance to the use of technologies by farmers	Chopping
Lack of timely collection due to shortage of labor	Lack of awareness ,lack of storage facilities, termites, poor storage practice	No processing of feeds except traditional chopping of maize, no feeding troughs and proper feeding place	Occasionally feed by mixing with wheat bran for oxen
		No processing of feeds, access and input supply shortage, no treatment and conservation	Thinning and treating with salt dissolved water

Source: (Solomon *et al*, 2017)

2.1.8. Nutritional Qualities of Barley Straw

Feed quality means the ability and the extent to which feed has the potential to produce the desired animal response. Thus the quality reveals the level of nutrient chemical composition, palatability and intake, digestibility, anti-nutritional factors and animal production performance (Abeysekara, 2003). The nutritive value of ruminant feed is determined by the concentration of its chemical compositions, as well as the rate and extent of digestion in the rumen. The most practical approach to feed analysis is one of chemical composition direct determinations of dry matter, ether extract (fat), ash (mineral), nitrogen (crude protein), and fiber fractions.

Straws are rich in fiber, and poor in nutrients including protein, sugars, minerals and vitamins. Oat and barley straw is generally considered to be more nutritious and palatable than wheat

straw. According to (Kassahun *et al* 2016), the crude protein (CP) content of crop residues varied from 3.6 (wheat straw) – 8.14% (Noug chaff). This study also showed that the highest in vitro dry matter digestibility (IVDMD) was recorded in noug chaff (84.5%) while the lowest was in field pea straw (49.9%).The nutritive value of natural pasture in the central highlands of Ethiopia is low. It has low protein content and a high amount of fiber, and also low digestibility (Seyoum, 1989; Zinash, 1995 and Solomon, 2004). Low digestibility is a major factor constraining voluntary intake of high-fiber low-protein roughage in ruminants. These are the high cell wall contents and the low content of rumen degradable nutrients, especially nitrogen (N) and sulfur (S) and also low content of micro and macro minerals (Leng, 2009a).

The Dry matter contains the essential nutrients within a given feed ingredient or forage. Feeds, and thereby diets, vary widely in their dry matter content. Pasture feeds that have dry matter content usually have greater than 85% DM. The feed protein content is often considered a good determinant of quality. Low crude protein (CP) diets may result in rumen degradable protein deficiency and impact negatively on rumen fermentation and microbial synthesis, decreasing metabolizable energy and protein availability for livestock. As indicated in (Kazemi *et al.* 2012), legumes, grasses and grass-legume mixtures containing greater than 19% CP are rated as having prime standard and those with CP values lower than 8% are considered to be of inferior quality. The CP content of pasture and hay is less than 7%, which is very much below the requirement for adequate microbial function in the rumen (Van Soest, 1982). The protein content of hay on a DM basis was usually less than 5%, which is below the level of maintenance required for ruminants (Solomon *et al.,* 2008a).

The quality of legumes and grasses can be assessed by the type and quantity of fibrous material in the plant. Neutral detergent fiber (NDF) is the cell wall material of the plant and is comprised of the hemicelluloses, cellulose, and lignin. This proportion of cellulose, hemicelluloses and lignin affects the digestibility of the NDF fraction. With the less digestible forages, fewer nutrients are provided to the animal for production or growth (Kawas *et al.*, 1989). Increasing levels of NDF in plants and/or diets have been found to limit dry matter intake (DMI). Forage NDF has a slower passage rate and a higher rate of digestion than most non forage NDF (Mertens, 2002). Differences in the rate and extent of digestion of NDF and

ruminal digestibility of NDF are related to volatile fatty acid production and ultimately the ability to feed to maintain ruminal pH (NRC, 2001).

Acid detergent fiber (ADF) is comprised of cellulose and lignin and is closely associated with digestibility. An increase in the indigestible lignin complex in the ADF fraction reduces the digestibility of the plant. Therefore, ADF and digestibility are negatively correlated. Both NDF and ADF increase as the plant matures causing a decline in the quality of the forage (Jim Linn and Carla kuehn, 2007). According to (Mtimuni 1996) lignin percentage decreased with increasing maturity of the cereal forage due to increasing grain to stem and leaf ratio.

Crop residues are generally characterized by relatively low nutrient content, low CP, minerals and vitamins and high fiber contents, low digestibility and low voluntary intake (limited consumption) by animals. Crop residues are potentially rich sources of energy as about 80% of their DM consists of polysaccharide, but usually underutilized because of their low digestibility, which limits feed intake (FAO, 2002). The nutrient supply of many cereal straws such as teff, barley, and oat straws is closer to the nutrient supply of medium quality native grass hay. Thus good quality straw can be regarded as a good roughage source for livestock next to native grass hay (Adugna, 2008), and necessitate some degree of supplementation or treatment to support reasonable livestock performance (Kassahun *et al*, 2016). The crop residues have long been known as important maintenance for livestock. However, when used alone, they are of very low feeding value with poor metabolizable energy (ME), negligible available Protein and seriously deficient in mineral and vitamins. On the other hand, crop residues vary greatly in chemical composition and digestibility depending on varietal differences and agronomic practices. The feeding value of crop residues is also limited by their poor voluntary intakes, low digestibility and low nitrogen, energy, mineral and vitamin contents (Alemu *et al*., 1991).

Crop residues are fibrous and high in lignin content, which limits the feeding value (McDonald *et al*., 2002 and Adugna, 2009). The dry matter (DM) content of all crop residues was above 90% in both agro ecologies, which agreement with (Wondatir *et al*. 2011) and (Solomon *et al* 2008). The crude protein content is insufficient to fulfill even the maintenance requirement of animals (Rehrahe and Ledin, 2004). (Solomon *et al* 2008) reported that all

crop residues had higher than 70% NDF contents. Roughage feeds with NDF content of less than 45% are categorized as high quality, 45-65% as medium quality and those with more than 65% as low _quality roughages (Sigh and Ousting, 1992). They are inherently low in crude protein, digestibility, and intake and are deficient in minerals (Rehrahe, 2001). The lower nutrient contents reduce rumen efficiency, rumen micro-fauna and milk production performance. Hence, proper supplementations, with agro-industrial byproducts and/or concentrates, are suggested to make animals produce (Melese, 2008 and Girma, 2010). However, such supplements are out of the reach for the poor farmers due to cost and availability (Nurfeta, 2010).

In vitro digestibility of barley straw is higher than most of the crop residue, and the fibre content is lower than most other cereal crop residues. In a chemical examination of the dry matter, it was shown to have about 400–450 g/kg dry matter of cellulose, 300–500 g/kg dry matter of hemi-cellulose and 60–120 g/kg dry matter of lignin (Seyoum e*t al.*, 1998). This is an indication that barley straw has relatively better nutritional value than most of the crop residues.

Preston and Leng (1987) reported that straws from various species of grain crops appear to be highly variable in in vitro digestibility. In general, the organic matter digestibility (OMD) and estimated metabolizable energy value of barley straw is marginal, which makes barley straw a low quality basal feed. Apart from the low digestibility, a major disadvantage is the low intake obtained when barley straw is given to ruminant animals. According to, (Seyoum et al. 1998), a cow will consume up to 10 kg of medium quality grass hay, whereas it will consume only about 5 kg of barley straw. Furthermore, voluntary intake of cereal crop residues generally varies from 1.63% to 2.5% and from 1.87% to 1.91% of live weight for small ruminants and large ruminants respectively. It is therefore necessary to consider some sort of nutritional manipulation for barley-straw-based feeding systems.

2.1.9. Factors Affecting Quantity and Quality of Barley Straw

The nutritive value of a given feed is generally determined by nutrient composition, intake and utilization efficiency of digested matter. Yield and nutritional qualities of barley straw is influenced by numerous factors representing ecological conditions and management activities

and also barley productivity and its quality has been affected by a number of factors, which include species of the crop, variety, the production location and prevailing climatic condition in the growing area, different agronomic practices, post-harvest management and storage practices. Those factors include frequency of cutting, species composition, and maturity stage of the plant, climatic conditions, soil fertility status and season of harvesting (Yihalem, 2004)

The nutritive value of crop residues is also variable depending upon the species, and variety of the crops, time of harvest, handling and storage conditions and other factors (Hassen et al., 2010). Crop residues are mostly stored by stacking them outdoor near homesteads (Hassen *et al.*, 2010 and Mulugeta, 2005). Decay due to sunlight and unexpected rain or moisture condition was the major storage problem of almost all types of crop residues that could affect the quality and quantity of crop residues efficient utilization.

3. MATERIALS AND METHODS

3.1. Description of the Study Area

The study was conducted in Kofele district, West Arsi zone of Oromia Regional State, Ethiopia. Kofele district is located at 305 km from Addis Ababa towards South direction. It shares borders with Shashamene district in the West, Kokosa district in the South West and Kore district in the East directions (DOA, 2014). The district covers an area of 663 square kilometers and has 38 rural and two urban Kebeles. The total population of the district is 216159 (108156 males and 108003 females) having the rural population of 194531 (96652 males and 97879 females), an urban population of 21628 (11504 males and 10124 females) (CSA, 2014).

The major agro-ecologies of the district are high land (90%) and midland (10%) having loam soil type for highland and sandy loam for mid land soil types (DOA, 2014). The district is found within 2400 to 2700 m.a.s.l. It receives an average rainfall of 1800 mm per annum with a minimum of 2300mm per annum and a maximum of 2700mm per annum. The district has bi-modal rainfall distribution with small rains starting from March/April to May and the main rainy season extending from June to September/October. The average temperature is 19.5°C per year with a minimum of 17oC and a maximum of 22oC (DOA, 2014). The land use pattern of the district shows that 40260 ha is cultivable, 21629 ha is grazing land, 3852 ha is covered by forest, bushes and shrubs, and 4486 ha is being used for other purposes such as encampments, and infrastructure facilities. The district features a crop-livestock mixed farming system. The types of crops widely grown in the district are barley, potato, wheat, maize, inset, cabbage, and head cabbage. The district is known for its barley production (DOA, 2014).

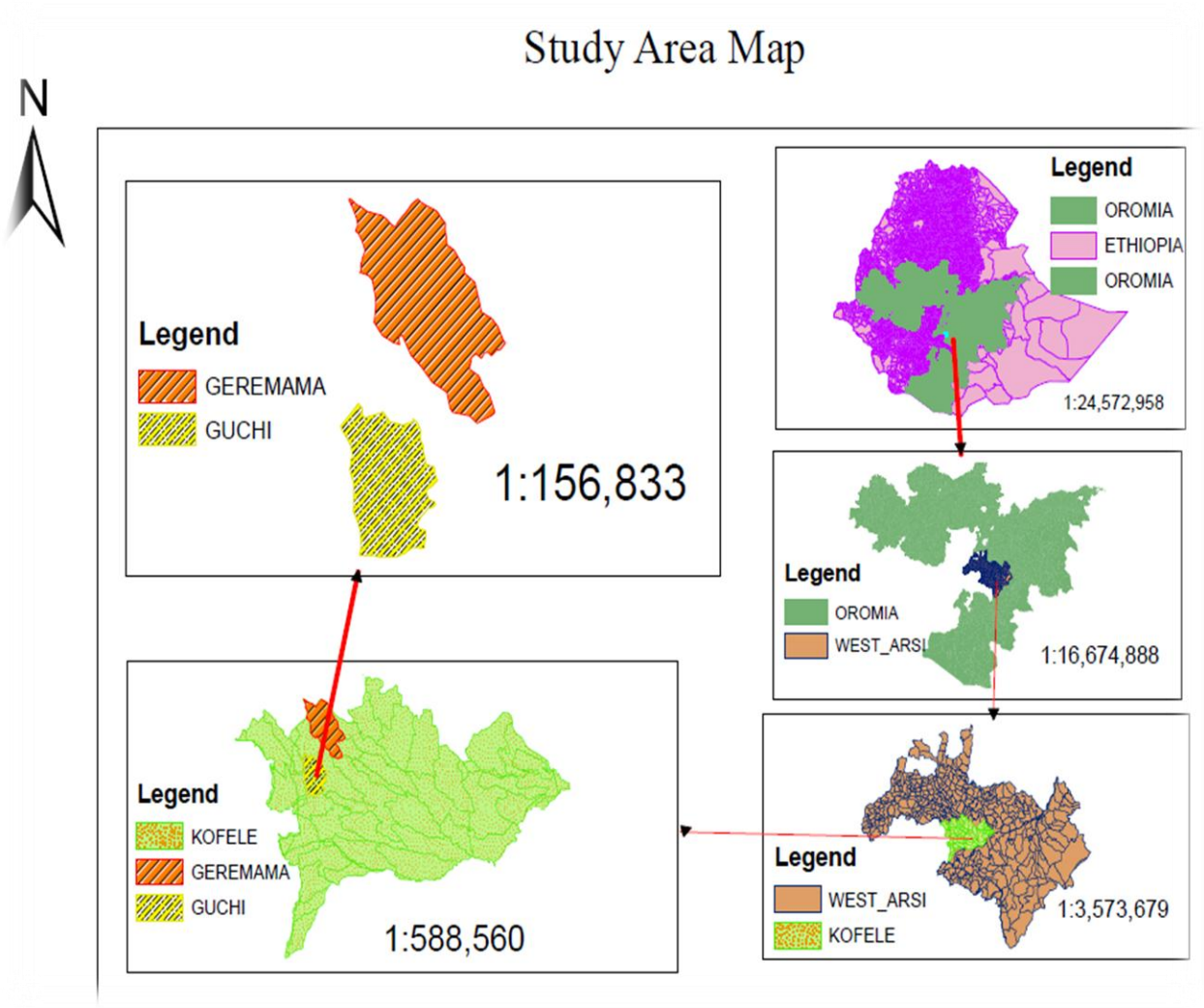

Figure 1. Geographical location of Kofele district and Shashamene in West Arsi Zone, Oromia, Ethiopia.

3.2. Sampling of respondents

A two stage sampling method was employed.Out of all kebeles (Kebele is the lowest administrative unit of Ethiopia) two kebeles (from the district) were selected purposively to encompass the dominantly barley producing kebeles. In the second stage, the households in each of the selected kebeles were stratified into three strata (poor, middle and better off) based on wealth status,and the volume of barley straw used for livestock feeding. Accordingly, two Kebeles (the lowest administrative unit in Ethiopia) namely; Germama and Guchi were purposively selected based on their representativeness and accessibility.From each PA, 90 respondents were selected using a random sampling technique, thereby making a total sample

size of 180 respondents, determined by the formula for determination of representative sample size proposed by Yamane (1967):

$$\mathbf{n} = \frac{N}{1+N(e)^2} \quad \text{----------} \quad \text{(Formula 1)}$$

Where: n = is the sample size of barley producer households, N = is the total barley producer households in the district and e = 0.05 is the level of precision defined to determine the required sample size at 95% level of precision.

The sampling frame was identified using wealth ranking criteria set by the community. Possession of livestock, cultivated land size, number of farming oxen and type of house owned were the most important criteria used for wealth ranking in the study area. The group which was used to establish the relative wealth position of the households in the community was composed of key informants in each Kebele (men, women, elders, and youth) based on the assumption that community members have a good sense of who among them is well off. According to the criteria set by the wealth ranking group, farmers who have greater than 10 cows, greater than 10 ha of cultivated land size, more than two pairs of oxen and house with corrugated iron or grass house with partition were considered as better off farmers. Farmers who have 4 to 10 cows, 3 to 10 ha of cultivated land, 1 to 2 pairs of farming oxen and house with corrugated iron or grass house with partition were considered as medium farmers. Farmers who have less or equal to 3 cows, less or equal to 2 ha of cultivated land, less or equal to 1 farming oxen and grass house were considered as poor farmers.

3.3. Survey data collection

The survey was conducted from January to February 2019. Data were collected employing primary and secondary methods on barley straw management such as collection, storage, processing and straw feeding system and constraints associated with such activities. Prior to data collection, respondents were briefed on issues associated with objective of the study and confidentiality of the information. Interviews were conducted when the situation was found convenient for both farmers and the interviewers. The questions were pre-tested to check for any possible sources of ambiguity. Four enumerators who have knowledge of the local

context and can speak local language were recruited. Training was given to the enumerators and the enumerators were supervised in the interview process.

Farmers were asked for information on grain yield of barley recorded during 2018 cropping season, and this value was used as input to estimate barley straw DM yield per hectare. Respondents were also interviewed to estimate the quantity of barley straw utilized for different purposes.

3.4. Sampling of barley straw for nutritional evaluation

Samples of the straw were collected from the field of farmers. The samples were categorized by variety types grown in the area. The varieties identified to be grown in the study area were: Ebon, Traveler, Kulumsa, Excel, and Grace. Straw sub-samples from each variety separetly were thoroughly mixed before and composite samples of 0.5 kg were dried in forced draught oven at 650 ^{o}c for 72 hours till constant weight. Then the dry samples were ground with whilley mill to pass through 1 mm sieve.

3.5.Laboratory analysis

The samples were evaluated for organic matter (% OM, 100-% crude ash), crude protein (CP, Nx6.25), crude ash and ether extract (EE) using standard procedures of AOAC (1990). Neutral detergent fiber (NDF) and acid detergent fiber (ADF) were determined sequentially by the method of Van Soest *et al*. (1991). NDF and ADF values were expressed inclusive of residual ash. Lignin (ADL) w

as determined by the solubilization of cellulose with H2SO4 (Van Soest and Robertson 1985). IVDMD was determined by the method of Van Soest and Robertson (1985).

3.6. Statistical Analysis

The computer software Excel was used for data management and entry. All the collected survey data were coded and entered into the computer with Excel. To analyze quantitative data the statistical package for social sciences (SPSS, version 20, 2012) was used. whereas GLM ANOVA was employed for Qualitative Data (Chemical analysis) and analyzed using

the SAS version 9.3. for barly straw by CRD design .Means with significant differences at ($P < 0.05$) were compared with each other using the Tukey pairwise comparison procedure.

The analysis included descriptive statistics (means, frequencies and percentages). Indices (weighted averages) were developed to obtain the aggregate ranking of barley straw feeding priorities of livestock types , straw type (crop residues) preference of households to feed livestock and factor affecting quality of barley straw calculated as Index by mega stat tool of microsoft excel.

The statistical model used is given below:

$Yijk = \mu + \alpha i + eijk$

Where: Yijk =quality and quantity of feed available

μ = Overall mean

ai = effect of varieties,

Eijk= random error

4. RESULTS AND DISCUSION

4.1. Household characteristics

Household size and the demographic characteristics of the respondents are presented in Table 2. The current result suggests that 137 (76%) of the respondents were males while 43 (24%) were females. From this result, males were the dominant. This may be associated with the fact that male headed households have more access to agricultural activities due to their exposure to different out-of-house issues. Age of the respondents ranged from 22 to 73 years with the mean of 25.6. Age of the respondents (83%) fell between 22 and 40 years implying that they were in active productive age range. The age of the household head can determine the agricultural activity of a family (Walker, 2003). In educational status, about 12% of the

farmers were illiterate and around 21 % of them were able to read and write. This event showed that about 33% of the farmers were not well educated at least in many schools. Bruna et al. (2014) reported that education is the main issue in agricultural development (especially primary and secondary schooling had higher impact on agricultural development compared to any other education level). Therefore, in the study area, these (33%) illiterate had its own impact on utilization of existing resources, technology transformation and adoption in the study areas.

Table 2 Demographic characteristics of the respondents Source: Field survey (2018)

Variable	Frequency	Percentage
Sex of respondent		
Male	137	76
Female	43	24
Age of respondent		
22-40	150	83
Above 40	30	17
Educational level		
Illiterate	21	12
Read and write	37	21
Primary (Grade 1–8)	110	61
Secondary (Grade 9–12)	12	7
B		
Married	125	69
Single	48	27
Widowed	3	2
Divorced	4	2
Household size		
3-6	40	22
7-10	110	61
Above10	30	17
Farming experience		
2-10	57	32
11-20	71	39
21-30	35	19
31-40	12	7
Above 40	5	3

Education is one of the important variables that increase an individual's ability to acquire, process and use agricultural information (Namara, 2003). The size of the households plays important roles in rural agriculture dependent parents. Household size of the respondent farmers ranged from 3 to 15 with an average household size of 7.1. It was reported that 60% of the respondents had more than six families per household.Farmers marry more than one wife around the study area or they have the trend of poly gamy marriage sytem.This might be due to the religious affairs which insist them to marry more than one spouse. This event indicates that the fertility rate was at least 6 children per mother which is above the national average (CSA, 2017). Household size plays many roles in rural agriculture (Nnadi, 2008). Farming experience of the sampled households was from 2 to 65 years, with average of 25.5 years. Older farmers apparently have more farming experience than that of the younger ones.

Table 3 Livestock population, land size holding and walking distance of respondents in the two kebele and the three wealth categories

Parameters	Mean±SD			
	Better off(N=60)	Middle(N=60)	Poor(N=60)	Over all Mean±SD
Animals				
Cow	11± 2.24	7± 1.8	3± 1.4	7± 1.81
Oxen	10±1.21	4±1.11	1±0.21	6±0.84
Sheep (number)	14±1.22	9±0.84	4±0.56	9±0.87
Equine (number)	4±0.54	2±0.34	1±0.21	1.5±0.36
Mean land size	12±1.2	8±1.3	2±0.9	7.44±1.14
Flat	3.06±0.8	2.04±0.8	0.51±0.7	1.87±0.77
Mild slop	7.1±0.7	4.73±0.6	1.18±0.5	4.34±0.6
Steep slop	1.84±0.3	1.23±0.5	0.31±0.4	1.23±0.4
Average walking distance to farm land (minutes)	13±10	10±4	4±4	9±6

The land and livestock holding characteristic of respondent is shown in Table 3. Mixed croplivestock production system is the dominant farming system in the district. Livestock production is subsistence oriented and is an important component of the mixed farming system and is well integrated with crop production. Livestock species kept by the farmers comprises of cattle, sheep, goats, equines and chicken.It shows that total number of cows and oxen were 7± 1.81, 6±0.84, and sheep and Equine, 9±0.87, 1.5±0.36 respectively in the study area. Average holdings of total livestock per household in the better off wealth status category in the study area were relatively higher than the middle and poor in the area. This might be due to more private grazing land availability from which higher proportion of livestock feed is derived is owned by the better off. Sheep were the dominant livestock species followed by cattle and Equine. The main objectives of livestock rearing in the study district were for drought power and income generation. In the study district, all respondents indicated that cattle are used for drought power, household milk consumption and for manure; small ruminant for income generation and donkey and horses for riding, transportation and social values and when farm produce is harvested.

In subsistence farming, the most important resources for agricultural production are land and labor. The types of crops widely grown in the district were barley, potato, wheat, maize, inset,

cabbage, and head cabbage. The total land holding of the respondents were 12±1.2 (better off), 8±1.3 (middle), and 2±0.9 ha (poor) per households. The largest land holding was recorded for better off (12±1.2) whereas the smallest was recorded for poor (2±0.9 ha/h). The average landholding of the respondents in the study district was 7.44±1.14 ha/h.

4.2. Availability of Barley Straw

Grain yield of the five varieties of barley is shown in Table 4.Traveller had higher grain yield than all the other varieties in both Kebeles (22.00 and 19.27) in Germamaand Guchi respectively. On the otherhand, kulumsa had lower grain yield than the rest.

Table 4 Barley grain production in Germama and Guchi kebele of kofele district Qt/ha

Grain Yield of straw variety	Kebele	N	Mean	Std. dv.
Exceller	Germama	90	14.00	1.64
	Guchi	90	14.20	1.23
Grace	Germama	90	15.27	6.71
	Guchi	90	13.00	4.64
Ibon	Germama	90	18.80	6.81
	Guchi	90	17.73	4.35
Trav	Germama	90	22.00	7.59
	Guchi	90	19.27	5.61
Kulu	Germama	90	13.00	4.25
	Guchi	90	11.87	4.96
Mean	Germama	90	16.61	5.64
	Guchi	90	15.21	5.78

Table 5 Different barley straw yield in ton/ha

Straw yield of different variety	Kebele	N	Mean	Std. Deviation	**SEM**
Exceller	Germama	90	14.27	13.06	**1.38**
	Guchi	90	10.20	5.10	**0.54**
Grace	Germama	90	4.20	4.65	**0.49**
	Guchi	90	4.67	4.68	**0.49**
Ibon	Germama	90	9.13	9.59	**1.01**
	Guchi	90	7.60	5.93	**0.62**
Traveler	Germama	90	26.13	27.36	**2.88**
	Guchi	90	17.93	8.25	**0.87**
Kulumsa	Germama	90	5.87	4.96	**0.52**
	Guchi	90	6.67	5.49	**0.58**
Mean Prod	Germama	90	11.92	5.87	**0.89**
	Guchi	90	9.41	8.77	**0.03**

Straw yield was also higher in Traveller than in the other varieties in both kebes from the table above in ton/ha.

This indicates that Traveler is found at large quantity as feed for livestock in study area. Compared to Guchi, straw production in Germama is higher (11.92>9.41ton/ha). The current estimate for barley straw production in both Kebeles appeared to be greater than the earlier estimate for other cereal straws with straw production of 0.75, 0.98, 0.96, 0.65 and 0.78 ton/ha for teff, barley, wheat, field peas and haricot bean, respectively (CSA 1984).But, the current results seems to be in agreement with that of Seyoum*et al*,(2004), who reported an estimates of total annual availability of basal feed resource of 33.4 million tones dry matter of which 57% is crop residues. Total feed/TLU (tropical livestock unit) varies from region to region, with an average of 0.68 t/TLU.

Table 6 Farmers barley cultivation experience at Germama and Guchi Kebele of Kofele district (years)

Practices of barley growing	N	Mean	Std.dev	Std. Error	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
Germama	90	17.80	9.730	1.026	15.76	19.84
Guchi	90	12.13	5.758	.607	10.93	13.34
Total	180	14.97	8.463	.631	13.72	16.21

The farming experience in barley growing of farmers in the two kebeles are depicted in the table 7 above.The experience of farmers in barley growing in Germama and Guchi was 17.80 and 12.13 yrs respectively with the total average of 14.97yrs.The current study indicates that farmers at the study site have long experience in barley growing based on their own traditional knowledge expereinces.

4.3.Barley Straw utilization

4.3.1.Use of Barley Straw

It was observed that different types of crop residues are used as livestock feed in the study area. In the present study sites, barley straw was reported to be used primarily for feeding cattle and sheep and is not preferred for equines and goats. The presented study also revealed that in Kofele, the preferred crop residue for calves, cattle, goat and donkey was barley straw and maize stover. The pattern of use of barley straw in the current study district is presented in Figure 3. The study indicated that barley straw to mostly be used for animal feeding which accounted for 78.75 % for Germama and 83.48% for Guchi. In Zimbabwe, Sibanda (1986) reported that most stovers were fed to animals in situ, while only some farmers harvest and store the residues for later use.

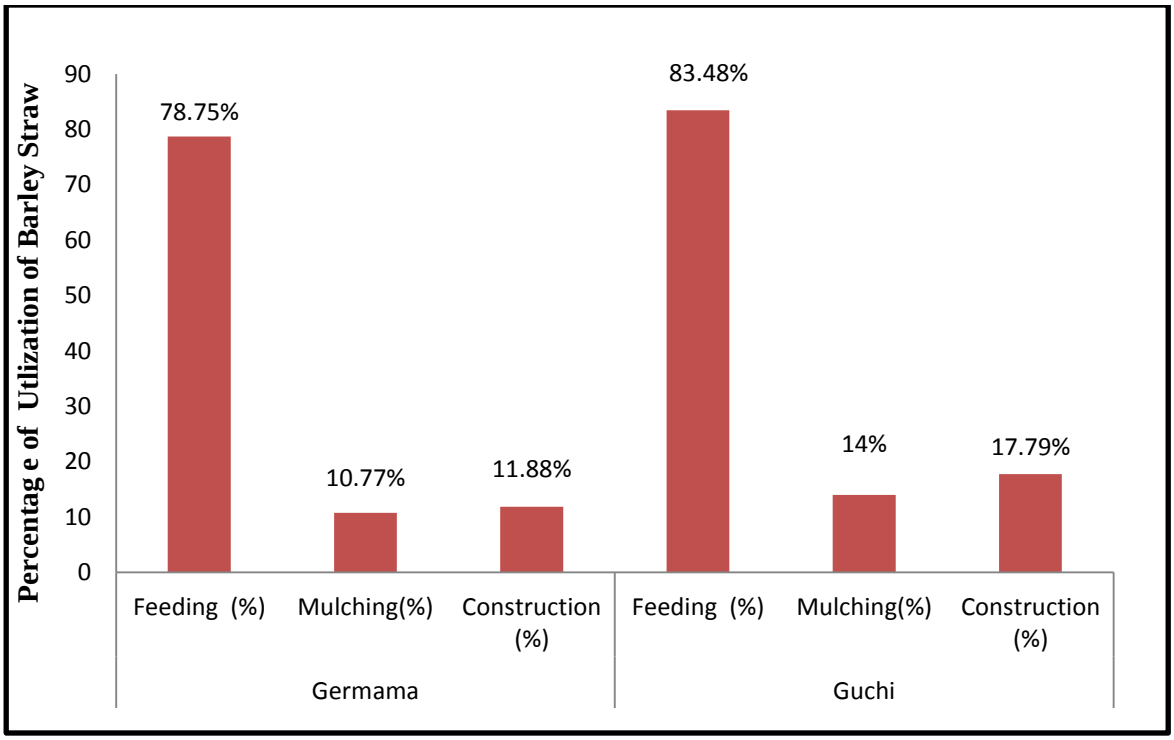

Figure 2 Use of Barley Straw at the study district

Barley straw was reported to be used for mulching (10.77%) in Germame and Guch (14%) (Figure 3). Farmers indicated that barley straw is available and comparatively more digestible and more preferred by animals than other straw during the dry season. The result is in agreement with the report of Jaleta *et al.* (2015) based on (CSA 2011)data. The findings of the present study is not in agreement with what was reported for sesame straw by Teferi *et al.*, (2014) for Kafta Humera and Metema districts

4.3.2. Barley Straw Conservation Methods

The practice of conserving barley straw in the present study area is shown in table 8. Barley is transported to a threshing ground located in the homestead area where they are threshed to separate the grain from the straws or is threshed in the field, and the utilization of the straw demands transporting the straw to homesteads where animals are kept or to use it later in the dry season. In situations of lack of transportation less straw are collected and stored for animal feeding. Baled or unbaled straw is stored in several ways, mainly classified as covered and uncovered. Stacks are made without shade, on the ground or on raised platforms, with

shape that facilitates rainwater run-off. Depending on the system followed the losses of nutrients due to leaching and microbial attack following rains would be variable.The use of covers is not common due to bulkiness of the material and the high costs for building or polythene. In many North Indian states straw stacks are mud-plastered to protect the straw from rains. Studies on nutrient losses from straw during storage are limited, and no information is available that compares the cost of storage with the cost of lost nutrients.

Table 7 Percentage of respondents practicing different ways of barley straw collection and storage in the two kebele and the three wealth categories

Collection and storage practices	**Germama**			**Guchi**		
	Better off	Middle	Poor	Better off	Middle	Poor
Collect and store all in open air	-	5	10	-	5	13
Collect and store all in shelter	37	25	20	35	20	16
Collect and store small amount	13	35	35	10	35	32
Leave all on threshing place	50	35	35	55	40	39

According to Tesfaye Alemu and Chairatanayuth (2007), more than 98% of barley straw is collected and stored for the dry season. Out of this, 97% of the barley straw is stored in an open area, whereas the rest is stored under shade. The straw is then stored in the form of a heap around the homestead. The heap is commonly fenced with locally available materials especially with thorny branches of trees and shrubs for protection from free roaming animals. The storage of the straws could be under tree shed or in an open field. About 50% of the respondents in Germama and 55 % of Guchi kebeles better of farmers do not have the habit of storing barley straw for future use as feed for their animals.

Table 8 Farmers practices in barley storage length in month at Germama and Guchi kebele of kofele district

Kebele	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
Germama	90	5.67	.70	.07	5.52	5.81
Guchi	90	5.40	.72	.08	5.25	5.55
Total	180	5.53	.72	.05	5.43	5.64

Table 9 shows farmers practices in barley storage length in month at Germama and Guchi kebele of kofele district .Accordingly the storage practice at Germama kebele is about 5.67 months and in Guchi 5.40 months with the overall average 5.53 months in both kebeles.

4.3.3.Factors affecting Barley straw conservation

Table 9 Major reasons of respondents (%) for not collecting and storing barley straw for future use in the two kebeles and the three wealth categories

Major reasons identified	Germama			Guchi		
	Better off	Middle	Poor	Better off	Middle	Poor
Lack of transportation	-	15	20		4	6
Field far from homestead	13.5		-	-	-	-
Use of straw for mulching	-	4.5	20		6	6
Availability of alternative feeds	-	-	-		9.5	8
Lack of awareness	70.5	60	30	72	59.5	45
Others	16	20.5	30	28	21	35

Most respondents do not practice collection and storing of barley straw for future use in the study area. The poor households and the medium undertake the storage practice than the better off in both kebeles no matter the number varies. Different reasons have been noted by respondents for not collecting and storing sesame straw (Table 10) and the main one was lack of awareness. Guchi, the presence of alternative feeds did not encourage farmers to collect and store the straw. Some of the middle and poor households indicated lack of transportation and the use of the straw for mulching as additional reasons for not collecting and storing sesame straw. Most of the better offs have huge farm land, and most of the land is located distant from home and was mentioned as a reason for not collecting barley straw. Similar report was published by Owen and Aboud (1988) who reported the bulky nature of crop residues and lack of means of transportation to be among the factors that constrain the collection and greater use of straws and stoves as feed. This also conforms to the report of McIntire et al (1989) who reported in situ grazing of crop residues throughout sub-Saharan Africa. Other reasons noted by respondents for not collecting and storing barley straw include shortage of time and labor, low palatability of the straw and lack of animals to be fed.

4.3.4. Ranking Barley straw feeding animals

Table 10 Ranking of feeding priorities of livestock with Barley straw as reported by respondents in Germama and Guchi Kebeles of Kofele district

Livestock type	Kebeles	Barley straw feeding rank (frequency of respondents)					
		1	2	3	4	Index	Rank
Cattle	Germama	55(61.11)	25(27.78)	10(11.11)	-	0.88	1
	Guchi	60(66.67)	15(16.67)	10(11.11)	5(5.56)	0.86	A
Sheep	Germama	5(5.56)	33(36.67)	40(44.44)	12(13.33)	0.59	3
	Guchi	7(7.78)	45(50.00)	35(38.89)	3(3.33)	0.66	B
Goat	Germama	5(5.56)	11(12.22)	26(28.89)	48(53.33)	0.43	4
	Guchi	3(3.33)	10(11.11)	20(22.22)	57(63.33)	0.39	D
Equines	Germama	25(27.78)	21(23.33)	14(15.56)	30(33.33)	0.61	2
	Guchi	20(22.22)	20(22.22)	25(27.78)	25(27.78)	0.60	C

Note:On the above table, numbers indicates that ranking for Germama Kebele, Letters indicates ranking of Guchi.

Different type of crop residues serve as livestock feed in the study area. Barley straw is primarily used for feeding cattle, Equine, Sheep and Goat and is not fed much to Sheep and Goats (Table 11). In Germama Kebele of Kofele district barley straw ranked first rank by virtue of its being soft, fine and less rain damage during rainy season. Similar ranking systems by which farming community select the soft, fine and ease of management for conservation and utilization of crop residues were reported for Sinana Dinsho districts (Solomon et al., 2008). Wheat straw ranked 2nd in terms of palatability and easy of management in highland and Pulse straw could be 3 $^{rd.}$

4.3.5. Straws type ranking to feed for animals

Table 11 Preference of households in the two Kebeles for different crop residues to feed livestock (values in tables are frequency and percentage)

Type	Kebele	1	2	3	Index	Rank
Wheat	Germama	6(6.67)	75(83.33)	9(10.00)	0.66	2
	Guchi	8(8.89)	73(81.11)	9(10.00)	0.66	B
Pulse	Germama	6(6.67)	6(6.67)	78(86.67)	0.40	3
	Guchi	8(8.89)	3(3.33)	79(87.78)	0.40	C
Barley	Germama	78(86.67)	9(10.00)	3(3.33)	0.94	1
	Guchi	74(82.22)	14(15.56)	2(2.22)	0.93	A

Note:On the above table, numbers indicates that ranking for Germama Kebele, Letters indicates ranking of Guchi.

From the point of view of using crop residues efficiently in feeding to different ruminants, it is important to know whether or not the farmers prefer one type of crop residues over the others. The farmers in the study areas have traditional knowledge of ranking order of available crop residues. This knowledge helps them to conserve the most palatable and easily manageable crop residues and feed their livestock preferably

4.3.6.Supplementary feeds used by the farmers

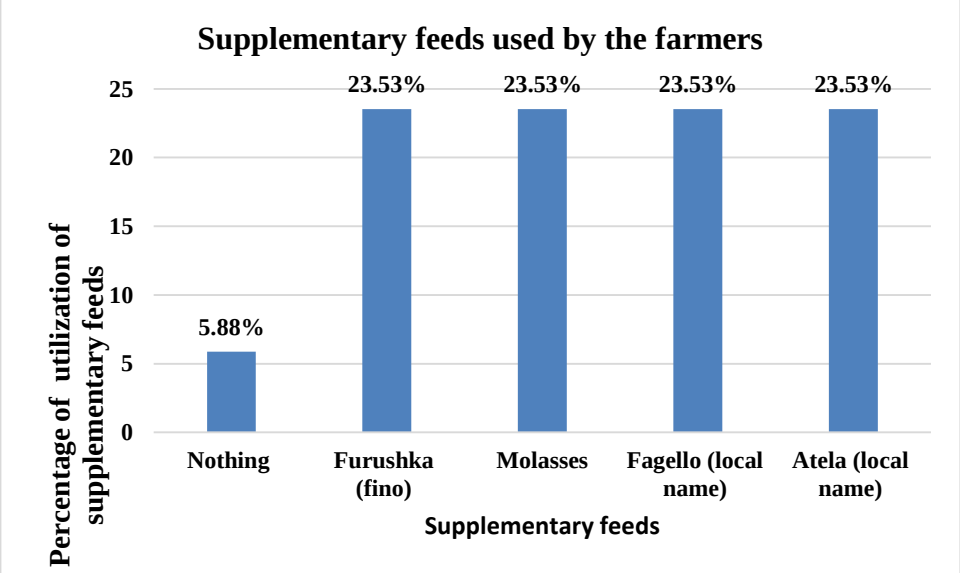

Figure 3 Supplementary feeds used by the farmers

The current practices of barley straw nutritional improvement strategies of respondents are shown in figure 4. The study revealed that respondents use different methods to improve barley straw such as Furushka or fino, Molasses, atela, and Fagello of straw. The majority of respondents equaly (23.53%) use either of the above feed as supplementary. Only few (5.8 %) donot supplement . Report from the above graph indicates farmers have traditional knowledge of using supplementation more likely to be applied than treatment. Also contributing has been the lack of convincing evidence showing production responses to using cheap locally available supplements. Smallholder farmers do not apply better nutritional improvements on barley straw such as urea treatment due which might be associated with lack of inputs and awareness.

However, as barley straw is usually low in crude protein, it is vital that supplementation of with a protein source and a more easily accessible energy source will improve the performance and production of the animals (Sarnklong *et al.* 2010; Alam e*t al.,* 2016). This finding indicates that many extension demonstration works should be done in the area about the utilization and feed value when to feed , how much to feed and how to feed the above mentioned supplements in the study area. Barley can be used effectively as a source of supplemental energy in ewe diets. Research conducted using lactating crossbred cows in Ethiopia, urea treated barley or teff straw were noted to replace native hay, and ammoniation was found to be economically feasible producing in milk production of cows (Derso, 2009; Hailu *et al.,* 2011). However, none of the respondents suggested chemical treatment as an option of barley straw which might be associated with lack of awareness and cost implications of urea and labor. Research conducted at Montana State University compared barley, soybean meal, barley plus blood meal, barley plus feather meal or control (no supplement) as supplements for gestating ewes grazing dormant native range (Thomas *et al*., 1992). Nonsupplemented ewes lost more weight than ewes fed supplements, ewes fed barley alone had intermediate weight gains, and ewes fed soybean meal, barley plus feather meal or barley plus blood meal had the highest weight gains. No differences were noted in subsequent reproductive performance, indicating that the economic advantage lies with the low-cost supplementation program.

4.3.7.Farmers' methods of judging Barley straw quality

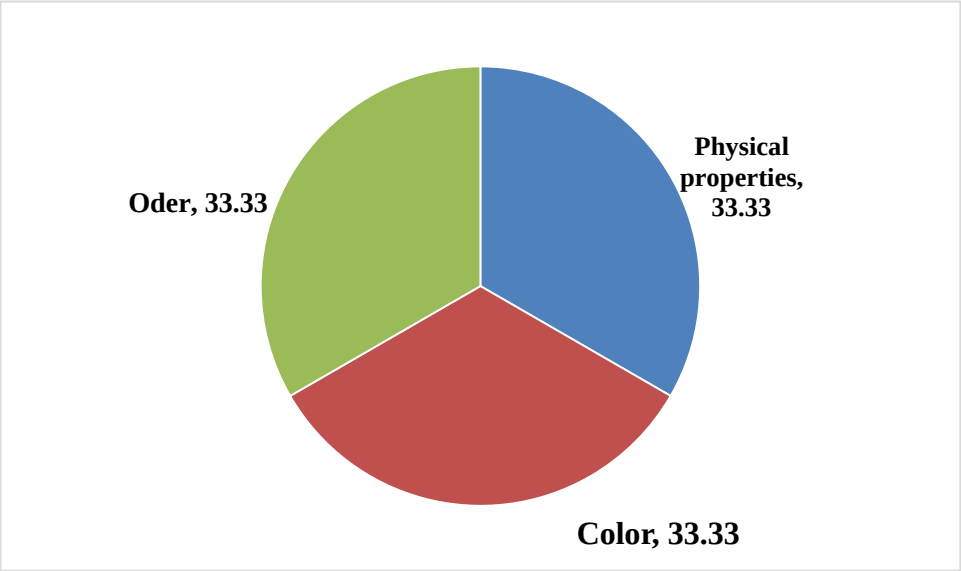

Figure 4 Farmers' methods of judging Barley straw quality

The quality of straw was expressed in different ways at the study area. Farmers were known to prefer to the Physical properties like: stem thickness, leaf content, sweetness or colour, and odour or smell whereas scientists use terms like crude protein, organic matter, cell wall and cell contents, digestibility and voluntary dry matter intake. Fortunately, these terms often express similar things e.g digestibility and intake are normally related with sweetness and leaf content. The low nitrogen and high fibre (cell wall) content are the principal factors affecting straw nutritive value in terms of voluntary intake and digestibility.

4.3.8.Farmers Training Stutus at Barley Straw Production ,Utilization ,source of information at utilization and Indigenous knowledge at Judging quality

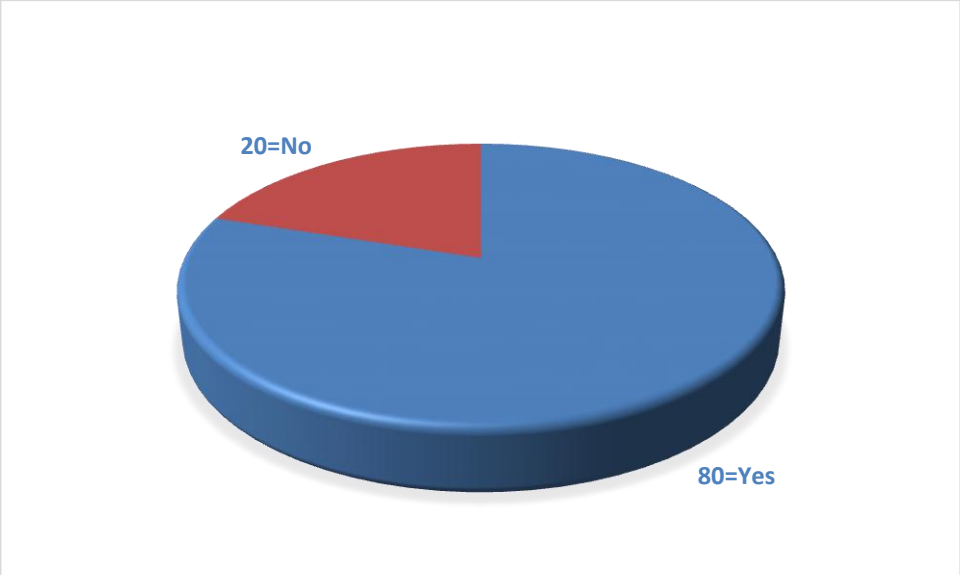

Figure 5 Farmers who received training on the production and utilization of barley straw

Among barley producers respondents the majority (80%) have got training on barley straw production and utilization techniques while only 20% has not got any training. The status of training of respondents in the current study dis agree with the report of Asmare et al. (2016) for desho grass utilization in Burie zuria district in northwestern Ethiopia. Also, the importance of training and visit to farmers' field has significant importance on the adoption of technology in tropics (Hussan et al., 1994; Rahman, 2007). In line with this, (Ampaire and Rothschild, 2010) indicated that farmers who had received more training and support had less disease in pigs in the six months preceding the study than those who had not been trained or who had the animals for a shorter period of time.

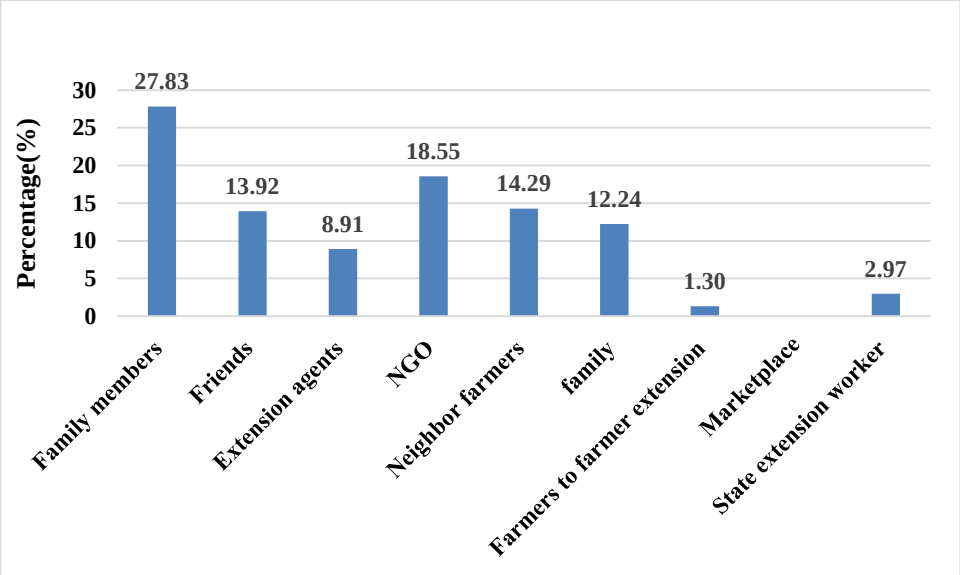

Figure 6 Source of information about barley straw utilization

Role of organizations in improving barley straw utilization was shown in the above graph from the point of view of using barleys straw efficiently in feeding to different ruminants, it is important to know whether or not the farmers are well awared in utilizing barley straw. The farmers in the study areas have traditional knowledge of utizing available barley straw. This knowledge helps them to conserve the most palatable and easily manageable straws and feed their livestock. The major actor involved in increasing productivity of barley straw were far mers themselves which was mentioned by 27.83% of the respondents. About quarter (18.55%) of the respondents stated that they do have support in organization like NGOs in barley straw utilization (figure 7).

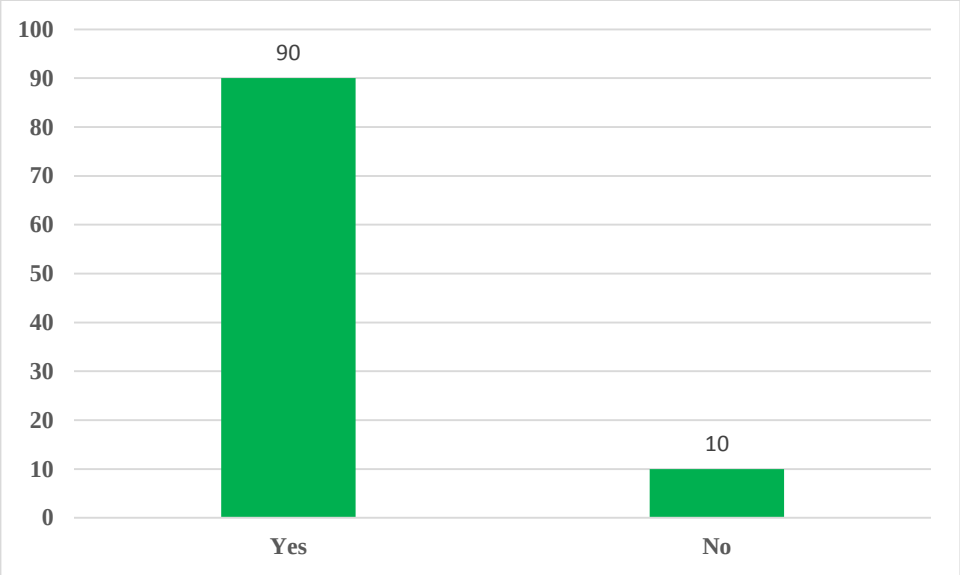

Figure 7 Indigenous knowledge of respondents in Judging the quality of barley straw

As can be seen in figure 8. The more respondents, 90% had the judging experience on barley straw quality whereas 10% of had none. The judgment comes from the stem thickness, leaf content, sweetness or color, smell or odor.this agree with the report of (Joshi, 1995) the quality of straws is expressed in different ways. Farmers are known to refer to the stem thickness, leaf content, sweetness or color, whereas scientists use terms like crude protein, organic matter, cell wall and cell contents, digestibility and voluntary dry matter intake. Fortunately, these terms often express similar things e.g digestibility and intake are normally related with sweetness and leaf content. The low nitrogen and high fibre (cell wall) content are the principal factors affecting straw nutritive value in terms of voluntary intake and digestibility.

4.3.9.Factors Affecting Quality of Barley Straw

Of the factors affecting barley straw quality to choose or use as an animal feed, many of them put at Germama kebele rain during storage and mold at Guchi kebele as the most (Table 13) factors affecting quality of barley straw. In this regard, Devendra (1982) observed a decrease in nutritive value of rice straw due to exposure to weather. Following the respondents, termite and Insects, application of herbicide,contamination with soil and others also affects their barley straw quality at diferent proportion .The information available at this time indicates that improving straw quality need atention.The nutrition characteristics of a straw was

affected by the blow table 13 mentioned list beside from determined by its genetic make up, the conditions under which it is grown (environmental and management), and the harvesting, threshing and storage procedure

Table 12 Factor affecting quality of barley straw (Rank in %)

Factors	**Kebele**	**Factors affecting quality of barley straw rank (% of respondents)**							
		1	2	3	4	5	6	Index	Rank
Mold	Germama	33.3	22.2	24.4	11.1	3.3	5.6	0.76	2
	Guchi	15.6	46.7	11.1	26.7			0.75	A
Rain during storage	Germama	50.0	27.8	11.1	5.6	5.6		0.85	1
	Guchi	43.3	21.1	11.1	24.4			0.27	F
Termite and Insect	Germama	5.6	22.2	33.3	38.9			0.66	3
	Guchi	5.6	11.1	30.0	42.2		11.1	0.58	B
Contamination with soil	Germama	5.6	16.7	31.1	33.3		13.3	0.59	4
	Guchi		21.1	33.3	6.7		38.9	0.50	D
Application of herbicide	Germama	2.2				88.9	8.9	0.33	5
	Guchi			14.4		54.4	31.1	0.33	E
Others	Germama	3.3	11.1		11.1	2.2	72.2	0.31	6
	Guchi	35.6				45.6	18.9	0.54	C

Note:On the above table, numbers indicates that ranking for Germama Kebele, Letters indicates ranking of Guchi.

In addition to the above factors the farmers noted that, equipment use, harvest facilities, traditional attitudes and climate influence the harvesting, threshing, and storage techniques for grain and straw. Harvesting is done either manually or by machine depending on factors like a scale of farming, crops planted, availability and cost of machinery around the study area

Table 13 Factors affecting barley straw utilization as indicated by key respondents

Parameters	Distance from homestead	Slope of farm land	Farm size	Livestock size	Extension service	Family size	Farming experience	Score	Rank
Distance from homestead	-	1/2	0	0	0	0	0	1/2	5
Slope of farm land	1/2	-	0	0	0	0	0	1/2	5
Farm size	1	1	-	0	0	0	0	2	
Livestock size	1	1	1	-	0	0	0	3	4
Extension service	1	1	1	1	-	1	1	6	1
Family size	1	1	1	1	0	-	1	5	2
Farming experience	1	1	1	1	0	0	-	4	3

1=the most important factor, 0= the least important factorFactors affecting barley straw

Utilization also ranked in the table 15 above using key informants responded that extension service is most affecting factors and distance from homesteads and slope of farm land equally the least affecting factors of barley straw utilization at kofele district Germama and Guchi kebeles together. The result indicates that farmers by good extension services can improve the utilization of barley straw such as better and proper collection and storage, and feeding for livestock as roughage source. At study area key informant answered that there is a difference between farmers utilization of barley straw due to the gaining of extension service advice. Even though there is no study report specific to barley utilization affected by extension service at study area, there is a report that show a comprehensive package approach applications in agricultural production in the Ethiopian context, the comprehensive package approach involved the coordinated application of different but fundamentally related strategies, such as improving the existing infrastructure, dispensing better and well organized social service and providing effective transportation services, and popularizing appropriate, well-tested and locally-adapted improved agricultural technologies. The traditional for the comprehensive package approach was that progress made in selected sites would have multiplier effects on the surrounding areas by a way of demonstrations and through social interaction (Kassa Belay,2003). The second affecting factor of barley straw use at the study

area is family size. The key informant answered that family with large number has a chance of collecting and storing at fast and proper way ,so that the probability of wastage and exposure to factors that affect its quality will be minimized.study by Abrha, B.K., 2015, shows that family size has possetive effect in agricultural proddaction.

4.4.Nutrient composition of selected barley straws

The results of the laboratory chemical analysis of selected species of barley straw varieties are depicted in Table 16 below. The current result indicated that there is no significance difference between the dry matter contents of barley straw varieties ranged between 91.85 and 92.76%.But, the result of the current study was in agreement with that of Ahmed (2006), Sisay(2006) and Solomon et al. (2008) who emphasized that, the dry matter (DM) content of all crop residues was above 90%. Ash of Excel variety of barely straw is the highest (10.1%) whereas the smallest ash values were recorded by four of them at (P<0.05).

Table 14 Chemical composition and in vitro organic matter digestibility from the five barley straw varieties (n = 3)

Parameters	Variety					Mean	LSD	CV	p-value
	Exceler	Grace	Ibon	Trav	Kulu				
DM%	91.85 [a]	92.69 [a]	92.76 [a]	92.33 [a]	92.28 [a]	92.38	2.62	1.56	0.94(NS)
ASH%	10.08 [a]	7.06 [b]	7.88 [b]	8.23 [b]	8.03 [b]	8.26	1.54	10.26	0.016(**)
CP%	4.76 [b]	2.63 [e]	4.13 [c]	5.54 [a]	3.65 [d]	4.14	0.39	5.14	0.0001(***)
NDF%	72.57 [a]	71.49 [a]	72.19 [a]	74.36 [a]	75.35 [a]	73.19	5.7688	4.33	0.57(NS)
ADF%	52.31 [a]	54.90 [a]	57.29 [a]	54.38 [a]	58.004 [a]	55.38	10.86	10.77	0.77(NS)
ADL%	10.48 [bc]	9.86 [c]	12.34 [a]	11.24 [ab]	9.57 [c]	10.69	1.31	6.76	0.005(**)
IVOMD%	48.63 [a]	47.04 [a]	46.10 [a]	49.43 [a]	46.73 [a]	47.59	5.8	6.7	0.69(NS)

*[a, b c]Means with different superscript letters in a row under Variety differ; DM = dry matter; CP = crude protein; NDF = neutral detergent fiber; ADF = acid detergent fiber; ADL = acid detergent lignin; IVOMD = in vitro organic matter digestibility; *= P≤0.1; **= P<0.05; ***= P<0.01 respectively; NS: not significant (P>0.1)*

The highest CP value was recorded for Traveller(5.54%) whereas the smallest values were recorded for Grace(2.63%) . The CP (5.54%) content recorded from Traveller barley variety straw in this study was also higher than that of 4.08% reported by Kassahun (2016). There was no significant difference between barley straw variety in NDF and ADF contents. The NDF values recorded in this study was observed to be higher than the national average NDF value reported for cereals (68.1%-72.8%) (Seyoum and Fekede, 2008). The ADL contents of Ibon variety was the highest (12.34%) whereas low in others. Mean IVOMD value of all varities is 47.59% and there is no significant diference betwen all varities. The mean IVOMD%(49.43%) obtained from Traveler barley straw variety was slightely higher than that of IVOMD of 47%reported as national average for cereal straws (Seyoum and Fekede. 2008) and IVOMD of 46.4% reported by Mesfin and Ledin, 2004).

5. CONCLUSIONS AND RECOMMENDATIONS

Barley is a major crop widely cultivated in the study area due to suitabilty of the climate and for direct supply as malt barley. As a result,a huge amount of barley straw is obtained in the area. Barley straw is used for different purposes including animal feed in the study area. The straw utilization indicated that the majority of respondents in the study area use barley straw as animal feed, followed by both house construction and mulching. Farmers themselves have the traditional knowledge of choosing and managing barley straw as feed for their livestock and also they use supplementary feeds to improve the nutritional quality of the straw. Similar to other crop residues barley straw is generally low in nutritional value. Most of the straw is wasted mainly due to the lack of awareness about the resource as animal feeds. Therefore,efficient utilization of barley straw in the study area necessitates for designing appropriate strategies to enhance the feeding value of the straw,along with the creation of awareness about the potential of the resource as feed.

- ✓ Due to barley straw is the source of rouphage, attention should be given to the treatment of straw and balancing with legume and supplementation of the straws with concentrates especially for high producing animals at studied ration ratio must be supplied.
- ✓ Management and improvement of the straw: The post-harvest period is the most critical period to consider in relation to residues and harvested straw management and utilization.
- ✓ Awarness creation and capacity building of smallholder farmers should be strengthened by skill training and continual coaching and mentoring sessions.
- ✓ Research on feed utilization: A priority research area in the face of unavailability and high cost of commercially formulated rations from the big feed processors could be the development of rations based on locally available resources.

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8. APPENDIXES

Questionnaire used

Appedixs 1General information

1.1Location……; 1.2.Name of enumerator…….

1.3. Date of the interview……../……/2018; 1.4. Time of interview:

Start…….End …….

Appedixs 2 Attributes

Demographic information	
2.1 Name and mobile number of household head	
2.2 Sex of household head	[___]Male [__] Female
2.3. Age of household head	
2.4. Education of household head (schooling in years)	
2.5. Marital status of household head	Single [___]married [___] widowed [___]
2.6. Household size	2.6. Total [___] 2.7. Male [___] 2.8. female [___] 2.9. Below 15 years old [___] 2.10. 15-60 years old [___] 2.11. >65 years old [___]
2.7. Land size (ha), otherwise, please, mention the unit.	2.7. Total [___] 2.8. Crop [___] 2.9. Forage production [___] 2.10. grazing [___]
2.8. Number of animals	2.12. Cows [___], 2.13. Calves [___], 2.14. oxen [___] 2.15. Male sheep [___], 2.16. female sheep[___] 2.17. Bucks (male goats) [___], 2.18. female goats [___] 2.19. donkeys [___] 2.20. horses[___]
2.9. Type of cereal crop produced	2.21. barley ……ha 2.22. maize……..ha 2.23. sorghum……..…….ha 2.24. wheat ……...ha 2.25. millet…….……ha 2.26. teff……ha 2.27. other specify……,……ha
2.10. % of household head's time spent on major jobs or occupations (or give ranks/scaling of 1-5)	2.28. Agriculture on own farm [___] 2.29. As hired labor on others' farms [___] 2.30. Other (specify) [___] _____
2.11. % share of each item in total household income (or give ranks/scaling of 1-5)	2.31. Crop production [___] 2.32. livestock production [___] 2.33. off-farm income [___] 2.34. Other (specify) [___] _____
2.12. Which farmers' association are you a member of?	2.35. [___]cooperative 2.36. [___]…… 2.37. [___]……..

Appedixs 3 Status of Burley grain and straw production and utilization	
3.1. When did you start producing Barley ?(year)	a. 1 year b. 2 years c. 3 years d. 4 years e. 5 years f. 10 years g. 15 year and above
3.2. Where you found barley *seed?*	a. Research Centre b. Agriculture office C. Neighbour Farmer d. other please specify_____
3.3. Which varieties do you use for production	A. malt barley: _____,_____,_____ B. Food Barley: _____,_____,_____
3.4. From the total land you have, how much area is covered by *barley*	Ha_____
3.5. How much is the production of *barley grain* per unit area?	A. Malt barley (local units per unit area)_____ B. Food Barley (local units per unit area)_____
3.6. How much is the production of barley straw per unit area?	A. (Malt barley (local units per unit area)_____ B. Food Barley (local units per unit area)_____
3.7. When do you plant barley?	_____month
3.8. Do you apply fertilizer on your barley farm	a. yes b. no c. I don't have information.
3.9. If your answer is yes for the above question, what kind of fertilizer you apply on Barley Farm?	a. DAP b. Urea c. Manure d. depends on availability
3.10. what are the main factors affecting production of barley	
3.11. For what purpose you use Barley primarily	A. food B. Animal feed C. other please specify
3.12. For what purpose you use Barley straw primarily	A. Animal feed B. Mulching C. House constriction D. other specify _____
3.13. If you are using *Barley straw* for animal feed for which species do you feed?	a. Cattle b. Sheep and goat c. Equine d. Other (specify)_____
3.14. In what form are you feeding *Barley straw* for your animals?	A. Mixing with green feed B. chopping C. wetting with water and salt D. wetting with water alone E. other please specify _____
3.15. What is the role of *barley straw* for animal?	a. Basal diet b. Supplement c. both
3.16. From animal feed aspect, please describe the special characteristics of *barley straw?*	
3.17. How do you store barley straw.	

3.18. List any disadvantages of *barley straw* in terms of production, utilization and feeding.	_____ _____
a. What are (is) the problems associated with *barley* production?	_____ _____
b. What are (is) the utilization constraints of *barley straw to use as Animal Feed*?	_____ _____
3.19. What are (is) the feeding problems of *barley straw?*	_____ _____
3.20. what are the main factors affecting quality of barley	
3.21. Have you got training on production and utilization of barley straw for Animal feeds?	a. yes b. No
3.22. If your answer is yes, please describe the topic of training and the organization offered the training.	_____ _____
3.23. Do you require training or support in terms *of Barley straw*?	a. Yes b. No
3.24. If your answer is yes, in what areas you need training?	a. Production b. Utilization
3.25. Please describe the general comments to increase the utilization of *Barley straw as Animal feed* in your area?	_____ _____ _____

Barley Straw transportation

Barley straw storage

Discussion with keyinformant

Laboratory analysis