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ASSESSMENT OF FEED RESOURCES, FEEDING SYSTEMS, CONSERVATION PRACTICES OF MAIZE STOVER IN WEST SHEWA ZONE AND EVALUATION OF GREEN MAIZE STOVER SILAGE FOR FEEDING LACTATING JERSEY COWS

PhD Dissertation

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Addis Ababa University, College of Veterinary Medicine and Agriculture

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PhD program in Animal Production

June, 2020

Bishoftu, Ethiopia

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A Thesis submitted to the College of Veterinary Medicine and Agriculture of Addis Ababa University in fulfillment of the requirements for the degree of Doctor of Philosophy in Animal Production

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Department of Animal Production

As members of the Examining Board of the final PhD open defense, we certify that we have read and evaluated the Dissertation prepared by Habte Abebaye Yeneneh titled: "**Assessment of Feed Resources, Feeding Systems, Conservation Practices of Maize Stover in West Shewa Zone and Evaluation of Green Maize Stover Silage for Feeding Lactating Jersey Cows"** and recommend that it be accepted as fulfilling the Dissertation requirement for the Degree of Doctor of Philosophy in Animal Production.

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BIOGRAPHICAL SKETCH

The author was born in 1970 at Dembecha town, West Gojjam administrative zone, Amhara Region. He attended his elementary and junior educations at Dembecha Elementary and Junior Schools, and high school education at Dembecha Senior Secondary School. After completion of high school education, he joined Addis Ababa University, Awassa College of Agriculture, in 1989 and received diploma in Animal Science and Technology.

Soon after graduation, he was employed by the Ministry of Agriculture and worked as Animal Production and Forage Development Junior expert for about nine years in North Shewa, Oromia Regional State. Then, he joined Hawasa University the then Debub University in 2000 as a regular student and received BSc.degree in Animal Production and Rangeland Management in July 2002. Right after graduation, he was employed by Ministry of Agriculture (MOA) as senior instructor and taught for ten years at Holeta ATVET College. In addition to teaching, he also served as department head and practical coordinator in the same college. In July 2007, he joined the school of graduate studies of Mekelle University to pursue his MSc. Degree in Livestock Production and Pastoral Development. Three years after graduation, he was employed by Addis Ababa University, College of Veterinary Medicine and Agriculture as a lecturer at Selale campus (now, Selale University) where he taught for four years. Then, he joined Addis Ababa University, College of Veterinary Medicine and Agriculture (Department of Animal Production Studies) in September 2015/16 to pursue his PhD study in Animal Production. He is married and a father of two daughters.

STATEMENT OF THE AUTHOR

First, I declare that this thesis is my *bonafide* work and that all sources of materials used for this thesis have been duly acknowledged. This thesis has been submitted in fulfillment of the requirements for PhD degree at Addis Ababa University, College of Veterinary Medicine and Agriculture and is deposited at the College library to be made available to borrowers under rules of the Library. I solemnly declare that this thesis is not submitted to any other institution anywhere for the award of any academic degree, diploma or certificate.

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This dissertation manuscript is dedicated to my father Abebaye Yeneneh and my brother Menwagaw Abebaye who passed away few years ago and my mother Emebet Birhanu for nursing me with affection towards success in my life.

ABBREVIATIONS AND ACRONYMS

ADF	Acid Detergent Fiber
ADL	Acid Detergent Lignin
AEZs	Agro-ecological zones
ANOVA	Analysis of Variance
AOAC	Association of Official Analytical Chemists
CP	Crude Protein
CSA	Central Statistical Authority
DM	Dry Matter
DMB	Dry Matter Basis
DMI	Dry Matter Intake
EARO	Ethiopian Agricultural Research Organization
EIAR	Ethiopian Institute of Agricultural Research
EM	Effective Micro-organisms
FCM	Fat Corrected Milk
FJLB	Fermentative Juice of Lactic Acid Bacteria
GMS	Green Maize Silage
GMSS	Green Maize Stover Silage
HARC	Holeta Agricultural Research Centre
HC	Hemi-cellulose
HH/hh	Household
hoLAB	homolactic acid bacteria
IVOMD	*In vitro* Organic Matter Digestibility
Kg	Kilogram
LA	lactic Acid
LAB	Lactic Acid Bacteria
ME	Metabolizable Energy
MS	Maize Stover
MY	Milk Yield
NDF	Neutral Detergent Fiber

NRC	National Research Council
NSC	*Noug* Seed Cake
OM	Organic Matter
S	Salt
SAS	Statistical Analytical System
SE	Standard Error
SPSS	Statistical Package for Social Sciences
TDMI	Total Dry matter intake
TMR	Total mixed ration
U.S.A	United State of America
V	Volume
WB	Wheat Bran
WSC	Water Soluble Carbohydrate

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ABSTRACT

*The survey part of the study was aimed to assess the feed resources available, feeding systems and conservation practices of maize stover in three selected districts of West Shewa Zone, Oromia Regional State. A total of 357 farmers were randomly selected for interview. Primary data were collected from smallholder farmers in a single visit interview by semi-structured questionnaire. The data collected through interview were also supported by observations. The silage experiment was conducted at Holetta Agricultural Research Center to determine the optimum ensiling duration and type of additive to make quality silage from GMS. The treatments were combinations of four additives (without additive, 1% EM (Effective micro-organism), 1% FJLB (Fermentative Juice of Lactic acid Bacteria) and 3% molasses) on fresh weight basis of green maize stover and three ensiling periods (4, 6 and 8 weeks). Treatments were arranged by a 4*3 factorial setup using a completely Randomized Design with five replications. The Physico- chemical characteristics of the silages were analyzed. The feeding experiment was conducted at Ada-berga dairy farm to evaluate the feed intake, digestibility, and milk yield and milk composition of Jersey cows fed GMSS based TMR graded with concentrate (%):30, 40 and 50, and conventional feeding(control diet) where cows received GMSS adlibitum and formulated concentrate of 0.5 kg/liter of milk separately. A total of eight lactating Jersey cows of more or less similar milk yield (8-10kg/day) with the same stage of lactation (mid-lactation) and parity range of one through four were used for the experiment. A Double 4*4 Latin Square Design was used for handling the* *`experiment. The concentrate was formulated from wheat bran, noug cake and salt of 69%, 30% and 1%, respectively. Supplementation of this concentrate at the rate of 0.5 kg/liter of milk was assumed to meet the protein and ME requirement of lactating cows with milk yield of 8-10 liters/day with a butter fat content of 4.4% fed grass hay. The experiment was conducted for a total of 96 days which consisted of 4 periods. Each period had 24 days (14 days of adaptation and 10 days of data collection). Results of the survey identified 5 major feed resources in the study areas, of which natural pasture and crop residues were used by almost all the surveyed farmers. The estimated feed resource available satisfies only 81% of the DM and 69.7% of the protein maintenance requirement of the livestock population. Free grazing was the major (96.3%) feeding system in the study areas. Conservation of the green maize stover after the green cob has been removed in the form of silage was uncommon due to lack of awareness. The laboratory result depicted that GMS silage made with the inclusion of 3% molasses at six weeks ensiling period had lower NDF, ADF and ADL contents, but resulted in relatively high in-vitro organic matter digestibility (54.47%), metabolizable energy (8.72MJ/kg DM)' and crude protein content (5.9%). The measured physical characteristics of GMS ensiled using 3% molasses for six weeks were within the recommended range of quality silage. In the feeding experiment the total daily dry matter, OM, CP and ME (MJ/kg) intake of (T4) was significantly ($p<0.05$) higher than (T2) and (T1). Similarly, (T3) was significantly ($p<0.05$) higher than (T1) in terms of total daily dry matter, OM, CP and ME (MJ/kg) intakes. The milk yield of cows fed TMR with concentrate inclusion rate of 40(9.29lt) and 50% (9.65lt) showed significant ($P < 0.05$) differences as compared to 30 %(8.09lt) concentrate inclusion and conventional feeding (7.90lt) system. The milk yield of T2 was higher by 2.4% than T1. The partial economic analysis made by using the cost of feeds and milk price per liter suggested that cows fed TMR with 40% concentrate would be more profitable. Thus, it could be concluded that the use of GMS silage based TMR with 40% concentrate seemed more economical to sustain milk production.*

Keywords: Additives, concentrate, Green maize stover silage, Jersey cows, Total mixed ration

1. INTRODUCTION

Ethiopia is naturally endowed with different agro-ecological zones and has suitable environmental conditions for livestock production (Samson and Frehiwot, 2014). It is believed to have the largest livestock population in Africa and is a home for about 59.5 million cattle, 30.70 million sheep, 30.20 million goats, 2.16 million horses, 0.41 million mules, 8.44 million donkeys, 1.21 million camels and 56.53 million poultry (CSA, 2017). Livestock plays great roles in generating income from 37% in the livelihoods of smallholder farmers in the mixed farming system to 87% in pastoralist communities, creating job opportunity and serves as security against crop failure (Gebremariam *et al.,* 2010). Moreover, livestock are the most important sources of draft power in the mixed farming system. Even though there is huge livestock population and favorable environmental conditions, the current output obtained from the sector is very low. The low productivity is principally due to inefficient nutrition and management practices, low genetic merit of the indigenous cows, high prevalence diseases and parasitic incidence, poor access to extension and credit services (Belay and Geert, 2016). Among these constraints, however, inadequate and poor quality feed supply was identified as a major limiting factor to the development of the livestock sector in general and dairy production in particular (Belay *et al*., 2012). Feed shortage is more serious during dry season of the year for animals depending on natural pasture or kept under extensive management system (Jabbar *et al*., 2007).

In the mid and highland areas, where mixed farming system predominates, the contribution of grazing land is declining from time to time due to poor grazing land management practices and ever-increasing human population/urbanization, and expansion of cropland at the expense of grazing land (Hiwet, *et al*., 2017). In the long dry season, this small grazing pasture land unable to provide sufficient feed of reasonable quality and quantity to satisfy the nutritional demands of livestock (Suttie, 2000).

Due to this fact, the use of crop residues and stubble grazing as livestock feed is increasing from time to time in mixed farming system and it provides on average about 50% of the total feed supply for ruminant livestock and sometimes the contributions of crop residues can be stretched up to 80% during the dry seasons of the year when feed scarcity become sever (Adugna, 2007). Cereal crop residues such as maize and sorghum stover and teff straw are mostly stacked and fed to livestock when the grazing land exhausted in many parts of the country. However, crop residues are characterized by low metabolizable energy and crude protein contents, and high lingo-cellulosic cell wall component, which can hardly support ruminant requirements unless supplementary feeds are provided. On the other hand, the cost of supplementary feeds or industrial by products such as wheat bran, wheat midllings etc, is increasing from time to time (Yayneshet, 2010).

This necessitates for assessing the feed resources available, feeding systems and feed conservation/storage practices of an area in order to design intervention strategies and look for other cheaper and alternative feedstuffs to sustain and improve livestock production in general and dairy production in particular. Moreover, the baseline information obtained from the survey study will create a fertile ground to conduct further research for better utilization of feed resources available and thereby, boosting livestock products and meet the ever increasing milk and meat demand of the human population.

Green maize stover (GMS) left after the green cob has been harvested for selling/home consumption is one of the cheapest and quality feed resources largely available in maize growing regions of Ethiopia. This feed resource could support livestock production if properly exploited.

Ethiopia is among the major maize producing countries in Africa (Abdisa *et al.,* 2001) and maize is the second crop next to teff, which is widely cultivated and grown under diverse agro-ecologies under rain-fed production systems (Tsedeke *et al.,* 2015). On average green maize harvest/utilization accounts for about 25% of the total maize yield ranging from 12% in Mecha to 52% in Awassa Zuria (Berhanu *et al.,* 2007) resulting in the production of considerable amount of feed. Green maize stover is highly palatable and is comparable with average quality grass hay but it loses its quality when dried. The dry stover either left on the field or collected for latter use is nutritionally poor (e.g. 3.7% CP as compared to 8.8% in green maize stover) and less palatable for cattle feeding (Fanos, 2014). In general, wet crop residues soon after grain harvest are better relished than those are completely dried (Gouri, 2012). Green maize stover is one of the wet crop residues and potential feed resource if it is freshly used or conserved as silage for dry season feeding.

Among the field crops grown in West Shewa Zone, maize is the most popular one. Green cob harvesting at dough stage for home consumption and/or selling as source of cash income is also very common practice in these areas as elsewhere in the country. This shows that there is a substantial green maize stover production that could be used as livestock feed immediately after green cob has been harvested or conserved in the form of silage for feeding during dry season when there is serious feed shortage. Hence, ensiling green maize stover is one option for conserving and feeding during the dry season.

However, application of relevant additives before ensiling for silage crops, particularly to those crops which have low level of WSC content, helps to improve the fermentation processes and reduces nutrient loss and/or improves its nutritive value (Jones *et al*., 2004). Although anaerobic conditions can be obtained by proper ensiling for silage crops having high level of WSC content, there can still be considerable activity of aerobic microorganisms during the very early stages of ensiling and when there is an improper silage management practices (Melkamu and Birhan, 2014). Due to this fact, the application of additive during silage making has a paramount importance to produce quality silage. Various types of additives have been used to control undesirable microorganisms (e.g, aerobic bacteria and fungi) and improve aerobic stability in silages (Pedroso *et al.,* 2008). Molasses, effective micro-organisms (EM) and fermentative juice of lactic acid bacteria (FJLB) are the cheapest and available additives found in Ethiopia. The effectiveness of these additives and the fermentation period required varies on the type of silage crop used. However, there is no any documented information indicating the best additive type and ensiling period to make quality silage from green maize stover (GMS). Silage from green maize stover can easily be blended with concentrate to make Total Mixed Ration (TMR) as it is already chopped before ensiling. Mode of feeding affects the productivity and profitability of dairy cows more than any other single factor (Donna *et al*., 2002). TMR diet allows the cows to consume as close to energy and protein requirements as possible and maintaining physical or roughage characteristics required for proper rumen function (Donna *et al*., 2002).

In conventional feeding system various feedstuffs like pasture, concentrate, pellets and other agro industrial by products are fed separately in different time intervals. This type of feeding system results the biological and chemical environment of the rumen to be changed depending on the type of feed provided and consequently, the rate of digestion and absorption will be affected(Calsamiglia, 2002). Similar studies revealed that the process of digestion, rate of passage and dry matter intake was improved while dairy cattle fed on TMR diet (Soriano *et al*., 2001; Bargo *et al*., 2002). According to Ronaldo (2006), cows consumed roughage blended with concentrate diet, showed optimized milk production and better health status. Moreover, feeding balanced nutrition improves animal output and also reduces the cost of production per unit of animal product, thus can increase net daily income by 10–15 percent (FAO, 2012). However, there is no any documented information on optimum level of concentrate and GMS silage to make GMS silage based TMR. Moreover, no comparative study has been conducted on GMS silage based TMR and conventional feeding system (feeding GMS silage and concentrate separately) under Ethiopian conditions.

Therefore, the general objective of this study was to assess the feed resources, feeding systems, conservation practices and evaluate the effects of additives and ensiling period on GMS silage quality and production performance of Jersey cows fed TMR.

The specific objectives of the study were:

1. To assess the available major feed resources, feeding systems and maize stover conservation practices in the study areas.
2. To determine the optimum ensiling duration and type of additive for producing quality silage from green maize stover.
3. To evaluate the feed intake, digestibility, milk yield and milk composition of Jersey cows fed GMS silage based TMR graded with concentrate against conventional feeding

2. LITERATURE REVIEW

2.1. Feed Resources in Ethiopia

The availability and nutritional quality of feed resources are the most important factors which determine the productivity of livestock (Yayneshet, 2010; FAO, 2012). Livestock feed resources are categorized into natural pasture, crop residues, aftermath grazing, improved pasture and forage, agro-industrial by products, other by-products like food and vegetable leftovers; of which the first two contribute the largest share (Alemayehu, 2004)

2.1.1. Natural pasture and grass hay

Native pasture is the major source of feed for ruminants both in mixed farming system and pastoralism. However, this resource is neither quantitatively nor qualitatively adequate to support animal production (Seyoum *et al.*, 1997 and Alemayehu, 2004). The quantity and nutritional qualities of pasture are affected by numerous factors such as ecological/climatic conditions and management activities like frequency of cutting, soil fertility status, plant composition, and stage of maturity and season of harvesting (McDonald *e t al*.2010). As the stage of maturity progressed, it is characterized by high content of fiber with a higher level of lignifications and low protein content (McDonald *e t al*.2010). Obviously, in the central highlands of Ethiopia, natural pasture is also harvested and conserved as hay for latter use when feed shortage becomes more serious. However, its nutritional quality is closer to most cereal crop residues which can be primarily attributed to delayed harvesting (Alemayhu, 2004). As reported by Kitaba and Tamir (2007), hemicellulose and cellulose contents of pasture increased with advancing stage of harvesting from 24.5 to 26.3 % and 15.5 to 27.0 % at 30 to 120 days of harvesting, respectively. On the contrary, the CP content decreased from 6.8% at 30 days to 4.8% at 120 days of harvesting. Mixed pastures are relatively better in terms of nutrient contents than sole pasture. The more the proportion of the legume in the pasture, the higher the crude protein content of the mixed stand and thereby, results in better livestock productivity (Yihalem *et al*., 2006). The pasture grass land in crop-livestock system, however, is diminishing from time to time at the expense of expansion of croplands due to increased human population and urbanization (Hiwet,*et al*., 2017). This finally, would cause feed supply imbalance or overgrazing unless and otherwise some intervention strategies are designed in order to alleviate the root causes of the problem. Though the natural pasture is too small, it is still a main source of basal diets, in many part of Ethiopia (Zewdie and Yoseph, 2014; Wondatir, 2015; Zemene *et al*. 2016). Moreover, the natural pasture is influenced by season and rainfall fluctuation, but it is relatively adequate from the onset to the end of the main rainy season (Alemayehu, 2004). Hay harvested from the natural pasture can be stored for latter use when feed scarcity becomes serious. Hay making and feeding to dairy cows is commonly practiced in Addis Ababa milk shed areas of central highland of Ethiopia (Fekede, *et al*., 2013) and in Jimma town by farmers engaged on fattening business(Zemene *et al*. 2016). On the contrary, hay making was uncommon in the central rift valley of Ethiopia (Zewdie and Yoseph, 2014). Hay produced from natural pasture is better than crop residues in terms of nutrient content if and only if it is timely harvested and properly handled or proper storage measures are applied (Yayneshet, 2010). According to Yayneshet(2010), though there is vast area of rangeland in the lowland part of the country, the productivity is limited due to poor grazing management, bush encroachment and recurrent droughts. In general, in areas where crop production is the main activity, the attention given to natural pasture/grazing land is very low and livestock feeds has been replaced by crop residues and aftermath grazing.

2.1.2. Crop residues

Of the major livestock feed resources identified in the mid and highland part of Ethiopia, crop residues are the ones which played the lion share. According to Yayneshet (2010), crop residues are plant by-products obtained from the cultivation of cereals, pulses, oil crops, roots and tubers. The role of crop residue is great to bridge the feed gaps observed during the dry period when other feed resources are scarce. Crop residues contribute about 50% of the total feed supply in Ethiopia and this figure can be higher if the feed crisis is more and more severe (Tolera *et al*. 2012). In the mixed farming system (highland and mid altitude), most farmers conserve/store crop residues like teff, barley, wheat, maize and sorghum, traditionally (Daniel, 2018). Straws from cereal crops such as teff, barley and wheat form the largest component of livestock diet in mid and highland areas while the stovers of maize and sorghum constitute the larger proportion of livestock feed in lower to medium altitudes (FAO, 2018). However, these feed resources are characterized by low / poor nutritional quality and they are unable to satisfy the nutrient requirement of a given animal (Tolera, *et al*. 2012). Of the crop residues, cereal 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 in turn limits the feed intake of the animal (FAO, 2002). Likewise, Solomon *et al*. (2008) also reported that crop residues are low in CP and *in vitro* DM digestibility, unless and otherwise some energy and protein rich feed supplementations are given or some chemical/physical treatments are carried out to support satisfactory digestion and thereby, improve the livestock performance.

Crop residues are mainly stacked either outside in the field (54.4 and 74%) or under shade (39.2 and 24%) in the highland and mid-altitude agro-ecologies areas, respectively and would be given to livestock when animals come back home during the evening in many extensive farming systems(Daniel, 2018). During feed scarcity oxen and milking cows would be given priority access to hay and crop residues supplementation (Seyoum *et al.,* 2001). Similarly, Getachew *et al.* (1993) reported that straw is commonly fed to working oxen and milking cows during the dry season and an ox would be supplemented on average 5 to 10 kg of straw each day. Moreover, crop residues were also used for construction, fuel and as source of cash income through selling to livestock owners in mixed farming systems (Beyene *et al*., 2011)

2.1.3. Concentrate feeds/ agro-industrial by products

The major agro-industrial by products commonly used as livestock feeds are obtained from flour milling industries (wheat bran, wheat short, wheat middling and rice bran), oil extracting factory (*noug* cake, cottonseed cake, peanut cake, linseed cake, sesame cake, sunflower cake, etc), breweries(brewery grain or brewery yeast), and sugar factories (molasses, bagasse)(McDonald *et al*., 2010). Concentrates are rich in digestible nutrients and contain less amounts of fibre than rouhages (Yayneshet, 2010). Concentrates/agro-industrial by products are not available everywhere and are relatively expensive, and hence, rarely used by smallholder farmers in rural livestock production system (Belay *et al.,* 2012). According to Yayneshet (2010), molasses and other industrial by-products are used mainly by beef and dairy producers in and around the major cities. The dairy producers in urban areas have little or no access to grazing land and are mainly depend on purchased feeds (agro-industrial by-products and/or commercial concentrates (Belay and Greet, 2016). Moreover, concentrates and non-conventional feeds like *Atella* (by-product of local beer or *tella* and *katikala*) are also identified as major feed supplements in central highlands of Ethiopia (Solomon, 2011).

2.1.4. Improved forage crops

Integrating improved forage crops in agricultural systems has many advantages such as reducing soil erosion, pests and diseases control in addition to their primary use as high quality animal feeds (Getnet, 2012). Similarly, Mulualem and Molla (2013) also reported that if improved forages are integrated with crop-livestock production system, animal productivity will be increased. According to Getnet(2012), different types of annual and perennial forage crops have been tested under rain fed conditions in Ethiopia for different AEZs. Improved forages mainly legumes, can improve the productivity of natural pastures by improving the soil fertility status and also improve the feed value of the native pastures as they have more protein content than naturally occurring sole grasses (Yeshitila *et al.,* 2008). However, adoption of the technology and use of improved forages as livestock feed is lower than its expectations in most parts of Ethiopia (Alemayehu and Getnet, 2012). For instance, Belay *et al.* (2012) reported that majority of the farmers in Dandi district did not cultivate improved forage (grasses, legumes or mixture) mainly due to scarcity of land and lack of awareness. Similarly, Poor utilization of forage trees (Sesbania sesban and Tree Lucerne) planted around homesteads as live fence is associated to lack of awareness. Access to strong agricultural extension services and having enough capital played the greatest share to adopt new technologies (Alemayehu *et al.,* 2018)

2.2. Feed Conservation /Silage Making/

In areas with a long dry season, tropical pastures can hardly support year-round feed of reasonable quality and quantity to match with the nutritional requirements of livestock (Suttie, 2000). This calls for conservation of excess forages available during rainy season as hay or silage for feeding livestock when feed shortage is more serious during dry season of the year. Silage making has great potential to solve seasonal feed shortage for ruminants by preserving excess forage produced during the wet season for use at the dry period (Olorunnisomo and Adesina, 2014). Ensiling of forages is generally considered as better preservation technique to produce a better quality roughage than hay making as silage making requires less time to wilt, and consequently less nutrient loss (Jones *et al*., 2004). Hay making requires a longer period of rain free-days which are often rare in tropics during the rainy season when excess forage is available (John, 2005). Postponing the harvesting period to the beginning of the dry season resulted in decreased nutritional quality of the pasture crop considered (Driehuis *et al*., 2001). Thus, ensiling is an alternative preservation method which can be practiced during the rainy season and may yield higher quality and quantities of preserved forage. Conserving forage as silage can contribute towards alleviating feed constraints and maintaining animal productivity during the dry periods (Mannetje, 2000).

Almost all fodder plants can be used to make silages as far as the dry matter and water soluble carbohydrate content of the crops is within the recommended ranges (McDonald *e t al*.2010). Of the popular silage crops recommended, whole maize is the one which is used as a major food crop in Ethiopia. Since corn silage typically contains ten times more naturally occurring lactic acid bacteria than alfalfa, no additives or preservatives are recommended when whole-plant corn silage is made at the proper moisture level, but additives may be more effective when corn is immature, overly dry, stressed by drought, or killed by frost (Jones *et al*., 2004)**.** Inclusion of maize silage in dairy cows ration showed increased feed intake, milk yield and milk protein content (Peyrat *et al.,* 2016) as a result, the cultivation of silage maize has been increased significantly in many parts of the world over the past few decades. Maize silage has become the major forage component in the ration of dairy cows next to grass under most dietary regimes (Peyrat *et al.,* 2016). However, Fodder conservation as silage is not a common practice in many parts of Ethiopia with the exception of hay production in the central highlands around Addis Ababa (Adugna *et al*., 2012; Fekede *et al.*, 2013) and animals would be more dependent on crop residues during dry season when the grazing land exhausted, but crop residues are poor in its digestibility and nutrient content to satisfy their nutrient requirement.

The primary goal of silage making is to retain the original nutrients as much as they are in the forage crop for feeding at a later date (McDonald *e t al*.2010). Unfortunately, fermentation in the silo is much uncontrolled process usually leading to less than optimal preservation of nutrients. Even under ideal conditions, loss of at least 8% of the forage dry matter is expected throughout the ensiling process (McDonald *et al*., 1991). In order to improve the ensiling process (better energy and DM recovery) and subsequent improvements in animal performance the use of silage additives is very essential (Kung, 2014).

2.2.1. Factors affecting silage quality

The fermentation processes reaches to the greatest stage a few hours after the material being ensiled, but may continue for a week or more depending on the acidity, compaction, available carbohydrates, moisture level, available oxygen and other factors (Kamstra *et al,* 1979). These factors (stage of maturity, moisture content, crop type, chopping length and compaction and air exposure) during storage influence the fermentation process and consequently, the quality of the silage. Of these factors, stage of maturity is the most important factor affecting forage quality; plants continually change in quality as maturity stage increased (Jones *et al*., 2004). As plant gets mature, indigestible lignin accumulates. Plant maturity changes are so rapid that showed significant declines in forage quality every two or three days (Collar and Aksland, 2001). The ideal materials used for silage making should have a moisture content of 60 to 70 per cent or dry matter in the range of 30 to 35 per cent (tested by taking a small bundle of the fodder and wringing with two hands and if no moisture comes out, it is ready to ensile). In rainy periods when the fodder is too wet, containing more than 70 per cent water, wilting is advisable to reduce the moisture to the recommended level (Bal *et al*., 1997).

Moreover, maize maturity can be determined by the stage of kernel development, which can be characterized by the position of the kernel milk-line or when the milk line appears as a whitish line separating the kernel starch and milk. The milk line stage associated with specific moisture contents and will vary among seasons, but generally the crop will approach 70 percent moisture at one-quarter milk line, which is when all the kernels are dented and milk line has descended 25 percent of the way down the face of the kernel and the crop will reach 65 percent moisture sometime around one-half milk-line, when the milk line has descended half way down the face of the kernel (Jones *et al*., 2004).

Crops such as maize, sorghum, oats, pearl millet, and Napier grass are very suitable for ensiling because they contain fermentable carbohydrates (sugar) necessary for bacteria to produce sufficient organic acid that acts as a preservative, but the high protein and low sugar levels make leguminous fodders difficult to undertake rapid fermentation (Jones *et al*., 2004). Harvesting maize or sorghum when their seeds are soft but not too much milky, napier grass at about one meter height and legumes having young pods, which are not dry, are ideal for silage making (Guyer, 1986)

Chopping the fresh forage to a length of 1cm to 3cm using a cutter and compacting the chopped silage material properly to expel maximum air out in every 15cm thickness layer until the pit gets filled in is required (Jones *et al*., 2004). Woolford (1990) stated that the single most important factor which influences the efficiency with which forage crops are conserved as silage is the degree of anaerobic condition achieved in the silo. Aerobic spoilage during storage often is responsible for a large portion of the total DM loss in forage conserved as silage and may be as high as 15 to 25% or higher in areas of poor compaction (Kung*, 2014)*. Generally speaking, considering moisture level/ DM content of the silage material, maintaining the correct chopping length, even distribution of silage material in the silo, and proper compaction are key factors to make quality silage. If air has been excluded and anaerobic conditions persist within the fermenting forage, dry matter losses from bacterial activity and plant respiration could be as low as 5 to 6 % (Kamstra *et al*, 1979).

2.2.2. Silage additives

The ultimate objective of using silage additives is to enhance the fermentation process and produce well-preserved silages (Knický and Spörndly, 2014). The physico-chemical characteristics of silage would be influenced with the application of additives. As described by (Kung, 2014), fast fermentation is believed to improve the ensiling process (better energy and DM recovery) with subsequent improvements in animal performance. Recently, many silage additives have been identified. However, fermentation stimulants (bacteria inoculants, enzymes, fermentable substrates) are the most widely used additives in many countries (Kung, 2014). The use of additive to silage crop had improved some nutrients. According to Zhang (2003) as cited by (Gouri, 2012) also reported that ensiling green maize stover with additives improved CP contents by 25.51%. However, the crude protein content of MGS (Mott grass silage) was not affected by the type of additive used (Nisa *et al*., 2005)

2.2.2.1. Molasses

Molasses is a sticky dark by-product of sugar cane or sugar beets industry and contains 79% soluble carbohydrates; 45 to 50% sucrose (McDonald *et al*., 2010). Molasses has been used as a fermentation stimulant for many years. In previous studies, the silage crop ensiled with molasses showed better results in terms of physical characteristics like colour, odor flavor (Bilal, 2009; Getahun *et al*. 2018). The texture of elephant grass silage was also improved due the application of molasses (Mtengeti *et al.,* 2014). The pH values of silage crops treated with additives decreased more quickly than silage without additives (Bilal, 2009; Nhan *et al.,* 2009; McDonald *et al*., 2010). According to Kung (2014), molasses provides a relatively cheap source of fermentable carbohydrate for lactic acid bacteria and has been applied at a rate of 40-80 lb per ton of fresh forage. The amount of molasses used varies on the type of silage crop used. Studies indicated that up to 10% molasses can be added to forage to provide fast fermentable carbohydrate to ensile tropical herbages. As stated by Henderson (1993), relatively high concentrations (4% to 5%) of molasses should be used for tropical grasses and for crops of very low DM content as a considerable proportion of the additive may be lost in the effluent during the first days of ensilage. Moreover, molasses is a source of quick energy and an excellent source of minerals for farm animals (Senthilkumar, 2016). The calcium content of sugar cane molasses is high (up to one percent), whereas the phosphorus content is low. Molasses is better used by diluting in water at a ratio of 1:2 to 1:4-6 (molasses: water) and given together with dry forages or concentrates (Senthilkumar *et al*., 2016). Molasses in numerous silage experiments has been proven to be an effective silage additive in terms of promoting lactic acid fermentation, reducing silage pH, discouraging a undesirable micro-organisms and /or decreasing organic matter losses (kung, 2014). According to the review of Keady (1996), the use of molasses as silage additives improved silage preservation and silage DM intake. The silage plant named (*Chromolaena odorata*) treated with molasses showed increased dry matter, crude protein, *in vitro* dry matter digestibility and reduced NDF, ADF contents as compared to other additives (cassava tuber flour, corn meal, rice bran) used (Rusdy, 2015). According to Yunus, *et al*. (2001), molasses addition at the rate of 3% increased DM of Napier grass silage from 19.57% to 20.86% and the pH value decreased significantly from 5.13 to 3.97. These authors also added that the addition of molasses increased LA (lactic acid) production from 1.24% to 14.30%, but the control silage without additive showed significantly higher BA (butyric acid) production (0.25%) than molasses treated silage.

Another studies also indicated that molasses addition to Napier grass before ensiling enhanced the fermentation process and consequently, avoided the DM loss (Bolsen *et al*. 1996) by early stabilization of the medium. High DM recovery was indirectly related to homolactic fermentation (Weinberg and Muck, 1996; Sharp *et al.,* 1994). However, total DM loss, up to 5% during fermentation process is tolerable and considered normal, presumably due to the loss of soluble nutrients (McDonald *et al*., 2010). Moreover, Getahun *et al*. (2018) reported that addition of (4%) molasses to green SCT silage increased the DM content over the same forage treated with (1%) urea. The ADF and

NDF contents of the silage crop decreased with the increasing level of molasses because molasses has little ADF and NDF content (Gouri, 2012; Ofori and Nartey, 2018).

2.2.2.2. Effective micro-organisms (EM)

EM stands for "Effective Microorganisms" and was developed by Dr. Teruo Higa of the College of Agriculture at the University of the Ryukyus in Okinawa, Japan. Effective Microorganisms (EM) is a commercially produced liquid containing a variety of lactic acid bacteria, yeasts and phototrophic bacteria. The integration of these organisms create favor conditions and mutual support that enable them to compete against pathogenic organisms through the production of useful substances such as vitamins, enzymes, hormones, amino acids and anti-oxidants (Higa, 1994; Zimmermann and Kamukuenjandje, 2008). Higa (1994) further described that EM is a liquid with a pH value of 3.5 is formed at high pressures by the interaction of a diverse group of naturally occurring, aerobic and facultative anaerobic microorganisms. EM includes high populations of lactic acid bacteria (*Lactobacillus* and *Pedicoccus*) at 1 x 10^5 CFU/ml suspensions, yeast (*Sacharomyces*) at 2 x 10^6 CFU/ml suspension and fewer amounts of photosynthetic bacteria, actinomyces and other organisms (Guim *et al*, 1998). The first intention of EM production was to make the agricultural sector free from the side effect of large scale commercial fertilizer. However, the use of EM was further expanded for improving soil conditions for better plant growth, treating waste water, controlling pests and diseases, improving animal growth, enhancing compost production and extending the shelf life of harvested crops are the most important roles of effective micro-organisms (Zimmermann and Kamukuenjandje, 2008).

The CP content, and IVOMD and metabolizable energy of fiber feeds (barley straw) showed improvement due to EM inoculation (Mulugeta, 2015). Similarly, the nutritive values of coffee pulp (husk), was improved due to the application of EM as silage additive (Yonatan *et al*., 2014). According to Amanullah *et al*. (2014), barley ensiled for 100 days with EM showed significantly ($p<0.05$) higher DM and crude ash contents than untreated one, but the ADF, NDF and hemi-cellulose contents as well as the *in vitro* DM digestibility were not affected. However, the pH value and ammonia-N concentration were higher ($p<0.05$) for silage which was not treated with EM additive. This indicates that the quality of barley silage was improved due to the application of bacterial inoculants (EM additive).

Some of the benefits of EM in the livestock sub-sectors include improved meat and egg quality, improved animal health status, reduction of bad odors and absence of toxic effects on animal farms (Safalaoh, 2006). In Brazil, for instance, the feed DM intake and degradability of sheep fed on elephant grass silage was improved due to application of EM additive (Guim *et al.,* 1999). The use of EM is beneficiary not only to increase animal production but also to reduce environmental pollution (Safalaoh, 2006).The improvements in production might be associated with the greater flow of microbial protein and amino-acid to the duodenum, increased number of rumen cellulolytic bacteria which improves fiber degradation, changes in the volatile fatty acids contents (Aemiro *et al.,* 2014). The CP content of sorghum stover was improved from 2.93 to 5.33 % due to application of EM; the improvement is higher by 81.9% (Daniel, 2018).

2.2.2.3. Fermentative juice of lactic acid bacteria (FJLB)

The ensilage of forage crop depends on natural fermentation, in which the epiphytic lactic acid bacteria (LAB) convert water-soluble carbohydrate (WSC) into lactic acid (LA) under anaerobic conditions and when pH decreases to a certain extent (approximately 4.2), the harmful microbiological activity will be inhibited and consequently, the silage will be preserved for a long period (McDonald *et al*., 1991). Although it has been well known that the epiphytic LAB plays an important role on silage fermentation, the number of epiphytic LAB on the standing crop is found to be lower than that of aerobic bacteria, yeast and molds (Bureenok *et al.,* 2005). Silage crops which have higher concentration of soluble carbohydrate can attain anaerobic conditions if proper ensiling procedures are practiced. However, there can be, sometimes, unavoidable activity of aerobic microorganisms during the very early stages of ensiling and it is generally accepted that the activity of aerobic bacteria after ensiling is undesirable. In this case, inoculation of LAB in the ensiling process has been recommended in order to make good quality silage

(Bureenok *et al.,* 2005). Similarly, silage produced from Oat (*Avena sativa* L.) and Italian Ryegrass (*Lolium multiflorum* Lam.) showed lowered pH values to 3.63 and 3.59, respectively, after 30 days of ensiling due to the application of pre-fermented juice of epiphytic lactic acid bacteria (FJLB) silage additive (Shao *et al*., 2005). Recently, researchers have reported that the numbers of the epiphytic LAB can be improved by inoculating LAB using fermented juice of epiphytic LAB (FJLB) as a silage additive obtained by macerating crop silage with chlorine free water and anaerobic incubating for 2 days (Ohshima *et al*., 1996). It is well documented that addition of FJLB to silages is effective in improving the fermentation quality of silage, and often results in increased LA and reduction of ammonia-N (AN) even when the addition of commercial LAB was ineffective (Ohshima *et al*., 1997). According to the reports of Yahaya *et al*. (2004) addition of FJLB to the silage material immediately before ensiling promoted the onset of LAB fermentation, and increased the rate of LA production and pH reduction, and decrease the loss of WSC by arresting undesired bacterial activity. Quality silage can be produced when the number of lactic acid bacteria (LAB) is dominant in the fermentation process, and the activity of undesirable bacteria like clostridia would be restricted. The pH value of the Guinea grass silage treated with FJLB, which was extracted from the same plant 3 days before harvesting, decreased rapidly and reached to the lowest pH value within 7 days of start of fermentation, as compared to the control (Bureenok *et al.,* 2005). Tropical Elephant grass (*Pennisetum purpuereum*) and temperate Italian ryegrass (*Lolium multiflorum*) silage showed lower neutral detergent fiber (NDF) and acid detergent fiber (ADF) than the control (with no FJLB) due to the addition of FJLB during the ensiling period. This is mainly due to the increased number of LAB (cfu) and lactate concentration in the silages (Yahaya *et al*., 2004). As Ohshima *et al*. (1997) described, the use of epiphytic LAB improved the quality of lucerne silage even more than the commercial LAB inoculants.

2.2.3. Physical and chemical characteristics of maize silage

Corn silage is used as an energy and fiber source for cattle, mainly for dairy cows (Borreani and Tabacco, 2010). The nutritive value of the corn silage can be affected with variety, crop density, growing conditions, degree of maturity and moisture of the crop when harvested, and ensilage conditions (Satter and Reis, 2012 as cited by Silva *et al.,* 2015). One can gain significant insight as to the quality of silage, by its smell, sight and feel. In other words, sensory evaluation may suggest the need for further chemical analysis (Wren, 2000). Odor and colour are often enough to identify poor quality silage, but evaluating the pH, dry matter, and fermentation acid profile may be useful when determining the extent of adverse fermentation (Jones *et al*., 2004). Silage that has undergone normal fermentation has a light green to green-brown colour and slightly sweet odor of lactic acid. Silage with a rancid, fishy or putrid odor, yellow-green or brown colour, and slimy texture may result from clostridial fermentation (Jones *et al*., 2004). This silage probably contains high levels of bound protein and might reduce dry matter intake.

The pH value is a measure of acidity for silage feeds, silage feeds with high moisture content are unstable with respect to pH and a wide range is found; good quality silages being associated with low pH (Wren, 2000). Corn silage should have a pH of 3.8 to 4.2, while hay crop silages have a slightly higher pH at 4.0 to 4.8. High pH at high water content is associated with proteolysis (Clostridial fermentation), but low pH is associated with high lactic acid production (Jones *et al*., 2004). Temperature is a measure of the amount of heat generated within the silage. It could be measured easily using a digital thermometer placed deep at the center (Jones *et al*., 2004). Elevated temperatures above ambient temperature suggest oxidative respiration by molds or fungi and feed instability (Wren, 2000). On the farm, warm silage is not always an absolute indicator of spoilage because large silos often retain relatively high temperatures even in the winter. In a recent study, the silage temperature record was as high as 32-33°C in some silos kept for three months (Olorunnisomo and Ibhaze, 2013). Thus, steam coming out from the silage mass during silo removal is not necessarily a sign of aerobic spoilage. Aerobically spoiled silage can often reach temperatures as high as 48-50°C in short periods of time (Kung, 2014). In general, the important signs observed while silage is aerobically spoiled includes temperature exceed 42-43 °C in the back of the silo face, visible mold, lack of a sharp or sweet smell to the silage and/or a flat or moldy/musty smell and a moldy smell coupled with a high pH may also be a good indicator that a feed has undergone aerobic deterioration (Kung, 2014). Green maize stover is highly palatable and it is comparable with average quality grass hay. The dry stover either left on the field or collected after being dried showed lower protein content (e.g. 3.7% CP as compared to 8.8% in green maize stover) and less palatable for cattle feeding (Fanos, 2014). The chemical composition of green maize stover in and around Shashamane district indicated that the (DM) and CP content was 30.61and 12%, respectively (Girma, *e t al*. 2014). The same authors revealed that the *in vitro* organic matter digestibility (IVOMD) for green maize stover was about 61.7% and consequently, the energy content was 9.25 MJ/kg DM. The same study indicated that NDF, Lignin and ash were estimated to be 62.3, 6.24 and 7.6 percent, respectively. Similarly, a study reported by Ashenafi (2010) in Hawassa, Bako and Ambo areas indicated that the overall average chemical composition of green maize stover from 15 maize varieties harvested at green (*eshet*) stage (g/kg DM) contain 70, 674, 346, 39 and 328 for CP, NDF, ADF, Lignin, and Hemicellulose, respectively.

2.3. Feeding Systems/practices

The feeding systems of livestock varied from place to place depending on forage availability, production systems, grazing land availability, or season of the year and type of livestock the owner prioritize to feed, etc. For instance, in the lowland areas of Ethiopia grazing and browsing naturally available forages is the main feeding system. (Malede and Takele, 2014), however, Crop residues and conserved hay are supplemented if they are available. Another study conducted in Benishangul-Gumuz region, western Ethiopia revealed that grazing of natural pasture and stubbles after crop harvest was the most commonly feeding system practiced (Beyene *et al*., 2011). As described by Zinash *et al*. (1995) in the central highlands of Ethiopia, grazing was carried out on fallow land, permanent pasture lands and stubbles after crop harvest. Production problems common to most Ethiopian livestock feeding systems are seasonality in animal feeds supplies and of poor quality in that the quality of most harvested and conserved feedstuffs is often insufficient to provide even for the maintenance needs of livestock. The majority of smallholder dairy farmers in Dire-Dawa town practiced intensive or zero-grazing, feeding system (Emebet and Zeleke, 2008). The types of dairy cattle feeding systems identified in the East Wollega zone, Ethiopia by Misgana *et al*. (2015) were grazing (own and communal pasture), intensive feeding, combination (grazing, cut and carry and intensive) and tethering. According to Getachew *et al*. (2015), two feeding systems (tethering and free grazing) are prominent in Fogera district. Similarly, Belay and Geert (2016), reported three types of dairy feeding systems in Jimma (zero- grazing/stall feeding, partial-grazing and full time-grazing). Similar study conducted by Dessalegn *et al*. (2016) also showed that stall feeding and combinations of feeding systems were mainly practiced in Bishoftu and Akaki areas. Generally, grazing with/without supplementation is characterized by mixed farming system and pastoralist system. Stall feeding system is mainly experienced in large scale intensive dairy production, and urban and peri -urban systems.

2.4. Total mixed ration feeding

A total mixed ration (TMR) is a homogeneous mixture of mechanically mixed ingredients that typically combine roughages (forages) and concentrates such as grains to optimize animal performance (Zheng, 2013). Feeding TMR helps a dairy cow to achieve maximum performance. This is possible by feeding a nutritionally balanced ration at all times or allowing cows to consume as close to their actual energy and protein requirements as possible and maintaining the physical or roughage characteristics, required for proper rumen function (Lukuyu *et al*., 2012).The importance of feeding TMR diet, as opposed to feeding roughage and concentrate at different intervals , make every bite of feed complete nutritionally and milk fat depression, and other digestive upsets were less likely to occur (Schingoethe, 2017). Feeding balanced feed to dairy animals can play a pivotal role in a successful dairy development. To maximize the productivity of an animal, one needs to be ensured that they receive the required quantity of protein, energy, minerals and vitamins (FAO, 2012). The ratio of concentrate and forage requires due attention while blending the diet for milking cows. Animals fed on concentrate-rich diets (> 60%), may go off-feed due to ruminal acidosis that is because a low pH is detrimental to the rumen fibre digesting bacteria which may cause a depression in fat content in the milk and can also affect the animal's health status (FAO, 2012 and Lukuyu *et al*., 2012).

Many researchers indicated that the total daily dry matter and nutrient intakes showed improvements as cows allowed to feed TMR. For instance, Gupta *et al. (*2014) reported that lactating crossbred cows fed TMR showed higher feed intake by 15.92 percent over the conventional mode of feeding. The author further stated that crude protein and energy intakes were also increased in cows fed TMR based ration as compared to conventional feeding. Similarly, Dejene *et al*. (2017) reported that the DM intake of cows fed TMR natural pasture hay based was higher than conventional feeding methods. Similar study also pointed out that the total daily DM and CP intake was also higher for Holstein cows fed 100% TMR than cows fed 75% TMR supplemented with legume hay, however, NDF intake was similar in both treatments (Muya *et al*. 2011). On the other hand, Khan *et al*. (2010) stated that crossbred cows fed total mixed ration in the form of pellets showed improved dry matter and CP intake as compared to conventional feeding. Higher daily feed intake was observed for cows fed TMR than cows allowed pasture grazing (Kolver and Muller, 1998). Moreover, wheat straw based total mixed ration showed increased energy, DCP and TDN intake as compared to feeding of wheat straw and concentrate feeds separately (Pachauri *et al*., 2010).Heifers fed hay and concentrate separately showed lower intake than heifers fed TMR hay based ration (Geberemariyam, 2018). The author also reported that the organic matter and crude protein intakes were higher for heifers fed TMR diet. Hundal *et al*. (2004) reported that TMR of Berseem hay based and TMR of Oat hay based diet showed higher DM, OM and NDF digestibility percentage than that of the conventional feeding system. Moreover, Khan *et al.* (2010) stated that the DM and CP digestibility was higher in lactating cows fed complete ration in pellet form or un-pelleted form than the conventional feeding. According to Pachauri et *al*. (2010), the digestibility of DM, CF, EE and NFE was higher in wheat straw based TMR than conventional feeding method (feeding of wheat straw and concentrate separately). Better digestibility of organic matter, NDF, ADF and ADL was resulted in natural pasture hay based TMR than roughage and concentrate supplied separately (Geberemariyam, 2018).

2.5. Nutrient requirement of dairy cows

Nutrition has a profound influence on productive and reproductive performance of dairy cattle. Lactating cows have special demand for nutrient supplement because of high metabolic rate and requirement for milk secretion (Indetie, 2009). Many studies indicated that milk yield and composition can be influenced mainly by the dietary supplies of energy and protein (Tadesse *et al.,* 2003). Among the nutrients energy and protein are the prime nutrients in determining nutritional adequacy and feeding levels for different classes of livestock (Streeter, 2006). The ration formulated should meet the desired amount of nutrient required per animal per day (Adugna, 2008). The ration which has been balanced properly should avoid severe negative energy balance and an excess intake of specific dietary components (Leroy *et al.,* 2010) that means unbalanced feeding could lead to the excess feeding of some nutrients at the expense others. This type of feeding not only reduces productivity and increases costs per kg product but also influence various physiological functions (Yisehak and Geert, 2014)

2.5.1. Protein

Protein is one of the most important nutrients in all living organisms and much expensive nutrient as compared to energy feed sources. Feeding excess amount of protein is considered as wastage of protein as it doesn't stored in the body but is broken down by microorganisms in the rumen and excreted in the form of urea (McDonald *et al.,* 2010). Moreover, it demands additional energy to remove the excess nitrogen which would not be used for milk production, in the form of urine (Lukuyu *et al*., 2012). As the same author further stated, sudden reduction of protein from lactating cows feeding regime causes a sudden drop in milk production and causes excessive weight loss if the deficiency is severe. Obviously, lactating cows have higher protein requirement than dry cows. Lactating cow weighing 350 kg requires 507gram/day crude protein or 235 gram/day of digestible protein for maintenance purpose. However, beyond the maintenance requirements, cows require more protein for milk production based on the milk yield and composition (Paul *et al.,* 2004). As the above authors described milk yield with 5% fat composition requires 103 grams of protein or 72.4 grams of digestible protein /liter of milk. Similarly, small breed lactating cows weighing about 454 kg and producing 10 liters of milk with milk composition of 5 and 3 percent for fat and protein respectively, requires diet containing 11.7% CP (NRC, 2001).

2.5.2. Energy

Quantitatively, the energy feeds are the most important ingredients considered during ration formulation for dairy cows (Lukuyu *et al*., 2012). Like that of protein, energy is also required both for maintenance and production. The energy requirement depends on breed, live-weight, sex and physiological state (pregnancy, lactation) of the animal. For maintenance, lactating cow weighing 350 kg needs 48.4MJ of ME per day (Paul *et al.,* 2004). A basal diet from native grass hay, pasture grass provided *ad libitum* can fulfill maintenance needs of crossbred dairy cows if it is harvested in right time (Gebrewold, *et al*., 2000). However, milking cows required additional energy depending on the amount of milk produced and the fat composition of milk, the higher the fat content, the more energy required (Lukuyu *et al.,* 2012). For instance, 6.28 and 5.68 MJ ME is required for milk containing 5 and 4.5 % of fat per liter of milk, respectively. A dairy cow of400 kg body weight and 40 g butterfat content require 5 MJ of ME for each kg of milk produced (Brännäng and Persson, 1990). It is important to supply adequate energy to avoid negative energy balance and lowered fertility rate resulted from energy imbalance.

2.6. Maize Production and Stover Utilization in Ethiopia

Abdisa *et al.* (2001) stated that Ethiopia is among the major maize producers in Sub Saharan African countries, where smallholder farmers dominate the major share of production. According to CSA 2015/16 private peasant holdings *meher* cropping season reports, out of the total land allocated for grain production 79.88% (9,974,316.28 hectares) of land was covered with cereal crops. From the total land allocated for cereal production, maize crop covers 16.91% (about 2,111,518.23 hectares land) which is the second in terms of area coverage. Cereal crops contribute 86.68% (about 231.3 million quintals) of the grain production (CSA 2015/16). However, maize production takes the lion share 26.80% (71.5 million quintals) in the oromia region and it is the first crop in terms of yield. The maize stover could be estimated from the maize yield obtained by a conversion factor of 2(FAO, 1987). Among the regions, Oromia Regional State is the most productive region in Ethiopia. From the total cultivated land (1,146,899.78 hectares) in the region in 2017/18 *meher* cropping season, 46,767,440.66 quintals of maize was produced or average maize production rate in the region was 40.78 quintal/hectare (CSA 2017/18 (2010 E.C)). The same report described that the average maize production in West Shewa Zone is higher than the other zones of Oromia (41.10 quintal/ha). Crop yield and stover left as by-product, has relationship. Stover produced can be estimated from the grain yield. In Oromia, maize stover availability is the highest (39 percent), followed by straws of sorghum (22 percent), wheat (16 percent) and teff (15 percent) (FAO, 2018). However, this abundant feed resource is not utilized efficiently as ruminant animal feed (Ashenafi, 2010). Among many factors; variety of the crop, growing and harvesting conditions, threshing and storage methods affects the yield and quality of the stover (Ashenafi, 2010). In the maize belt areas of Ethiopia, maize account for about 77% of the total residue fed to the animal and the majority of the farmers use maize residue to feed milking cows and oxen (Berhanu *et al*., 2007). On the other hand, farmers around Bako and Ambo areas are less interested to conserve/store the stover after harvesting the grain rather it will be left on the field to be consumed by grazing animals believing that the manure deposited by the animals would restore the soil fertility (Ashenafi, 2010). Dry stover is low in nutrients (e.g. 3.7% CP as compared to 8.8% in green stover); as a result it is less palatable for cattle feeding (Fanos, 2014).

2.7. Feed Intake of Lactating Cows

A cow will reach her highest daily milk output 6-8 weeks after calving but will only reach her highest intake of dry matter 10-12 weeks after calving (Lukuyu *et al*., 2012).

Feed consumption is generally expressed in terms of Dry Matter Intake (DMI), the weight of feed material consumed excluding the moisture it contains. Digested feed clearly has a major effect on nutrient supply; the most important factor governing the extent to which cows can meet their energy, protein and other nutrient needs is the amount of feed they consume (McDonald *et al.,* 2010).

The total DMI of Boran-Freisian crossbred dairy cows fed with different levels of vetch (*Vicia dasycarpa*) hay and concentrate on a basal diet of fresh cut Napier grass (*Penissetium purpureum)* was ranged from 3.17% to 3.63% of their body live weight (Aemiro *et al*., 2010). Similarly, according to Berhane (2012), the feed intake of lactating Jersey cows was at the range of 10.81 to 11.34 kg/day/cow. The lowest feed intake was recorded for cows fed T1 (natural hay *ad lib* + concentrate mixture formulated with only conventional feed ingredients) and highest on T2 (natural hay *ad lib* + concentrate mixture formulated by inclusion of 35% field pea hull). However, Dejene *et al*. (2017) has reported higher (12.82kg) feed intake for early lactating Jersey cows fed TMR. The feed intake of dairy cows can be affected by different factors. According to Girma *et al* (2014), the production systems and the scale of farm type showed variation in feed intake.

2.8. Factors Affecting Milk Yield and Composition

The variation in composition and daily milk yield is a regular phenomenon in all milking animals (Adebabay, 2009). Genetic makeup and environmental factors are the two determinant factors for these variations. Among others factors, breed, species, parity, stage of lactation, environmental stress, changes in feeding, etc play the greatest role (Lukuyu et *al.,* 2012). A thorough understanding of the factors can be used to take advantage of some of the changes in milk composition and yield (Lukuyu et *al.,* 2012). It is up to the dairyman to manage these factors so as to achieve high milk production and increase profit (Adebabay, 2009). From the factors, the quantity and/or quality of feed has a paramount effect on milk yield and composition. For instance, milking goats fed microbial inoculated corn silage showed higher milk yield than goats fed un-inoculated corn silage (Abedo *et al*., 2013). Generally, however, underfeeding reduces the amount of milk production, the fat and solids-not-fat (SNF) contents of milk produced. The type of feed supplied to dairy cows influences milk yield and its composition. It is also believed that the fat content is influenced more by roughage (fibre) intake and the SNF content can fall if the cow is fed a low energy diet, but it is not greatly influenced by protein deficiency unless the deficiency is sever (O'Connor, 1994).

Research findings revealed that milk from pasture-fed cows (grass and clover) had significantly higher concentrations of fat, protein, true protein, and casein as compared to cows fed TMR (O'Callaghan *et al.*, 2016). Similarly, stage of lactation and the parity order affected the milk yield and contents of milk. As stage of lactation advanced the protein content decreased significantly ($p \leq 0.05$) and solids not fat (SNF) contents also showed similar trends. However, higher fat value in the late lactation was observed (Shuiep *et al.*, 2016). This indicated that milk fat composition and milk production are inversely related. The same study also indicated that the parity order of the cow influence the chemical constituents of milk except lactose. Another study conducted in temperate cows revealed that the fat and SNF percentages tend to be higher in the early weeks of lactation, dropping by the third month then rising again as milk yield gradually declines (O'Manhony, 1988). The milk immediately after calving contains a very high percentage of total solids (up to 19%) mainly due to the very high fat and milk protein contents (O' Connor, 1994).

Generally, high yielding cows have lower milk fat content than low yielding cows and milk fat content is higher in early and late lactation than in mid-lactation, being negatively correlated with milk yield (Auldist *et al*., 2007). Milk fat content increases during milking, since it partially separates from the water in the milk during storage in the udder, thus efficient emptying of the udder during milking results in higher fat content in the milk obtained. In systems, where the calf is allowed to suckle after milking, lower fat content has been reported in saleable milk (Fröberg *et al*., 2007). Like fat content, milk protein content is influenced by breed, stage of lactation and nutritional factors and is also higher in early and late lactation than mid-lactation (Auldist *et al*., 2007). The same author further explained that as that of milk fat, protein content was higher in low yielding than high yielding cows. Increased energy intake, either by increasing the level of concentrates or by improving the silage quality, increases the protein content in milk, but it is much easier to modify milk fat than milk protein content by feeding (Fröberg *et al*., 2007).

3. MATERIALS AND METHODS

This chapter describes the materials and methodologies used to conduct the studies (the survey work, green maize stover conservation trial (quality silage making) and dairy cows feeding experiment).

3.1. Survey on Feed Resource Availability, Feeding System and Green Maize Stover Utilization/Conservation Practices

3.1.1. Description of the study areas

The survey study was conducted in West Shewa Zone, Oromia Regional State at three selected districts i.e Bako-Tibe, Toke-kutaye and Ejere. The districts were selected purposively based on cattle population, maize crop production potential and accessibility. Bako-Tibe district is located at 250 km from Addis Ababa along Nekemte road at 9° 06' N latitude and 37° 09' E longitude. The soil type of the district is dominated by red loamy soil. The human population is 133,584 with a farming household size of 22,880 heads. It has 137,343 heads of cattle, 12,502 sheep, 15,381 goats, 96,742 chickens, 3,685 horses, 1,023 mules and 8,415 donkeys (Bako agricultural development office, unpublished). The dominant crops grown in the district include maize, teff and sorghum. The area receives a mean annual rainfall of 1200 mm, 90% of which falls between June and September and the elevation ranges from 1570 m to 2600 m above sea level with an average temperature of 19°C ranging from 9°C to 34.4°C (Bako agricultural development office).

Toke-Kutaye district is found along the highway from Addis Ababa to Nekemete road at a distance of 119 km or 12 km West of Ambo town. It is located at 8° 59' N latitude and of 37° 46' E longitude. The human population of the district is 123,565 with 26,331 household heads. According to the woreda livestock and health agency office, it has 185,596 heads of cattle, 47,349 sheep, 34,782 goats, 84,530 chickens, 10,850 horses, 2,371 mules and 1,398 donkeys. The major crops grown in the district include wheat, teff, barley, maize and sorghum. The altitude and rainfall of the area ranges from 1600-

3194 m.a.s.l and 800-1100mm, respectively, with a temperature range of 10-29^{0}C (Toke kutaye Agricultural development office, unpublished).

Ejere district is located at 43 km west of Addis Ababa along Nekemte road with latitude and longitude of 9° 02'N and 38^0 24'E, respectively. The total population of the district is 86,934 with household heads of 14,538. It has 97,237 cattle, 49,152 sheep, 12,778 goats, 12,031 horses, 20,721 donkeys, 165 mules and 73,058 chickens (Ejere agricultural development office). Teff, Wheat, Barley, Maize and Sorghum are common cereal crops grown. The altitude of the area ranges from 2060 to3185masl with average rainfall of 1100mm. The minimum and maximum temperature of the district is 9^{0}C and 28^{0}C, respectively (Ejere agricultural development office).

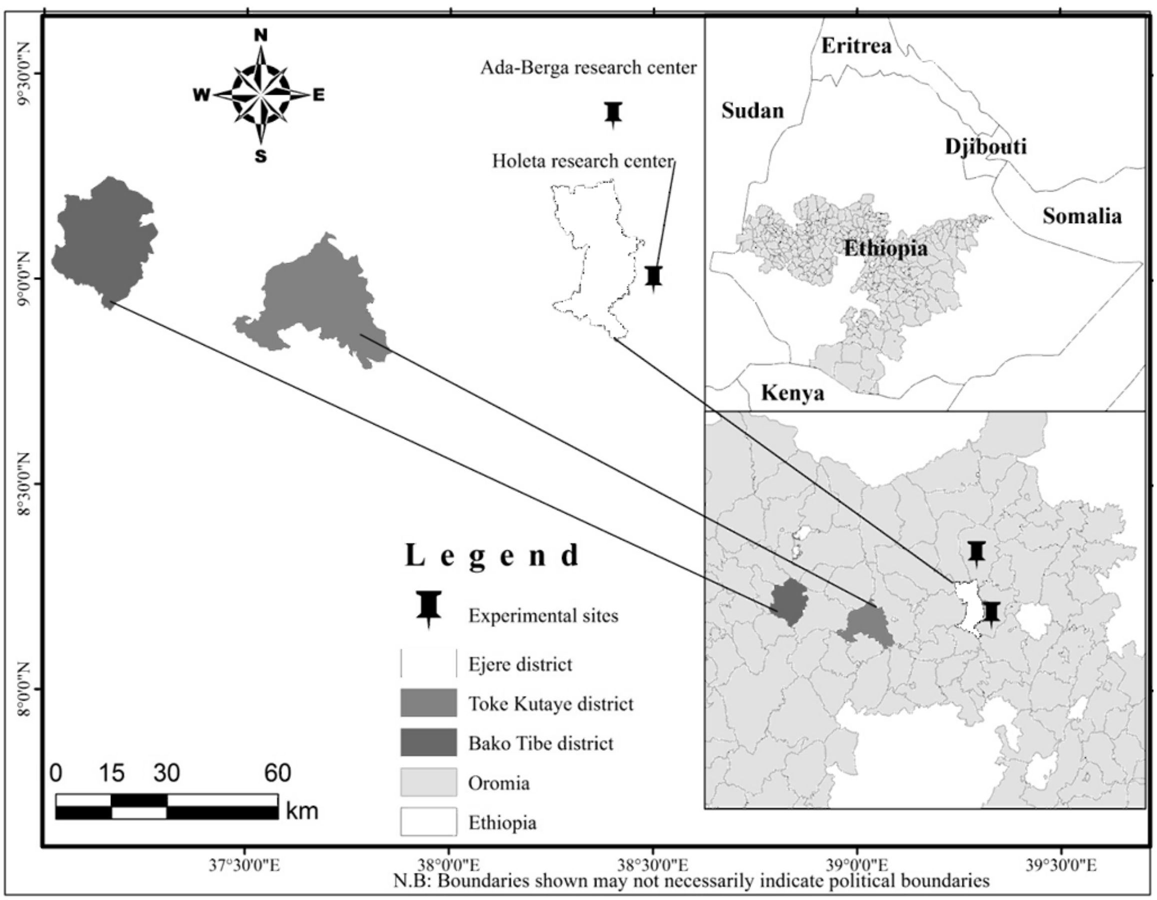

Figure 1. Map of Ethiopia and the study sites

3.1.2. Sampling procedures for the household survey

Multistage sampling procedure was used to select districts, peasant associations (PAs) and household heads. In the first stage, three representative districts (BakoTibe, Toke Kutaye and Ejere) were selected based on high cattle population, maize production and accessibility purposively from West Shewa, Oromia Region by the helps of zonal livestock and health agency and zonal agricultural development offices. In the second stage, two representative kebeles from each district were purposively selected on the basis of cattle population, maize production and accessibility by the help of the district livestock production and health agency experts, Agricultural development office experts and development agents. A total of 357 farmers were randomly selected for interview from the total six kebeles (two from each district) using Probability Proportional to Size (PPS) based on the population of each kebele (Table 1). The sample size was determined according to the following formula (Yamane, 1967)

$$n = N/1+N\ (e^2)$$

Where, n = the sample size

N = the population size

e = the acceptable sampling error/margin of error (5% was used at 95% Confidence level).

Table 1. Total sample size selected from the study districts

Districts	Kebeles	Household heads	Sampled proportion (%)	Sample size
Bako -Tibe	Dembi - Dema	690	20	72
	Bechera - Odagibe	546	16	57
Toke -Kutaye	Melka-Nega-Dembi	635	19	67
	Hemela-Dawi-Ajo	826	24	87
Ejere	Chiri	354	10	37
	Kusaye	346	10	37
Total		3, 397	100	357

3.1.3. Data collection

In order to address the objectives of the survey study, the primary data was collected from smallholder farmers using semi structured questionnaire in a single visit interview. The questionnaire was pre-tested to check clarity and appropriateness of the questions. Some of the information collected through interview was also supported by observations. A single-visit-multiple-subjects survey method was employed to gather quantitative and qualitative data from a household head (respondent) on various aspects such as: family size, educational status, land holding and utilization pattern, herd size and structure, feed resources availability and feeding system, maize stover availability /conservation and utilization practices, storage and feeding practices, water source and watering frequency, constraints of livestock production, feed balance in the study areas was estimated from secondary data obtained from the district agricultural development offices and previous research work. Some supplementary data and information were also collected from the district agriculture development offices, key informants and extension agents to augment data obtained from the formal survey.

The quantity of feed in dry matter basis obtainable from natural pasture was estimated by multiplying the grazing land owned by 2.0 t/ha (FAO, 1987). The quantity of available crop residues produced was estimated by using multipliers (conversion factors) (FAO, 1987). Accordingly, for wheat, barley, oat and *tef* straw, a multiplier of 1.5 was used, for pulse straw a multiplier of 1.2 was used, for maize a multiplier of 2.0 was used and for sorghum a multiplier of 2.5 was used. For *noug* and linseed a multiplier of 4.0 was used (Kossila, 1984 (as cited by Endale *et al*. (2016); FAO, 1987). The grazing potential of crop stubbles and forest areas were estimated using a mean value of 0.5 and 0.7 ton per ha, respectively, as reported by FAO (1987). Moreover, the quantity of potentially available crop residues for animal consumption was estimated by assuming 10% wastage and other uses (Adugna and Said, 1994). The total feed available per year and feed requirement of livestock population was compared. The metabolizable energy and crude protein balance was estimated from the mean ME and CP contents of feeds reported by previous researchers. For instance, according to Dirsha *et al*. (2018), the mean ME and CP contents of all feed resources available was 8.26 MJ/kg DM and 4.9% (49 g/Kg DM), respectively. Similarly, Zewdie (2010) also reported that the mean CP and ME of all the feed resources (natural pasture, harvested hay, crop residues, crop stubbles, non-conventional feeds (*atela* of local breweries), browse spp.) available to be 7.7% and 7.83MJ/kg, respectively. The average value of the two reports ME (8.05MJ/kg) and CP (6.3%) were used to estimate ME and CP balance of the current study.

Livestock population data obtained from the respective district livestock and health agency offices has been converted into Tropical livestock unit (TLU) using multipliers indicated below

Cattle = 0.7, sheep = 0.1, goats = 0.1, horses = 0.8, donkeys = 0.5, mules = 0.7, poultry = 0.01 according to Jahnke (1982). The maintenance DM and nutrient (ME and protein) requirement of one TLU (an equivalent of a bovine of 250 kg live weight) was estimated 4.6kg of DM day^{-1} and 337g protein and 7.4 Mcal per day Kearl (1982).

However, the livestock populations of the respondents were converted into Tropical Livestock Unit (TLU) as suggested by Gryseels (1988) and Bekele (1991).

3.1.4. Statistical analysis

The collected data were analyzed using Statistical Package for Social Sciences (SPSS, 2002; ver. 20.0). Descriptive statistics such as means and percentages and graphs were also used. Furthermore, one-way ANOVA was used to examine differences among continuous variables. Differences were considered significant at $p<0.05$.

Index was computed by employing the following formula (adopted from Mulugeta, 2015)

$$\text{Index} = \frac{Rn*C1+Rn-1*C2\ldots.+R1*Cn}{\Sigma Rn*C1+Rn-1*C2\ldots+R1*Cn}$$

Where;

Rn = Value given for the least ranked level (if the least rank is 5th, then Rn = 5, Rn-1 = 4, R1 = 1) Cn = Counts of the least ranked level (in the above example, the count of the 5th rank = Cn, and the count of the 1st rank = C1).

3.2. Silage Experiment (characteristics of silage made from green maize stover)

3.2.1. Experimental site

The silage experiment and the feeding trial (section 3.3.) were conducted at Holeta Agricultural Research Center (HARC) and Ada-berga Jersey cattle research sub-center, respectively. Holeta Agricultural Research Center (HARC) was established in 1966 under the Institute of Agricultural Research (IAR) now the Ethiopian Institute of Agricultural Research (EIAR). The center is located in the special Zone of Oromia Regional State, in Holeta town, 35 km West of Addis Ababa at an altitude of 2400 meters above sea level. The average annual rainfall of the area is 1040 mm and the average maximum and minimum daily temperatures are 21°C and 6°C, respectively.

Ada-berga Jersey cattle research is a sub-center under Holeta Agriculture Research Center and located at 70 km West of Addis Ababa and 35 km North West of Holeta town along the Muger road. The sub center is located in the central highlands of Ethiopia at 9^0 16'N latitude and 38^0 23'E longitude. It lies at an altitude of 2500 meters above sea levels. It is characterized by cool sub-tropical climate with the mean annual temperature and rainfall of 18^0C and 1225mm, respectively. The farm was established in 1986 for commercial milk production under government state farms by using 400 introduced pure Jersey pregnant heifers and two sires (foundation stock) from Denmark. Then it was transferred to Holeta Agricultural Research Center for genetic improvement research program since 2007. The farm has 330 cattle currently, of which 241 are pure Jersey breeds and the rest are Boran breeds bought recently for cross breeding program (Ada-berga Research office, unpublished).

3.2.2. Preparation of Silage Additives

3.2.2.1. Fermentative juice of lactic acid bacteria (FJLB)

Fermentative Juice of Lactic acid Bacteria (FJLB) was prepared from 200g fresh chopped green maize stover. The maize variety used for FJLB preparation would have to be used for silage experiment. The green maize stover harvested from Holeta crop research department was immediately macerated in 600ml of sterilized distilled water using a blender. The juice was filtered through a double layer of cheese cloth; the filtrate then transferred to a glass bottle and mixed with sucrose sugar thoroughly at the rate of 1% of the original weight of maize stover. Then, the bottle was capped and incubated anaerobically at 30°C for 2 days (Ohshima *et al*., 1996). After the end of 48 hours, the pH value of the extract was determined with pH meter and then used as a silage additive (Yahaya *et al*., 2004). The extract having pH value of 3.8 to 3.5 was recommended to be an additive (Ohshima *et al*., 1996).

3.2.2.2. Effective micro-organisms (EM2)

For this experiment one bottle with a capacity of one liter of EM2 solution was purchased with (40.00 Eth. Birr) from Woljejii PLC, Bishoftu, Ethiopia. However, EM2 was prepared by mixing EM1, molasses and chlorine free water in the ratio of 1:1:18, respectively.

3.2.2.3. Molasses

Molasses was purchased with (0.92 Eth. Birr/ lt) from Wonj Sugar Factory. It was diluted with water at the ratio of (1:1) in order to sprinkle uniformly.

3.2.3. Experimental feed preparation and Ensiling procedures

Green maize stover (from maize variety named “Arganie”) was harvested from Holetta crop research department when the maize crop reached to dough ”*eshet*” stage or when the milk line became between one-half to three-quarters to the way down the maize kernel. Cutting height was 5 cm from the ground to avoid soil contamination.

The green stover, shortly after the ear has been removed, was chopped with a forage cutter into pieces to an average length of 2cm for ease of compaction and consolidation. Except the control, the chopped green maize stover was weighed and treated with respective additive on a concrete floor plastered with plastic sheet, each with five replications. The experimental additives were EM (1%), FJLB (1%) and Molasses (3%) on fresh weight basis of the silage crop. The treated green maize stover was then filled into a plastic bucket having 4 liters capacity lined with plastic sheet and compacted simultaneously. Each silo has been filled with 1000 g of chopped and treated green maize stover by hand and periodic tamping with a wooden stick. The tightly packed silos were immediately closed and sealed. On the sealed silage, heavy load was placed over the top of the plastic bag to exclude air from the silage and incubated at room temperature for about 4, 6 and 8 weeks.

3.2.4. Treatments and experimental design

The treatments were four additives (control (with-out additive), EM at 1%, FJLB at 1%, and molasses at 3%) by three incubation periods (4, 6 and 8 weeks) factorial combinations each with five replications, a total of 60 mini silos were used in the study.
The level of additives applied was adopted from previous research reports studied elsewhere on other silage crops (Bureenok *et al.*, 2005; Bilal, 2009. A Completely Randomized Design **(**CRD) was used.

3.2.5. Silage pH, temperature and total dry matter loss measurements

Experimental silos were weighed at the beginning of the experiment and end of ensiling period to determine fermentation loss by difference (DM of forage - DM of silage)/DM forage*100) (Pedroso *et al.,* 2011)
The silage temperature was measured immediately after opening silos using a laboratory thermometer inserted into the silo's center. The ambient temperature at the time of silo opening was recorded at each incubation period.
After observing the mold occurrence, the silage was removed and thoroughly mixed for other physical and chemical analysis. Part of the silage was immediately frozen to avoid spoilage since it is a perishable product, while the remaining half was used for physical characteristics assessment or sensory evaluation of silage quality. For pH determination, about 20 g of silage sample per treatment was kept in a beaker and to which 100 ml distilled water was added. The samples were blended using a glass stirrer and left for one hour before filtering with filter paper. Silage pH was measured from the extract using a

conventional digital pH meter (Hanan Bench top pH meter), calibrated with buffer solutions (pH 4 and 7), according to (AFIA, 2011).

3.2.6. Sensory evaluation of silage quality

The physical parameters like colour, aroma, texture and moldiness were inspected and subjectively judged by a panel involving five personnel who had experience on silage quality characterization. The panelists were from the Livestock Research Department and were oriented on how to apply the criteria set (Table 2), and were exercised before commencing the actual evaluation. The physical quality characteristics (colour, smell, texture and moldiness) of the experimental silages were scored using a 0 - 4 scale (Ososanya and Olorunnisomo, 2015). Observation for mold formation was done before and after opening the plastic sheet, while colour, smell and texture were evaluated immediately after silo being opened. The score values of the panelists for all attributes were used in the statistical analysis. Four and zero were the maximum and minimum scores for each physical characteristic, respectively and the average sum of scores of all judges were taken as the quality score of each characteristic.

Table 2. Assessment scale for the sensory characteristics appraisal of maize stover-silages

Characteristics	Scale				
	0	1	2	3	4
Colour	Very dark	Dark	Olive yellow	Light olive green	Olive green
Smell/aroma	Very Offensive	Offensive	Almost pleasant	pleasant	very Pleasant
Texture	Slimy	Very soft	Soft	Fairly firm	Firm
Mold coverage	Extremely moldy	Highly moldy	medium	Scattered mold spot	Without Mold

0 = Very bad, 1 = Bad, 2 = Moderate, 3 = Good, 4 = Excellent

3.3. Feeding Experiment

3.3.1. Silage preparation

A hectare of maize variety named ("Arganie") was planted at the compound of Ada-berga dairy farm for preparing silage from the green stover. Five months after planting, the green cob was checked and harvested at dough "*eshe*t" stage or when the milk line became between one-half to three-quarters to the way down the maize kernel. Then green stover after the removal of the green cob, was immediately harvested and chopped to an average length of 2cm by a tractor driven chopper. The chopped maize stover was sprinkled with molasses diluted with chlorine free water at the ratio of (1:1), the best silage additive selected in experiment I. The sprinkling process was done at every 15cm thickness and compaction with tractor followed after being covered with film layer of the chopped stover. This process was repeated until the required silage was ensiled in the bunker silo. After the final filling and compaction, the heap was wrapped with plastic sheet to avoid air infiltration and water running into the silage. Finally, the heap was covered with a thick layer of soil on it and kept for six weeks, the best period that has been found in experiment I. The feeding experiment was commenced six weeks after ensiling.

3.3.2. Animal selection and management

A total of eight lactating Jersey cows with more or less similar milk yield (8-10kg/day); with the same stage of lactation (mid-lactation, i.e., 85-105 days after parturition) and cows of having closer body weight (312 ±18.7kg) and parity range of one through four were used for the experiment. The initial body weight of all experimental animals was measured early in the morning for two consecutive days before the feed was offered by using fixed weighing scale. The health status of the experimental animals was confirmed by a veterinarian. The cows were dewormed for internal parasites 3 weeks before the commencement of the experiment

3.3.3. Experimental feeds and design

Conventionally, the lactating dairy cows on station were fed grass hay with concentrate supplementation of 0.5 kg/liter of milk. The concentrate was formulated from wheat bran (69%), noug cake (30%) and salt (1%). The total ration was roughly assumed to provide the required protein (11.7% CP) and energy (10MJ ME kg^{-1} DM) to satisfy for a cow weighing 312 kg and milk yield of 8-10 liters/day and a butter fat content of 4.4% (NRC, 2001; Paul *et al*., 2004). The experimental feeds or the total mixed ration (TMR) were prepared by blending the formulated concentrate with silage in a graded manner (30%, 40%, 50%) of daily dry matter allowance, except the control diet where cows had received the formulated concentrate at the rate of 0.5 kg/liter of daily milk production offered with equal portions at 5:00 am and 5:00 pm during the morning and evening milking times, respectively. Individual feeding was practiced. A shift of feeds among the groups was performed every period. The experimental cows were allowed to drink water *adlibitum* and let exercise out of doors for about 30 minutes every morning. The daily ration for T2, T3 and T4 was blended based on their average body weight of 3% at the beginning of every experimental period (Paul *et al*. 2004; Lukuyu *et al*., 2012). Then after, the ration for these treatments was prepared per day with an adjustment to supply sufficient amount of feed which allows 10% refusal from the previous day offered on a dry matter basis. i.e. (feed offered*10/100). The total experimental period was 24 days (14 days of adaptation and 10 days of actual data collection) per each period and this was repeated four times in the same manner. A double 4*4 Latin Square Design was used for handling the experiment. With each square, cows were assigned randomly to the four dietary treatments indicated below.

The experimental feeds combinations were designated as

T1 = Control group (green maize stover silage alone *adlibitum*) and concentrate of 0.5kg /liter of milk yield

T2 = Green maize stover silage based TMR (70%GMSS: 30% Concentrate)

T3 = Green maize stover silage based TMR (60% GMSS: 40% Concentrate)

T4 = Green maize stover silage based TMR (50% GMSS: 50% Concentrate)

3.3.4. *Chemical Analysis and Determination of In-vitro Organic Matter Digestibility*

Chemical analysis and *in-vitro* organic matter digestibility determinations were done at Holetta animal nutrition laboratory. Feed samples taken from the silage experiment and the feeding trial were dried in a forced–air oven at 65^0C for 72 hours and ground to pass through a screen size of 1 mm sieve in a Wiley mill and stored in polyethylene bags until chemical analysis. In the silage experiment representative samples of fresh green maize stover were taken at the time of ensiling period while silage samples were taken at 4, 6, and 8 weeks of fermentation periods. The DM and ash content of feeds were determined by the standard methods of AOAC, (1990). Total nitrogen (N) content of the feed samples was determined using Kjeldahl method. The CP content was calculated as N*6.25. The NDF, ADF and ADL contents were determined according to Van Soest and Robertson (1985). *In vitro* organic matter digestibility of feeds offered were determined using procedures outlined by Tilley and Terry (1963). Metabolizable energy (ME) content was estimated from the *in vitro* organic matter digestibility (IVOMD) as ME (MJ/kg) = 0.016*g IVOMD/kg according to McDonald *et al.* (1995) and Hemicelluloses =NDF – ADF

3.3.5. *Feed and nutrients intake*

The daily DM and nutrients intake was calculated by subtracting the amount and nutrients of leftover, which was weighed every morning before the new meal supplied, from the total feed offered. The daily samples of feeds offered and refused were collected; bulked and representative sub samples were taken after thorough mixing for the determination of nutrient composition.

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3.3.6. *Apparent digestibility*

Apparent digestibility was determined for the total ration in each treatment using the procedures of total fecal collection method for a period of 5 consecutive days at the end of each experimental period. Contamination of feces was minimized by frequent washing of the concrete floor with high pressure running water using a plastic water hose. Attendants were assigned to receive feces and scoop it in to plastic buckets when animals defecated. Individual cow's feces was weighed and recorded every morning before fresh feeds was given to the animals. The feces of each cow were thoroughly mixed and a sample of 1% was stored in a deep freezer (-20^{0}C) until the end of the collection period. At the end of the collection period, the pooled samples were thawed and mixed thoroughly, and subsamples were taken for chemical analysis. The samples were dried at 65^{0}C for 72 hours and ground to pass through a 1-mm sieve size and stored in sample bottle at room temperature until analysis. Total feed and nutrient digestibility was calculated using the formula described by Khan *et al*. (2003)

$$\text{Apparent DM digestibility\%} = \frac{\text{DM intake - Fecal DM excreted *100}}{\text{DM intake}}$$

$$\text{Nutrient digestibility \%} = \frac{\text{Nutrient intake – Nutrient in feces * 100}}{\text{Nutrient intake}}$$

3.3.7. Milk yield and composition

Hand milking was carried out twice a day at 5 a.m. and 5 p.m. The milk yield was weighed and recorded throughout the experimental period. For milk composition analysis, milk sample from morning and evening was taken for three consecutive days in each milking period.

The sampling bottles were cleaned and sanitized properly before samples were taken to Holetta Agricultural Research Center dairy laboratory. The bottles were kept in ice packed cool box. The samples were chilled until analyzed for milk components. Lacto-scan (2016) analyzer was used to analyze fat, milk protein, Total solids, and lactose.

Determination of Fat Corrected Milk (FCM)

4% FCM = (0.4*kg milk yield) + (15*kg fat yield)

Where, kg of fat yield was calculated by multiplying kg of milk with percentage of fat

3.4. Statistical Model and Data Analysis

Experimental data were subjected to analysis of variance using the General Linear Model procedure of the SAS program (SAS, 2004). When the interaction between factors (silage experiment) was non-significant, only the main effect means were presented and discussed. Mean separation was done using Tukey test at 5% probability.

The following statistical models were used.

- **Silage experiment** : $Yijk = \mu + C_i + P_j + CP_{ij} + E_{ijk}$

  Where:

  Y_{ijk} = the dependent variable, μ = overall mean, C_i = effect of additives (i=1-4), P_j = effect of length of fermentation period (j=1-3), CPij= interaction effect, E_{ijkm}, = experimental error

- **Feeding trial** :$Y_{ijkl} = \mu + S_i + C_j + P_{k} + T_m + E_{ijkm}$,

Where:

Y_{ijkl} = response variable (intake, digestibility, milk yield & composition),

μ = overall mean, S_i = square effect (i = 1, 2), C_j = cow effect (parity) (j=1-4), P_k = effect of period (k=1-4), T_m= effect of treatment (diet) (m=1-4), E_{ijkm} = experimental error

The economic evaluation was done based on the cost of concentrate and the basal diet (silage), and price of milk/lt. Though the price of silage was not available, it was necessary to estimate its cost so as to suggest the cost-effective treatment. Therefore, the price of the silage in DM basis was assumed to be equivalent to natural pasture hay. The price of a bale of hay was 65.00 Eth. Birr *i.e* 4.10 birr/kg (one bale is equivalent to 15-17kg or average weight is 16kg). The price of milk was fixed (20.00 Eth. birr/liter) based on the local market price in the study area. The price of concentrate was 930.00 birr/quintal or 9.30 birr/kg obtained from the local market.

4. RESULTS

In this section the survey results including; household characteristics of the farmers, feed resource availability, feeding practices (system) and maize stover conservation and utilization (section 4.1), and results of the two experiments or physico-chemical characteristics green maize stover silage (section 4.2) and feeding experiment (section 4.3) are presented.

4.1. Feed Resources, Feeding System and Green Maize Stover Conservation/Utilization Practices

4.1.1. Household characteristics

Household characteristics of the respondents in the study areas are presented in Table 3. Majority of the respondents were male headed households (80.4%) and the rest were female-headed (19.6%). The overall average family size of the sample households was 6.53 (ranges from 2-12 persons). However, there was no significant ($P > 0.05$) variation among the districts. The average age of the respondents was 45 years with no significant difference ($P > 0.05$) among the surveyed districts. However, the age variation within the respondents was wider, ranging from 25 to 68 years.

In terms of educational level, majority (62.7%) of respondents were educated i.e. can read and write. Out of this, 10% attended 7th grade and above. In general, education has a positive impact on swift adoption and use of new technologies towards increasing production and productivity of livestock.

Table 3. Household characteristics of the respondents in the study districts (Mean ± SD)

Characteristics	Districts			Overall
	Bako-Tibe (n= 129)	Toke- Kutaye (n=154)	Ejere (n=74)	(N=357)
Age (years)	46.03±9.26	43.78±9.37	46.55±7.88	45.32±9.01
Family size	6.89±2.26	6.23±2.15	6.42±1.81	6.53 ±2.12
Sex of household heads	**n (%)**	**n (%)**	**n (%)**	**n (%)**
Male	101(78.3)	124(80.5)	61(82.4)	287(80.4)
Female	28(22.7)	30(19.5)	13(17.6)	70(19.6)
Educational status	**n (%)**	**n (%)**	**n (%)**	**n (%)**
Illiterate	53(41)	54(35)	26(35)	133(37.3)
Basic education	49(38)	51(33)	24(32.4)	124(34.7)
Primary(1-6)	19(15)	31(20)	13(17.6)	63(18)
Secondary(7-12) and above	8(6)	18(12)	11(15)	37(10)

N= number of households; SD=standard deviation; SE=standard error; figures in the brackets are percentages of respondents.

4.1.2. Landholding and Land Use Pattern of the Households

Table 4 shows the total land holding and land use pattern of the sample respondents in the study areas. The average total land holding of the respondents was 2.87 ha, ranging from 0.5 to 7 ha. However, about 48.7% of the farmers have less than the average land holding of 2.87 ha. The total land holding at Toke-Kutaye district is significantly ($p<0.05$) lower (2.66 ha/hh) than Bako-Tibe (3.0 ha/hh) and Ejere (2.96ha/hh) districts. The average land allocated for crop production per household in the study areas was 1.83 ha (64%) while the average land used for grazing was 0.45 ha (16%). The cultivated land allotted for crop production in Bako-Tibe district was higher ($p<0.05$) than both Ejere and Toke-kutaye districts. The grazing land in Ejere was higher ($p<0.05$) than Toke-Kutaye district. However, key informants in all the study districts depicted that mainly the communal grazing land was diminishing at fastest rate as the area targeted for investment, microenterprises and replacement reserve for those who had given their land for investors/ urbanization and hence, this limited grazing land was overgrazed due to letting unbalanced number of livestock and poor management practices. However, majority of the respondents had their own small grazing land including boundaries between two adjacent farms. For instance, in Ejere district about 80% of sample respondents had their own grazing land (Figure2). The size of fallow land is also showing similar trend to grazing land. Though the overall fallow land is limited, significantly higher (p<0.05) fallow land was observed in Bako-Tibe district.

Table 4. Land holding and use patterns of the sample households in study areas (Mean ± SD)

Land use	Districts			Overall
	BakoTibe	Toke Kutaye	Ejere	
Land size (ha)	3.0±0.82^{a}	2.66 ± 0.72^{b}	2.96 ±0. 95^{a}	2.87±0.83
Crop land	1.99±0.53^{a}	1.68± 0.43^{b}	1.82±0.63^{b}	1.83±0.53
Grazing land	0.45±0.19^{ab}	0.43±0.15^{b}	0.49±0.26^{a}	0.45±0.19
Fallow land	0.062±0.15^{a}	0.02±0.07^{b}	0.017±0.076^{b}	0.034±0.11
Homestead	0.61 ±0.39^{a}	0.53±0.46^{a}	0.60±0.35^{a}	0.57±0.41

$^{a, b, c}$ Mean values with different superscripts in a row indicate statistically significant differences among districts (p<0.05); SD= standard deviation

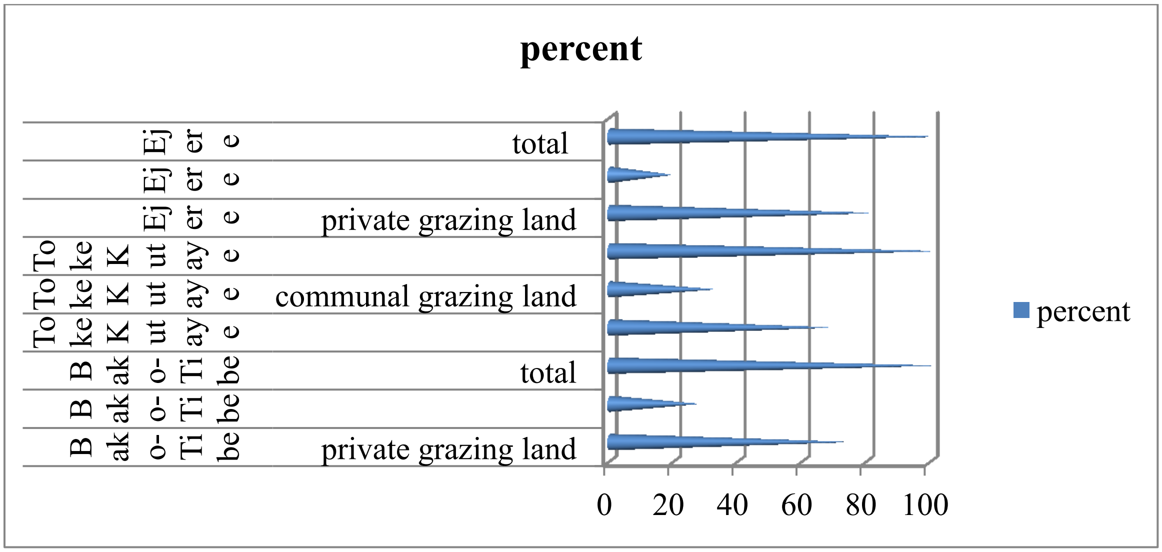


Figure 2. Total grazing land owned by the farmers and grazing land used in common in study areas (%)

Source: district agricultural offices of the study areas

4.1.3. Crop Land Use Pattern of the Study Area

Crop land utilization pattern of the study districts in 2016/17 cropping year is presented in (Table 5). The average land allocated for crop production in the study districts was 1.83 ha per household; out of this, land allocated for maize production takes the greatest share 0.78ha (42.62%)

According to the key informants, the crop fields closer to their homesteads are commonly planted with maize crop and 25 to 50% of the crop can be harvested being the cob green either for family consumption and/or selling to generate income and the rest would be harvested at the end of main rain season (November and December) when the grain matured and became dry.

In the current study, land used for maize production in Bako-Tibe was significantly ($P<0.05$) higher than Toke kutaye and Ejere districts. Similarly, cropland allotted for maize production in Toke kutaye was also significantly ($P<0.05$) higher than that of Ejere district. The overall cropland allocated for teff and wheat production was the second and third largest in the study districts, respectively. However, land used for teff and wheat production in Ejere was significantly (P<0.05) higher than that of Bako-Tibe and Toke-kutaye districts. Land size allotted for wheat production at Toke-kutaye was also significantly (P<0.05) higher than that of Bako Tibe district. Land used for other crops (sorghum, chili pepper, *noug*) production was higher at Bako than Toke kutaye and Ejere districts. This cropland use pattern difference might be due to agro-ecology and/or difference in soil type.

Table 5. Cropland use pattern in study districts (Mean ± SD)

Crop land	Districts			Overall
	BakoTibe (n=129)	Toke kutaye (n=154)	Ejere (n=74)	(n=357)
Crop land size (ha)	$1.99{\pm}0.53^{a}$	$1.68{\pm}0.43^{b}$	$1.82{\pm}0.63^{b}$	1.83±0.53
Maize	$1.18{\pm}0.44^{a}$	$0.59{\pm}0.27^{b}$	$0.46{\pm}0.25^{c}$	0.78±0.46
Wheat	0.09 ± 0.19^{c}	$0.34{\pm}0.23^{b}$	$0.49{\pm}0.26^{a}$	0.28±.27
Teff	$0.28{\pm}0.26^{b}$	$0.33{\pm}0.19^{b}$	$0.45{\pm}0.24^{a}$	0.34±0.24
Barley	$0.041{\pm}0.12^{b}$	$0.26{\pm}0.21^{a}$	$0.27{\pm}0.25^{a}$	0.18±0.22
Others(*sorghum, pulse, oil crops)*	$0.36{\pm}0.28^{a}$	$0.16{\pm}.21^{b}$	$0.16{\pm}0.23^{b}$	0.23±0.26

[a, b, c] Mean values with different superscripts in a row indicate statistically significant differences among districts (p<0.05); SD= standard deviation

4.1.4. Livestock Holding and Herd Structure

Livestock possession per household in the study areas is summarized in Table 6. The interviewed farmers in the study areas, keep different livestock species including cattle, sheep, goats, equines (donkeys, horses and mules) and chicken. Cattle are the dominant livestock species reared in all the three districts. The overall average cattle herd size per household was 6.73 TLU. The overall possession of livestock species other than cattle per household was 0.19, 0.22, 0.57, 0.43 and 0.040 TLU for sheep, goats, horses, donkeys and chicken, respectively.

There was no significant difference (*P>0.05*) in livestock holding in the study districts except for sheep and goats population where, the average holdings of sheep per household in Ejere and Toke-Kutaye districts was higher (P<0.05) than that of Bako-Tibe district. On the contrary, the average holdings of goats in Bako-Tibe district was significantly (P<0.05) higher than Ejere and Toke-kutaye districts. Equines were mainly kept for transportation and packing purposes in all the study areas.

Table 6. Livestock herd size and cattle herd structure (Mean ±SE) per household in the study areas in TLU

Livestock species	Districts			
	Bako-Tibe	Toke-Kutaye	Ejere	Overall mean
Total Livestock (TLU)	**8.30±2.46**	**8.56±2.42**	**8.77±2.43**	**8.52±2.44**
Cattle	6.76±1.90	6.70±1.77	6.75 ±1.42	6.73±1.71
Sheep	0.10±0.11[b]	0.19±0.15[ab]	0.28±0.20[a]	0.19±0.17
Goats	0.28±0.2[a]	0.23±0.18[ab]	0.15±0.12[b]	0.22±0.18
Horses	0.36±0.48	0.60 ±0.57	0.76±0.61	0.57±0.57
Mules	0.32 ±0.35	0.35±0.36	0.35±0.36	0.34±0.35
Donkeys	0.40±0.38	0.45 ±0.32	0.43 ±0.37	0.43 ±0.35
Chickens	0.048±0.028	0.036±0.024	0.049±0.020	0.040±0.024
Cattle Herd Structure				
Cattle	**6.76±1.90**	**6.70±1.77**	**6.75 ±1.42**	**6.73±1.71**
Cows	2.42±1.1	2.41±0.94	2.47 ±0.81	2.42±0.92
Oxen	2.27±0.87	2.19±0.79	2.38±0.84	2.26±0.83
Heifers	0.80±0.39	0.79±0.35	0.72±0.38	0.78±0.37
Young bulls	0.87±0.59	0.92±0.66	0.84±0.58	0.88±0.62
Calves	0.41±0.24	0.37±0.18	0.35±0.18	0.39±0.21

[a, b, c] Mean values with different superscripts in a row indicate statistically significant differences among districts (p<0.05); SD= standard deviation , TLU= Tropical livestock unit

4.1.5. Available Feed Resources, Storage Practices and Feeding Systems

As shown in Table 7, different feed resources were available in the study areas with different levels of contribution. About 5 major feed resources were reported to be available in the areas , of which natural pasture and crop residues were the most commonly used by all the surveyed farmers across the districts. The availability of grazing pastures largely relies on rainfall distribution and it is relatively adequate from the onset to the end of the main rainy season (June to October). The sampled respondents reported that when the private grazing lands get exhausted, aftermath grazing, road side and marginal land grazing were used as optional feed sources. In terms of utilization crop residue is the second feed resource next natural pasture. About 99.3% of the respondents used crop residues. In the dry period (in most cases from January to June), crop residues like maize stover, wheat straw, and *tef* straw were the main feed resources supplied either before letting the animals to graze or when animals came back to home during the evening.

Figure 3. Maize stover conserved as livestock feed in Bako Tibe district

Hay making was practiced by about 23% of the respondents in Ejere district, however, hay making was less common in Bako-Tibe(11.6%) and Toke Kutaye (7.8%). On the other hand, silage making was almost uncommon across all the districts. On the contrary, high proportion of respondents (29%) in Toke-kutaye district fed non-conventional feeds (local brewery residues, vegetable refusals) as supplement to their animals because of high production of vegetable refusals as the area has access to irrigation for vegetable production.

The overall cultivated forage production was limited (4.8%) in the study areas. However, relatively high proportion (9.5%) of sample respondents reported to produce improved/cultivated forages in Ejere district though the utilization and management practices were poor. The common improved/cultivated forages grown in the study areas include Oats, Vetch, Alfalfa, Rhodes grass, Elephant grass, Desho grass, and fodder trees such as Sesbania sesban and Tree Lucerne.

The use of commercial concentrates for feeding animals is also limited in the study areas due to limited access and high cost.

The feeding system in the study areas was almost free grazing (96.3%) except the type of supplementation provided when animals are at their home during the evening or before let them to their grazing land. About 67.2% of the sampled respondents reported that livestock were supplemented with conventional and non-conventional feed resources when they are available (local brewery residues with/without salt, vegetable refusal, salt alone, straws, etc). About 29% of sample respondents, however, use only crop residues as supplementation. Stall feeding (zero grazing) was practiced by limited number of farmers (3.64%).

Obviously, proper conservation/storage of livestock feed resources is very critical to minimize feed scarcity during dry season of the year. However, in the present study the storage system was more or less similar in all the study areas.

Out of the sample respondents who conserved/ stored feed resources (hay, crop residues, etc) for latter use, about 81% of respondents reported that these feeds stored in an open air and loose form (Table7), with direct exposure to sunlight and rainfall that could cause quality deterioration (Figure 3). But few respondents (19%) conserved/stored the feed resources under shade.

Table 7. Available feed resources, feeding system and feed storage practices in the study area

Feed resources	Proportion of respondents (%)			Overall
	Bako Tibe (n= 129)	Toke Kutaye (n=154)	Ejere (n=74)	(n=357)
Grazing(natural pasture and crop stubbles)	129(100)*	154(100)	74(100)	357(100)
Crop residues	129(100)	152(98.7)	73(98.7)	355(99.2)
Hay	15(11.6)	12(7.8)	17(23)	44(12.3)
Silage	-	1(0.65)	1(1.35)	2(1.27)
Non-conventional feeds(*atela, vegetable refusals*)	33(25.6)	45(29.2)	18(24.3)	96(26.9)
Improved /Cultivated forage	4(3.1)	6(3.9)	7(9.5)	17(4.8)
Feeding system/practice				
Free grazing	126(98)	148 (96)	70(95)	344(96.33)
Stall feeding (zero grazing)	3(2)	6 (4)	4(5)	13(3.64)
Tethering	-	-	-	-
Forms of feed storage practices				
Do you conserve/store feeds for latter use?				
Yes	129(100)	154(100)	74(100)	357(100)
No	-	-	-	-
Forms of storage:				
loose form/ Stacked under shade	22(18)	35(23)	11(15)	68(19)
Loose form/Stacked outside	107(82)	119(77)	63(85)	289(81)

*Figures in the parenthesis are percentages

4.1.6. Maize Stover Availability, Conservation and Feeding Practice

The availability, collection/conservation practice and storage durations of maize stover in the study areas are presented in Table 8. The quantity of maize stover produced was estimated by multiplying the maize grain yield with the conversion factor of 2 (FAO, 1987). The overall average maize stover production was about 6 tons per household. However, maize stover production in Bako-Tibe was significantly ($P<0.05$) higher than

Toke-Kutaye and Ejere districts. Similarly, maize stover production in Toke-Kutaye was also significantly ($P<0.05$) higher than that of Ejere district. This indicates that maize production may vary in terms of agro-ecology, soil, moisture, etc. Only about 40% of the sample households in the study areas reported to collect and conserve maize stover for livestock feeding. However, more proportion (50.7%) of sample respondents in Toke Kutaye district reported to practice conservation of maize stover for later feeding. Less number of respondents (28.7%) had been reported in Bako-Tibe district; this might be due lack of awareness and/or availability of alternative feeds.

The utilization of maize stover, started soon after collection (38.5%), one month after collection (40.6%), and two months after collection (21%) (Table 8). The proportion of respondents who reported to feed their animals soon after collection was relatively less than respondents who started feeding just after one month. This might be due to access to stubble grazing soon after crop harvesting. In the study areas, the maize stover was also used as source of fuel, construction material for granary and fencing to their compound.

Table 8. Availability, conservation and feeding practice of maize stover in the study areas (% of respondents, Mean ± SD)

Variables	Districts			Overall (n=357)
	BakoTibe (n=129)	Toke kutaye(n=154)	Ejere (n=74)	
Maize stover produced (tons)	9.29 ± 3.5^{a}	4.64 ± 2.16^{b}	3.65 ± 2.0^{c}	6.12 ± 3.6
Do you Conserve maize stover?	n (%)	n (%)	n (%)	n (%)
Yes	37(28.7)	78(50.7)	28(37.8)	143(40.1)
No	92(71.3)	76(49.4)	46(62.2)	214(59.9)
Time of feeding the conserved stover				
Soon after collection	14(37.8)	29(37.2)	12(42.9)	55(38.5)
One month after	18(48.7)	32(41.0)	8(28.6)	58(40.6)
Two months after	5(13.5)	17(21.8)	8(28.6)	30(21.0)

$^{a, b, c}$ Mean values with different superscripts in a row indicate statistically significant differences among districts ($p<0.05$); SD= standard deviation , Figures in the parenthesis are percentages

4.1.7. ***Conservation and utilization practices of green maize stover***

Utilization practices of green maize stover in the study areas are presented in Table 9. All sample respondents revealed that they use green maize for home consumption and/or selling to earn money. However, majority of the respondents (63.3%) leave the green maize stover on the field to dry. Various reasons were given for not utilizing this cheap feed resource and depicted below (Table 10). From those respondents who didn't utilizing green maize stover, about (60.2%) of them believed that the stover left on the field may restore nutrients to the soil while animals are allowed to graze on the stubble and crop residue right on the field (Fig. 4). About 30.1% of respondents reported that availability of other green forages at the time green cob harvesting, didn't give them sense to use it as livestock feed. The rest of respondents (9.7%) had no any justifiable reason for not utilizing this resource.

About 36.7% of the respondents reported that the fresh green maize stover was supplied to oxen and cows immediately after the ear has been removed. However, as in most other parts of the country, preservation of green maize stover in the form of silage was uncommon in study areas. The major reason for not conserving green maize stover as silage was lack of awareness by most of the respondents (74%). Few respondents (10%) had the awareness of the technology; however, lack of money was an important hindering factor for them. The rest of the respondents (16%) had no both awareness and capital to prepare silage (Table 9).

Table 9. Conservation and utilization practices of green maize stover in the study areas

Questions	Districts Bako Tibe (n= 129)	Toke Kutaye (n=154)	Ejere (n=74)	Overall (n=357)
Do you use green maize for consumption/selling?				
Yes	129(100)	154(100)	74(100)	357(100)
No	-	-	-	-
Fate of green maize stover				
Given to animals immediately	35 (27.1)	72 (46.8)	24 (32.4)	131(36.7)
Preserved in the form of silage	-	-	-	-
Left on the field to dry	94(72.9)	82(53.2)	50(67.6)	226(63.3)
Why is silage making uncommon?				
Lack of awareness	104(80.6)	108(70.1)	52(70.3)	264(74.0)
Lack of capital to buy necessary tools	11(8.5)	17(11.0)	8(10.8)	36(10.1)
Both lack of awareness and capital	14(10.9)	29(18.8)	14(18.9)	57(16.0)

Figures in the brackets indicate the percentages (proportion) of respondents, n= number of respondents

Table 10. Reasons for not using green maize stover as livestock feed

Reasons	Districts Bako Tibe (n= 94)	Toke Kutaye (n=82)	Ejere (n=50)	Overall (n=226)
Availability of alternative feeds	33(35.1)	21(25.6)	14(28.0)	68(30.1)
To restore nutrients to the soil	52(55.3)	56(68.3)	28(56.0)	136(60.2)
No reason	9(9.6)	5(6.0)	8(16.0)	22(9.7)

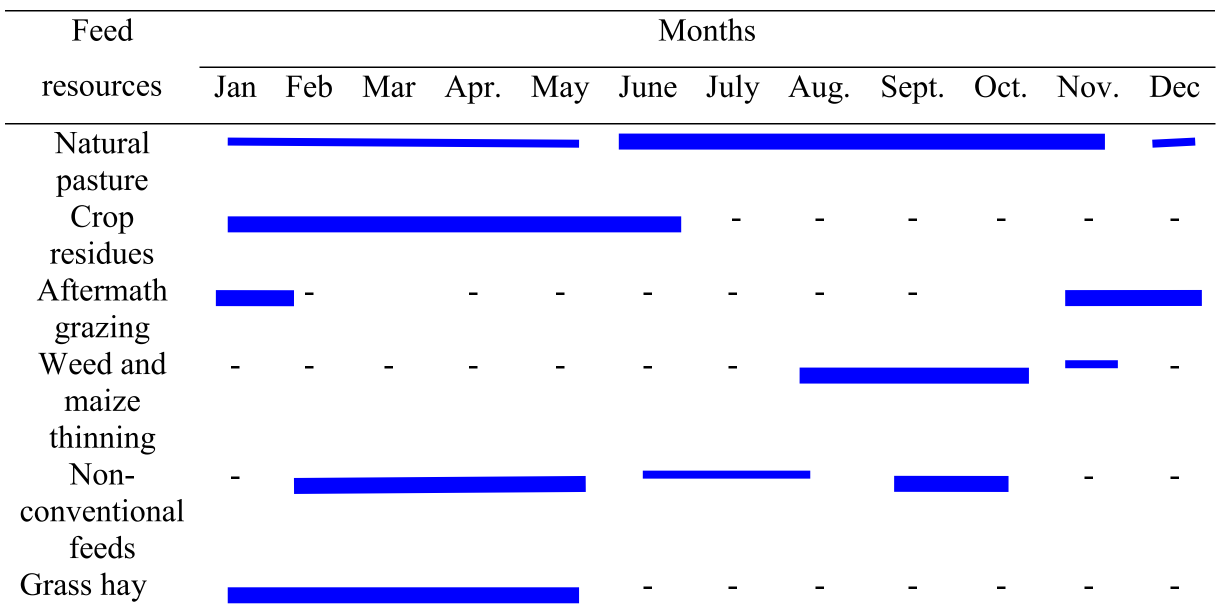
Figures in the brackets indicate the percentages (proportion) of respondents, n= number of respondents

Figure 4. Maize stover left on the field

4.1.8. Seasonal Availability of Feed Resources

Alike most parts of Ethiopia, natural pasture and crop residues were the main feed resources in the study districts. Major feed resources available across the different periods of the year are shown in Table 11. Grazing/browsing, crop residues, stubble grazing, harvested hay, and to limited extent improved forages and vegetable refusals constitute the major livestock feeds. Availability of the different feed resources varies with seasons. Animals depend on natural pasture for most part of the year starting from the onset of main rain season (June) to November, however, as the dry season extends its availability declines progressively. Weeds, maize thinning and stripping, green maize stalk after the green cob has been harvested were also used as livestock feeds from August to October. Stubble grazing was also the major feed resource during dry season of the year immediately following harvesting of major crops (November to February). In the dry period (in most cases from January to June) the sample respondents reported that stack of crop residues like maize stover, wheat straw, *tef* straw, barley straw and pulse straws along with the limited grazing/browsing form the major feeds. Of the non-conventional feeds, vegetables refusal were also an important feed resource in the study areas mainly at Toke kutaye districts. Local brewery by-products (*atella* and *areqi* liquor residues) were also important feed resources that could bridge the feed crisis encountered during the dry season of the year. Even though their availability is intermittent, it is relatively higher from January to May when there is crop harvesting and threshing, and during wedding ceremony and holidays. Hay is also another most important feed resource that could help to mitigate feed scarcity. However, according to this survey results, hay production and utilization in the study areas was limited. Only few respondents produce and conserve hay for the dry period feeding when feed shortage became serious (January to May).

Table 11. Feed resources availability across the different months of the year in the study areas



= Period of abundant availability, =Period of limited availability, - = Period of unavailability

4.1.9. Estimation of Feed Balance

Of the major livestock feed resources, crop residues, natural pasture and crop stubbles played great role in contributing dry matter production in the study areas. High proportion (80%) of dry matter was obtained from crop residues in the study areas. Among crop residues, maize stover represented the largest share of dry matter production. The average livestock population and feed available in the study areas has been estimated to be 119,127 tropical livestock units (TLU) and 162,452.4 tons, respectively. The feed resource available was calculated and estimated to be 1.36 tons per TLU/year. This is equivalent to 3.73 kg DM per day/TLU. The average protein and metablizable energy supply could be about 235 g and 30.0MJ per day, respectively. However, from the study areas, the feed deficit in Toke kutaye was more severe than Bako-Tibe and Ejere districts (Table, 12).

Table 12. Estimated quantities of available feed resources and feed balance in the study areas

Feeds	Annual DM production (ton)			Average
	Bako Tibe	Toke Kutaye	Ejere	
Crop residues	195,704.17	120,665.74	119,699.23	145, 356.38
10% wastage	19,570.42	12, 066.57	11,969.92	14535.64
Net utilizable residue	**176,133. 75**	**108, 599.2**	**107,729.3**	**130820.74**
Grazing and browsing	16692	16034	13582	15436.00
Aftermath grazing/crop stubbles	14050	13859	13151	13,686.67
Forest	2429	1992.2	3105.2	2508.80
Total feed	209,304.75	140,484.4	137, 567.5	162452.2
Total livestock(TLU)	107,770.2	154519.4	95,090.3	119126.63
Feed/TLU	1.94	0.91	1.44	1.36

Data source: District agriculture offices

4.1.10. Livestock Water Sources and Watering Frequency in the Study Areas

As most of the respondents reported shortage of water is one of the critical problems in the study areas during the dry season. Rivers (75%) and spring water (17.65%) were the major water sources for livestock during dry season (Table 13). However, the contribution of rivers was reduced to 32% during the wet season. Unlike the dry season, the contribution of other water sources during wet season has been increased. For instance, the proportion of respondents who watered spring water, rain and pond water was 20.17%, 27.17% and 13%, respectively.

The livestock watering frequency varies with season and type of feed supplied. The current survey results revealed that about 43.7% of the respondents water their animals once per day during dry season of the year. However, relatively less number of respondents (38.66%) watered their animals once per day in wet season (Table 14). The proportion of respondents (39.22%) who watered animals two times per day during the dry season was high in relation to respondents (18.21%) who were watering in wet season. However, the overall proportion of sample respondents who watered their animals once in two days during wet season was high (30.81%) as compared to dry season (2.52%). This could be associated to the moist feed eaten by the animals during wet season as there is rain and thereby, refuse to drink.

Table 13. Water sources for livestock in the study area

Seasons	Water source	% of respondents Bako-Tibe (n=129)	Toke- Kutaye (n=154)	Ejere (n=74)	Overall (n=357)
Dry	Pond	-	-	-	-
	River	101(78.3)	115(74.7)	52(70.3)	268(75.1)
	Spring water	23(17.8)	28(18.2)	12(16.2)	63(17.7)
	Pipe water	2(1.6)	3(2.0)	7(9.5)	12(3.4)
	Well water	3(2.3)	8(5.2)	3(4.1)	14(3.9)
	Rain	-	-	-	-
Wet	Pond	15(11.6)	22(14.3)	9(12.2)	46(12.9)
	River	45(34.9)	57(37.0)	15(20.3)	117(32.8)
	Spring water	27(20.9)	27(17.5)	17(23.0)	72(20.2)
	Pipe water	2(1.6)	5(3.3)	3(4.1)	9(2.5)
	Well water	6(4.7)	6(3.9)	4(5.4)	16(4.5)
	Rain	34(26.4)	37(24.0)	26(35.1)	97(27.2)

Figures in the brackets indicate the percentages (proportion) of respondents, n= number of respondents

Table 14. Livestock watering frequency in the study area

Seasons	Watering frequency	% of responses Bako-Tibe (n=129)	Toke-Kutaye (n=154)	Ejere (n=74)	Overall (n=357)
Dry					
	Three times per day	17(13.2)	23(14.9)	12(16.2)	52(14.6)
	Two times per day	54(41.9)	57(37.0)	29(39.2)	140(39.2)
	Once per day	55(42.6)	69(44.8)	32(43.2)	156(43.7)
	Once in 2 days	3(2.3)	5(3.3)	1(1.4)	9(2.5)
Wet					
	Three times per day	17(13.2)	21(13.6)	6(8.1)	44(12.3)
	Two times per day	27(20.9)	27(17.5)	11(14.9)	65(18.2)
	Once per day	46(35.7)	59(38.3)	33(44.6)	138(38.7)
	Once in 2 days	39(30.2)	47(30.5)	24(32.4)	110(30.8)

Figures in the brackets indicate the percentages (proportion) of respondents, n= number of respondents

4.1.11. Constraints of Livestock Production in the Study Areas

The major constraints of livestock production in the study areas are presented in Table 15. According to the sampled farmers in the survey study, feed shortage was the critical problem of livestock production in the study districts. About 52.7, 51.3, and 32.43 % of the sample respondents in Bako-Tibe, Toke-Kutaye and Ejere districts, respectively, reported that feed shortage was a severe problem mainly during the dry season. The overall index of feed shortage (0.26) realized this fact. Livestock disease (ticks) was the second problem reported in all the study areas. Water shortage and low performance of indigenous animals for were reported to be the third and fourth constraints. Generally, feed shortage, animal diseases, water scarcity during the dry season, poor genetic potential of local breeds, and market problems were identified to be the major challenges of livestock production and productivity in the study areas. Therefore, prioritizing and designing strategies to mitigate livestock production constraints should be a fundamental concern to stakeholders. Production of sufficient and quality feed resources that could meet the nutrient regiment of a given animal needs pay attention. Proper storage and efficient utilization of crop residues, improved forage production, efficient utilization of non-conventional feeds, conservation of excessive forages either in the form of hay or silage, and supplementation of protein and energy rich feeds should be considered as an option to alleviate feed shortage problems. Animal diseases were reported as the 2nd constraint prioritized by respondents in the study areas; of the diseases, ecto - parasite (tick) infestation was reported as major challenge. Though the extent varies in the study areas; water scarcity, poor genetic potential and market were also identified as major challenges following feed shortage and animal diseases.

Table 15. Major problems constraining livestock production in the study districts

Major constraints	Priority levels					Index	Rank
	1	2	3	4	5		
Bako Tibe (n=129)							
Feed shortage	68(52.7)	22(17.1)	17(13.2)	14(10.9)	8(6.2)	0.27	1
Livestock diseases	35(27.1)	56(43.4)	33(25.6)	4(3.1)	1(0.78)	0.26	2
Water scarcity in dry season	13(10)	30(23.3)	40(31)	11(8.5)	35(27.1)	0.19	3
Low performance of indigenous animals	8(6.2)	12(18.6)	29(22.5)	50(38.8)	30(23.3)	0.16	4
Market problem	5(3.9)	9(7.0)	10(7.8)	50(38.8)	55(42.6)	0.13	5
Toke Kutaye(n=154)							
Feed shortage	79(51.30)	34(22.0)	23(14.9)	18(11.7)	0	0.28	1
Livestock diseases	26(16.9)	23(14.9)	49(31.8)	37(24.0)	19(12.3)	0.20	2
Water scarcity in dry season	19(12.3)	32(20.8)	25(16.2)	42(27.3)	36(23.4)	0.18	4
Low performance of indigenous animals	18(11.7)	45(29.2)	26(16.9)	23(14.9)	42(27.3)	0.19	3
Market problem	12(7.8)	20(13.0)	31(20.1)	34(22.1)	57(37.0)	0.16	5

Table 15 *continued*

Constraints	Priority levels					Index	Rank
	1	2	3	4	5		
F`Ejere (n=74)							
Feed shortage	24 (32.4)	17(23.0)	14(18.9)	12(16.2)	7(9.5)	0.23	1
Livestock diseases	15(20.3)	26(35.1)	14(18.9)	19(25.7)	-	0.23	2
Water scarcity in dry season	9(12.2)	15(20.3)	29(39.2)	13(17.6)	8(10.8)	0.20	4
Low performance of indigenous animals	17(23.0)	10(13.5)	10(13.5)	13(14.9)	24(32.4)	0.20	3
Market problem	9(12.2)	6(8.1)	7(9.5)	17(21.6)	35(47.3)	0.14	5
Overall (n=357)							
Feed shortage	171(47.9)	73(20.5)	54(15.1)	44(12.3)	15(4.2)	0.26	1
Livestock diseases	76(21.3)	105(29.4)	96(26.9)	60(16.8)	20(5.6)	0.23	2
Water scarcity in dry season	41(11.5)	77(21.6)	94(26.3)	66(18.5)	79(22.1)	0.19	3
Low performance of indigenous animals	43(12)	67(18.8)	65(18.2)	86(24.1)	96(26.9)	0.18	4
Market problem	26(7.28)	35(9.8)	48(13.5)	101(28.3)	147(41.2)	0.14	5

Numbers in the brackets indicate the proportion of participants, n= total number of participants

4.2. Green Maize Stover Silage Experiment

4.2.1. Physical Characteristics of Silage

The colour, smell/aroma, texture and mold coverage of green maize stover ensiled with additives for different periods is presented in Table 16. There was no significant (P>0.05) differences among the treatments in terms of the observed colour in green maize stover ensiled for four weeks. Similarly, GMS silages that were ensiled for six weeks showed no significant (P>0.05) difference among treatments for the same parameter. However, at week eight ensiling period, silage treated with molasses and FJLB showed significant (P<0.05) variation as compared to the control for the same fermentation period.

In this experiment, the colour score values showed decreasing trend in all treatments as the ensiling period progressed. GMS silage which was ensiled for eight weeks without additive showed less values (P<0.05) in terms of smell compared to GMS silage treated with additives and ensiled for the same period.

Similarly, GMS silage ensiled with additives had firm texture than control. Texture of GMS silages ensiled for four weeks with additives were better (P<0.05) than the control for the same fermentation period. Moreover, the sensory evaluation scores indicated that the quality of silage in terms of texture decreased as the fermentation period prolonged in the control group.

Moldiness also showed similar trend to texture. As ensiling period progressed, the extent of mold coverage had increased in the control group. Mold coverage of GMS silage in the control group was significantly higher (P<0.05) than silage treated with additives at eight weeks fermentation period. This might be due to low concentration of lactic acid in the control.

Table 16. Physical properties of green maize stover treated with additives and ensiled for different periods (4, 6 and 8 weeks)

Additive-ensiling period interaction	Parameters			
	Colour	Smell	Texture	Mold cover
C-4wks	3.8^{ab}	3.4^{ab}	3.2^{b}	3.8^{ab}
C -6wks	3.2^{bcd}	3.4^{ab}	3.2^{b}	3.4^{ab}
C-8wks	2.6^{d}	2.8^{b}	2.6^{c}	2.6^{c}
EM- 4 wks	4.0^{a}	4.0^{a}	4.0^{a}	4.0^{a}
EM-6 wks	3.6^{abc}	3.8^{a}	3.8^{ab}	3.8^{ab}
EM-8 wks	3.0^{cd}	3.6^{a}	3.4^{ab}	3.2^{b}
FJLB-4wks	4.0^{a}	4.0^{a}	4.0^{a}	4.0^{a}
FJLB-6 wks	3.8^{ab}	3.6^{a}	3.8^{ab}	3.8^{ab}
FJLB-8wks	3.5^{abc}	3.5^{a}	3.8^{ab}	3.3^{ab}
Mol-4wk	4.0^{a}	4.0^{a}	4.0^{a}	4.0^{a}
Mol-6wks	3.6^{abc}	3.8^{a}	3.8^{ab}	3.8^{ab}
Mol-8wks	3.5^{abc}	3.5^{a}	3.5^{ab}	3.8^{ab}
SEM	0.25	0.20	0.17	0.22

$^{a-d}$ Means with different superscripts within the same column are significantly different(P<0.05), C= control, EM= Effective Micro-organism, FJLB= Fermentative Juice of Lactic acid Bacteria, Mol= Molasses, Wks= weeks

4.2.2. Silage pH, temperature and dry matter loss

Table 17 shows the changes in pH, temperature and dry matter loss of green maize stover silage as affected by additives and fermentation periods. Relatively, higher pH ($P<0.05$) value was recorded in the control group than other treatments. The pH values, however, did not differ significantly ($P>0.05$) across the fermentation periods. The pH values were not significantly ($P>0.05$) different among GMS silages treated with respective additives at all similar ensiling periods. Generally, a decreasing trend in pH values was observed in GMS silage treated with additives as fermentation periods prolonged to week six.

The relative high pH values of GMS silage in the control group (silage without additive) may be attributed to low concentration of fermentable carbohydrates. The pH value of silage in the control group was within an acceptable range for quality silage; this probably indicates that the GMS had the threshold soluble carbohydrate content that could trigger lactic acid production.

The temperature of the silage measured upon opening the silo/plastic bags, was ranged from 16.62 to 19.52°C (Table 17). The silage temperature of all the treatments was closer to the ambient temperature recorded. The slight increased temperature observed in silage treated with additive might be due the availability of water soluble carbohydrate that could serve as a substrate for multiplication of lactic acid bacteria and consequently, resulted high lactic acid production and slightly increased temperature. However, as a rule of thumb if the temperature level of the silage is much higher than the ambient temperature, it could be typical sign for aerobic respiration/ spoilage due to air entrance.

The DM recovery was higher for the silage treated with additives than the control (Table 17). A significant (7.55%) dry matter loss ($P<0.05$) was observed in the control group at the fermentation period of eight weeks as compared to the green maize stover silage treated with additives for the same and different ensiling durations. The DM loss of silage that was treated with EM and ensiled for eight weeks period was higher ($P<0.05$) than the DM loss of all silages ensiled for four weeks and additive treated silages at week six fermentation periods. However, there was no significant (P>0.05) difference in all treatments at 4 weeks fermentation period. In general, less DM loss/more DM recovery could be achieved through proper silage making practices. The relatively better dry matter recovery observed in additive treated silages could be attributed to the addition of water soluble carbohydrates and fermentation starter juice, which could have enhanced the fermentation process.

Table 17. pH, temperature and dry matter loss of green maize stover silage treated with additives and ensiled for different periods

Additives-ensiling period interaction	Parameters		
	pH	T(C ^{o})	TDML (%)
C-4wks	4.45^{a}	17.60^{ef}	4.80^{c}
C -6wks	4.53^{a}	16.62^{g}	5.26^{bc}
C-8wks	4.50^{a}	18.82^{bcd}	7.55^{a}
EM- 4 wks	4.01^{bc}	18.32^{cd}	4.58^{c}
EM-6 wks	3.96^{c}	17.44^{f}	4.95^{c}
EM-8 wks	4.08^{b}	19.20^{ab}	6.40^{b}
FJLB-4wks	4.04^{bc}	18.52^{cd}	3.40^{c}
FJLB-6 wks	4.01^{bc}	17.60^{ef}	4.70^{c}
FJLB-8wks	4.10^{b}	19.52^{a}	5.68^{bc}
Mol-4wk	4.04^{bc}	18.40^{cd}	4.40^{c}
Mol-6wks	4.02^{bc}	18.20^{de}	5.16^{c}
Mol-8wks	4.10^{b}	18.90^{abc}	5.53^{bc}
SEM	0.007	0.23	0.76

a-g Means with different superscripts within the same column are significantly different (P<0.05); TDML = Total Dry Matter loss ;T =Temperature C= control, EM= Effective Micro-organism, FJLB= Fermentative Juice of Lactic acid Bacteria, Mol= Molasses, Wks= weeks C^{o}= degree Celsius

4.2.3. Chemical compositions and in vitro digestibility of silage and fresh stover

The chemical compositions and *in vitro* organic matter digestibility of silages and fresh green maize stover are presented in Table 18.

The DM percentage didn't show significant differences among treatments for ensiling periods of week four and six. However, DM content of the control group ensiled for eight weeks period was less (P<0.05) than silage treated with molasses and ensiled for similar fermentation period. In general terms, the figures in the table indicate that the silage which was treated with molasses had relatively better DM percentage than other treatments. The crude protein content of the silage ranged from 4.85 to 5.9%. The CP content of GMS silages was improved due to use of additives; thereby CP content was increased by (3.53 to 15.7%) in the silage as compared to the fresh maize stover. The CP content of green maize stover silage treated with additives showed significant ($P<0.05$) difference from the control during all fermentation periods. Green maize stover silage treated with EM and ensiled for four weeks had lower ($P<0.05$) CP content than silage treated with molasses and FJLB and ensiled for six weeks. However, this silage, had higher ($P<0.05$) CP content than the control at all fermentation periods. The CP contents in the silage could be affected by the type additive used and length of fermentation period. The possible reason for an increased CP content of silage treated with additive could be due to the higher multiplication of lactic acid bacteria and efficient fermentation process and thereby, the natural bacteria which were present in the medium would be part of the silage material.

From the cell wall components, NDF was significantly lower ($P<0.05$) in silage treated with molasses and ensiled for six weeks than the control and FJLB treated silage across all fermentation periods. The GMS silage treated with molasses and ensiled for six weeks showed lower ($P<0.05$) ADF content than the control and EM treated silage at the fermentation period of four and eight weeks, respectively. However, no significant variation was observed within each treatment across the various fermentation periods.

The GMS silage treated with additives and incubated for six weeks had lower ($P<0.05$) ADL content than that of the control ensiled for four weeks. However, there was no significant variation across the fermentation periods within each additive treated silage and the control group.

The IVOMD (*in vitro* organic matter digestibility) and ME (MJ/kg) content was higher ($P<0.05$) in GMS silage treated with molasses and incubated for six to eight weeks than the control during similar fermentation periods.

The ash content didn't show significant (P>0.05) variation among treatments. But the numerical difference observed among treatments in table (18) might be due the type additive used.

Table 18. The chemical composition (%DM) and in vitro Organic matter digestibility of the ensiled green maize stover

Additive-period interaction	Parameters							
	DM	Ash	CP	NDF	ADF	ADL	IVOMD	ME (MJ/kg)
C-4wks	35.48^{bc}	7.50	4.85^{c}	70.66^{a}	43.31^{a}	9.19^{a}	45.64^{abc}	7.30^{abc}
C -6wks	36.01^{abc}	7.93	4.79^{c}	68.66^{ab}	40.93^{ab}	8.01^{ab}	42.26^{bc}	6.76^{bc}
C-8wks	34.85^{c}	7.69	4.79^{c}	67.39^{b}	42.31^{ab}	7.97^{ab}	41.99^{c}	6.72^{c}
EM- 4 wks	35.84^{abc}	8.21	5.28^{b}	67.41^{b}	40.41^{ab}	8.40^{ab}	52.87^{ab}	8.46^{ab}
EM-6 wks	36.21^{abc}	8.01	5.83^{a}	66.55^{bcd}	41.24^{ab}	7.83^{b}	50.03^{abc}	8.00^{abc}
EM-8 wks	36.81^{abc}	7.58	5.65^{ab}	67.17^{bc}	43.10^{a}	7.95^{ab}	46.93^{abc}	7.51^{abc}
FJLB-4wks	35.46^{bc}	7.73	5.60^{ab}	68.60^{ab}	41.36^{ab}	7.89^{b}	46.96^{abc}	7.51^{abc}
FJLB-6wks	36.01^{abc}	8.37	5.85^{a}	68.20^{ab}	42.36^{ab}	7.91^{b}	47.83^{abc}	7.66^{abc}
FJLB-8wks	36.69^{abc}	8.52	5.63^{ab}	67.11^{bc}	40.82^{ab}	7.87^{b}	45.13^{abc}	7.22^{abc}
Mol-4wk	36.97^{ab}	8.36	5.56^{ab}	64.59^{cd}	41.22^{ab}	8.05^{ab}	49.60^{abc}	7.94^{abc}
Mol-6wks	37.44^{a}	8.59	5.90^{a}	64.33^{d}	39.24^{b}	7.70^{b}	54.47^{a}	8.72^{a}
Mol-8wks	37.11^{ab}	8.19	5.68^{ab}	66.60^{bcd}	40.21^{ab}	7.65^{b}	53.77^{a}	8.60^{a}
SEM	0.77	0.37	0.035	3.84	2.66	0.34	24.65	0.63
P-Value	0.004	0.069	0.0001	0.0001	0.008	0.0162	0.0012	0.0012
Fresh green maize stover	35	7.12	5.1	65.28	41.9	9.79	45.98	7.36

$^{a\text{-}d}$ Means with different superscripts within the same column are significantly different (P<0.05); DM = Dry Matter; ME (MJ/kg) = Metabolizale Energy; ADF= Acid detergent fiber; ADL= Acid detergent lignin; CP= Crude protein; IVOMD= *in vitro* OM digestibility; NDF= Neutral detergent fiber; OM=Organic matter; SEM= standard error of the mean, EM=effective microorganism, FJLB=Fermentative Juice of Lactic acid Bacteria, Wks= weeks

4.3. Feeding Trial Using Green Maize Stover Silage

4.3.1. Chemical Composition of Experimental feed ingredients

The chemical composition of different feed ingredients used in the experiment is presented in Table 19. The average crude protein content of the silage, *noug* seed cake, wheat bran and the concentrate mix feed samples was 5.7, 33.1, 16.5 and 20.8 %, respectively. The crude protein content of the treatment feeds increased progressively from 10.3-12.9 percent with an increase in the concentrate mix ratio. Similarly, the metabolisable energy (ME MJ/kg DM) was also increased from 9.83 MJ/kg DM to 10.14 MJ/kg DM as the proportion of concentrate mix was increased from 30% to 50%, respectively. Except the green maize stover alone and TMR (70%: 30%) samples, other feeds analyzed contained less than 60% NDF. High (>60%) NDF content affects the voluntary feed intake of an animal as it needs more rumination time. Feeds which contained less than 40% ADF considered as high quality feeds. The feed analysis result had showed less than 40% ADF in all ingredients. The ADL percentage in TMR diets decreased as the proportion of concentrate mix increased. The *in vitro*-Organic matter digestibility values were negatively correlated with NDF(r = -0.6), ADF(r = -0.9), ADL(r = -0.9) content. However, *in vitro*-Organic matter digestibility was positively correlated with HC (r =0.2)

Table 19. Chemical composition (%DM) and *in-vitro* digestibility of experimental feed ingredients

Feed samples	DM	OM	CP	NDF	ADF	ADL	HC	IVOMD	ME (MJ/kgDM)
GMS	37.7	93.18	5.7	64.02	38.11	8.95	29.9	59.5	9.52
Noug seed cake (NSC)	91.0	91.20	33.1	40.95	31.64	8.79	9.31	63.05	10.09
Wheat bran (WB)	88.8	94.91	16.5	48.03	14.88	4.43	33.15	70.75	11.32
Concentrate mix	90.3	94.22	20.8	42.83	14.32	5.05	28.51	67.18	10.74
TMR(70%: 30%)	54.2	92.06	10.3	60.46	29.44	8.98	31.02	61.44	9.83
TMR (60%: 40%)	58.6	92.66	11.6	57.76	28.9	7.88	28.86	62.50	10.0
TMR (50%: 50%)	63.9	92.92	12.9	55.39	26.65	6.99	28.74	63.40	10.14

GMS= Green maize stover, S= salt, TMR= total mixed ration, TMR (70%: 30%) = GMS70%: Concentrate mix 30%, TMR (60%: 40%) = GMS 60%: Concentrate mix 40%, TMR (50%: 50%) =GMS 50%: Concentrate mix 50%, HC=Hemi-cellulose, concentrate mix = (WB 69%+NSC 30%+S 1%)

4.3.2. Daily Feed and Nutrient Intake

The values for voluntary feed and nutrient intakes of the experimental cows are presented in Table 20. The total daily DM intake was increased from treatment one to treatment four i.e. the amount of total intake was in the order of T4 > T3 > T2 > T1. Except T1 (34%), feed intake progressed as the level of concentrate increased from 30 to50%. The less total feed intake in T1 might be associated with the mode of feeding. The total daily dry matter, OM, CP and ME (MJ/kg) intakes of T4 was (p<0.05) higher than T2 and T1. Similarly, daily total dry matter, OM and CP intakes of (T3) was significantly (p<0.05) higher than T1. The CP intake ranges from 10.39 to 13.16%. The lower CP intake was for T2 and the higher was for T4, respectively. The NDF, ADF and ADL intake of cows receiving TMR diets didn't differ significantly, but the fiber (NDF, ADF) intake was (p<0.05) lower in the conventional feeding method (silage and concentrate separately). The metabolizable energy intake per day ranged from 96.7 to 127.13 MJ; T1 was the lowest while T4 was the highest. The variation in daily feed and nutrient intake might be attributed to feeding methods differences and level of concentrate inclusion in the TMR diets.

Table 20. Dry matter and nutrients intake of lactating Jersey dairy cows (Mean ±SE)

DM Intake (kg/day/cow)	T1	T2	T3	T4
Silage	6.75±0.07	-	-	-
Concentrate	3.45±0.04	-	-	-
Total DMI	10.20 ± 0.07^{c}	11.26 ± 0.24^{b}	12.07 ± 0.30^{ab}	$12.92\pm0.0.28^{a}$
OM	9.47 ± 0.21^{c}	10.43 ± 0.69^{bc}	11.23 ± 0.92^{ab}	12.03 ± 0.86^{a}
CP	1.17 ± 0.02^{c}	1.17 ± 0.10^{c}	1.43 ± 0.14^{b}	1.70 ± 0.72^{a}
NDF	6.18 ± 0.14^{b}	7.37 ± 0.40^{a}	7.67 ± 0.59^{a}	7.69 ± 0.58^{a}
ADF	3.56 ± 0.10^{b}	4.31 ± 0.25^{a}	4.35 ± 0.36^{a}	4.40 ± 0.46^{a}
ADL	0.94 ± 0.02^{a}	1.08 ± 0.08^{a}	1.05 ± 0.09^{a}	1.06 ± 0.09^{a}
ME (MJ/kg)	9.5 ± 0.13^{b}	9.25 ± 0.21^{c}	9.51 ± 0.15^{b}	9.84 ± 0.12^{a}

$^{a-d}$ Means with different superscripts within row are significantly different (P<0.05); T1=silage adlib and concentrate 0.5kg/lt of milk,T2=TMR (70%: 30%), T3=TMR (60%: 40%) T4= TMR (50%: 50%) =GMS 50%: Concentrate mix 50%

4.3.3. Apparent Dry Matter and Nutrient Digestibility

The apparent nutrient digestibility by lactating Jersey cows is presented in Table 21. The apparent digestibility of DM and other nutrients in T3 and T4 were significantly (P<0.05) higher than conventional feeding (control). The DM digestibility percentage of T1 was lower than T2, T3 and T4 by 5.39, 7.10 and 9.1 percent, respectively. Digestibility percentage of CP increased in the order of T1=T2<T3 <T4. The CP digestibility percentage of T3 and T4 were significantly higher than T2 and T1. In terms of NDF and ADF contents except the control group, there was no significant variation in apparent digestibility percentage among the TMR fed groups.

Table 21. Apparent digestibility in lactating Jersey cows fed on green maize stover silage based TMR or *adlibitum* green maize stover silage supplemented with concentrate mixture on the basis of milk yield (Mean ±SE)

Apparent digestibility (%)	T1	T2	T3	T4
DM	60.46±1.3^{c}	65.85±0.9^{b}	67.56±0.8^{ab}	69.52±0.9^{a}
OM	64.01±1.2^{c}	68.91±0.8^{b}	70.59±0.8^{ab}	72.37±0.8^{a}
CP	70.17±1.0^{c}	70.73±1.2^{c}	76. 02±0.8^{b}	79.94±0.7^{a}
NDF	55.56 ± 1.4^{b}	65.55±0.8^{a}	66.12±0.9^{a}	66.84±1.1^{a}
ADF	47.65±2.0^{b}	59.35±1.0^{a}	58.91±1.2^{a}	57.37±1.7^{a}

$^{a-c}$ Means with different superscripts within a row are significantly different (P<0.05) of mean; DM = Dry matter; CP = Crude protein; NDF= neutral detergent fiber; ADF acid detergent fiber; ME = Metabolizable energy; OM = organic matter

4.3.4. Milk yield and composition

The effect of dietary treatments on mean daily milk yield and compositions are presented in Table 22. The milk yield of cows fed on TMR with concentrate inclusion rate of 40 and 50 % was significantly (P < 0.05) higher than those fed with 30% concentrate inclusion and conventional feeding system. The experimental cows fed TMR diet with 40 and 50 percent concentrate inclusion produced extra daily milk of 1.20 and 1.39kg, and 1.56 and 1.75kg, over those cows which were maintained on TMR diet containing 30% concentrate and on the diet of conventional feeding system, respectively. The extra daily milk produced by cows under TMR with 50% concentrate may be due to the relatively larger daily DM intake and hence protein and energy intake per head.

The milk yield of cows fed on TMR (GMSS70:30%) was higher by 0.19kg (2.4%) from T1, but didn't differ significantly.

The average milk composition was 5.05, 4.77, 5.0, and 4.9 % for fat; 8.40, 8.56, 8.43 and 8.45% for total solids not fat (SNF) and 3.08, 3.14, 3.09, and 3.15 percent of protein in T1, T2, T3 and T4, respectively. However, feeding of dairy cows either by conventional feeding system or TMR graded with 30-50% concentrate didn't have significant effect on milk composition.

Table 22. Milk yield and composition of lactating Jersey cows fed on green maize stover silage based TMR or adlibitum green maize stover silage supplemented with concentrate mixture on the basis of milk yield (Mean ±SE)

Parameter	T1	T2	T3	T4
Milk yield (kg/day)	7.90±0.20^{b}	8.09±0.15^{b}	9.29±0.46^{a}	9.65±0.41^{a}
4% FCM	9.2±0.42^{b}	9.07±0.21^{b}	10.88±0.55^{a}	10.97±0.57^{a}
Milk composition (%)				
Fat	5.05±0.23^{a}	4.77±0.18^{a}	5.0±0.31^{a}	4.9±0.23^{a}
Protein	3.08±0.04^{a}	3.14±0.05^{a}	3.09±0.04^{a}	3.15±0.016^{a}
Lactose	4.62±0.05^{a}	4.71±0.08^{a}	4.63±0.05^{a}	4.65±0.04^{a}
Ash	0.67±0.01^{a}	0.71±0.01^{a}	0.70±0.01^{a}	0.70±0.01^{a}
TSNF	8.40±0.10^{a}	8.56±0.14^{a}	8.43±0.10^{a}	8.45±0.07^{a}

$^{a-c}$ Means with different superscripts within row are significantly different (P<0.05), SE=standard error, FCM = Fat corrected milk, TSNF = Total solid not fat

4.3.5. Economic evaluation of treatment feeds

Evaluating the economics of the feeding regimes and set recommendations based on biological and economic response of the cows is very important. The economic analysis was made using the cost of concentrate and the basal diet (silage), and price of mil/lt. Though the price of silage was not available, it was necessary to estimate its cost so as to indicate the cost-effective treatment. Therefore, the price of the silage in DM basis was assumed to be equivalent to natural pasture hay. The price of a bale of hay was 65.00 Eth. Birr i.e 4.10 birr/kg (one bale is equivalent to 15-17kg or average 16kg). The price of milk was fixed (20 ETB/liter) based on the local market price in the study area. The price of concentrate was 930.00 birr/quintal or 9.30 birr/kg obtained from the local market. To come up to the final conclusion, the total cost of production/cow/day and the return obtained was determined. The net return of T3 was relatively higher than the rest of the treatments. From this evaluation it could be suggested that T3 seemed more economical or more profitable (Table, 23).

Table 23. Economic comparison of treatment feeds

Variable cost	T1	T2	T3	T4
Cost of roughage (silage)/cow/day, Eth. birr	27.68	32.31	29.68	26.49
Cost of concentrate mix /cow/day, Eth. birr	32.09	31.43	44.92	60.08
Other costs /cow/day, Eth. birr	20.00	20.00	20.00	20.00
Total variable costs/cow/day, Eth. birr ,	79.77	83.73	94.60	106.57
Return or Price of milk /cow/day, Eth. birr	158.00	162.00	185.20	193.00
Net profit /cow/day, Eth. birr	**78.23**	**78.27**	**90.60**	**86.43**

5. DISCUSSION

In this section, the major findings of the survey work, physico-chemical characteristics of green maize stover silage and feeding experiment are discussed in detail by comparing and contrasting with findings of related studies.

5.1. Household Characteristics

The overall male and female-headed respondents in the study areas were 80.4 and 19.6 percent, respectively. The higher male - headed number observed in this study was comparable with the figures reported by Zewdie and Yoseph (2014) and Mulugeta (2015). In contrast to the present finding, Assaminew (2014) reported closely equal number of male and female-headed respondents in urban dairy production system. This indicates that the number of male- head households is higher in rural dairy production system (mixed crop-livestock farming system) as the crop production is part of this system. The overall average family size of the study areas was 6.53 ranging from 2-12 persons. This figure was consistent with the family size of 6.6 and 6.83 reported by Selamawit *et al*. (2017) and Fekede *et al*. (2013), respectively. On the other hand, lower (5.14) and higher (9.5) family size was reported by (CSA, 2016) and Zewdie and Yoseph (2014), respectively. It is known that the family labour is the main source of labor to the farming community in rural areas. Having more family members is considered as an asset in terms farm labour supply and also as security in times of retirement.

The average age of the respondents was 45 years, ranging from 25 to 68 years and was no significant variation among districts. This figure indicated that most of the respondents are within the productive age range. The average age of this study was comparable with the figure (45.32±0.88) reported by Mohammed *et al*. (2016) in Jimma areas. Respondents were categorized in to different educational status and ranged from totally illiterate to secondary education and above. Majority of interviewed households (62.7%) enable read and write or had basic education and above, however, the rest (37.3%) were illiterate. The number of literates in Toke Kutaye and Ejere districts was relatively higher than that of Bako-Tibe; the difference could be due to better access to schools in these areas. The literate proportion at Bako tibe was 50% some years ago (Berhanu *et al*., 2007) which was lower than the current figure (59%) of the district; this indicates that the number of educated farmers is increasing over time. The literacy rate of 62.7% of present study agrees with the figure (61.1%) reported by Endale, *et al*., (2015), but higher than the literacy rate of 44.5% in Harshin district (Fikru, 2015). In general, education is a basic tool for understanding and adopting new technologies so as to improve livestock production and productivity.

5.2. Landholding and land use pattern in the study areas

The average total land holding 2.87 ha per household in the study areas is comparable to the landholding 2.7 ha/hh reported by Bedasa (2012), but was relatively higher than the average holding described by (Belay *et al*., 2012) and CSA (2013) (as cited by Emama *et al*., 2015) in national (1.2 ha/hh) and regional (1.6 ha/hh) level. However, the landholding per house hold of the study areas was lower than the average land holding per household of Horro- Guduru district (4.11ha/hh) (Kassahun *et al.,* 2015*)* and Ziway areas (4.2 ha/hh) (Zewide and Yoseph 2014). The average landholding per household varied among the study districts. The land holding of Toke-Kutaye district per household was significantly (p<0.05) lower (2.66 ha/hh) than Bako-Tibe (3.0 ha/hh) and Ejere (2.96 ha/hh). In other words, it was lower than Bako-tibe and Ejere by 12.8% and 11.3%, respectively; which may be attributed to large human population in relation to the available land size in the district. The overall average land allocated for crop production per household in the study areas was 1.83 ha (64%) whereas the average land used for grazing was 0.45 ha (16%). Higher land area was allotted for crop production in Bako-Tibe district than Ejere and Toke-kutaye districts; this might be due to large total landholding and/or the higher attention given for crop production. The higher grazing land in Ejere district might be due to total land size difference per household and/or better awareness of respondents for hay making and thereby, livestock production. The average land allocated for cropping and grazing in the present study areas were comparable with the figure reported in Jeldu district (Bedasa, 2012). However, the grazing lands that have been serving as a source of natural pasture for livestock in Ethiopia is continuously shrinking due to high population pressure, land degradation and conversion of grazing lands into arable lands (Shimelis and Temesgen, 2016). Moreover, in all the study districts the key informants revealed that mainly the communal grazing land was diminishing at the fastest rate as it is the target area for investment, microenterprises and replacement reserve for those who had lost their land due to urbanization and other similar reasons. Moreover, the small communal grazing land was overgrazed due to overstocking and poor management practices. However, majority of the respondents had their own small grazing land including boundaries between two adjacent farms. The average grazing land per household of this study is in line with the reports of Bedasa (2012), but lower than 1.22ha (31.6%) reported by Endale (2015) at Meta robi district. This difference could be related to differences in total land size per household and/or population pressure.

5.3. Crop Land Use Pattern of the Study Areas

The average land allocated for crop production in the study districts during 2016/17 *meher* cropping season was 1.83 ha per household, of which land allocated for maize production takes the greatest share 0.78 ha (42.62%). In consistent with the present findings, the largest proportion of cultivated land per household was allotted to maize crop in the central rift valley of Ethiopia (Zewdie and Yoseph, 2014). Almost all the crop field closer to their homestead was planted with maize crop in the study areas. At dough stage, part of the maize plot was used for family consumption /sold to generate an income during September to Mid-October while the remaining plot is harvested when the grain gets matured and dry (November to December). The land used for maize production in Bako-Tibe and Toke kutaye was higher than Ejere district; which might be attributed to agro-ecological difference among districts and/or soil, moisture, etc. Next to Maize, the second and third large sized land was allocated for teff and wheat production, respectively. In consistent with the current study, from the area cultivated for staple crops, maize accounted for (47%) of the area and followed by teff (16%) (Berhanu *et al*., 2007). On contrary, the crop land allocated for teff production was larger than land allocated for maize production at national and regional (Oromia) level (CSA, 2017/18) though maize was higher than teff in terms total production. In Oromia region, the crop land (20%) allotted for maize production (CSA (2017/18) during *meher* cropping season, was far lower than the finding of the present study. However, land used for teff and wheat production in Ejere was significantly ($P<0.05$) higher than that of Bako-Tibe and Toke-kutaye districts. The crop land allotted for wheat production in Toke-kutaye was significantly ($P<0.05$) higher than Bako Tibe, but the land used for other crops (sorghum, chili pepper, *noug, etc*) was larger at Bako districts than Toke kutaye and Ejere.

5.4. Livestock Holding and Herd Structure

Farmers in the study areas, keep different livestock species including cattle, sheep, goats, equines (donkeys, horses and mules) and chicken. The total livestock holding (8.52 TLU /hh) recorded in the study areas was comparable with the figure reported by Zemene *et al.* *(*2016) at Jimma zone, but was lower than 13 TLU in Horro - Guduru district and 13.9 TLU in the central Ethiopian highlands reported by by Kassahun *et al*.(2015) and Fekede *et al*.(2013), respectively. Cattle are the dominant livestock species reared in all the three districts. The overall average cattle herd size per household was 6.73 TLU. This figure was closer to the figure reported by Bainesagn (2016), but was lower than 11.8 TLU and 15.6 TLU reported by Fekede *et al*. (2013) at central highland areas and Zewide (2010), respectively. However, the figure of the current study was higher than the figures (5.35 TLU) and (5.31 TLU) reported by Bedasa (2012) at Jeldu and Shitahun (2009) at Bure districts, respectively. The higher proportion of cattle in the study areas could be related to the high demand for oxen for draft power. The sheep holding per household in Ejere was higher ($P<0.05$) than that of Bako-Tibe district. However, on the contrary, the average holding of goats in Bako-Tibe district was significantly ($P<0.05$) higher than Ejere districts. This might be related to environmental differences between the two districts. Equines were mainly kept for transportation and packing purposes in the study areas.

5.5. Livestock Feeds and Feeding Practices

The major feed resources identified in the study areas were natural pasture, crop residue, crop stubbles, hay, improved forages, and non-conventional feeds. From these feed resources, natural pasture and crop residues were reported to be the most commonly used feeds by most surveyed farmers across all the districts. The current results was comparable with the previous finding of Zewdie and Yoseph, (2014) who reported that natural pasture and crop residues were the main basal diets, in central rift valley of Ethiopia with crop residues supplying the largest proportion of dry matter. The seasonal dynamics of rainfall influences the feed supply/availability from natural pasture. Thus, availability of pastures largely relies on rainfall and it is relatively adequate from the onset to the end of the main rainy season (Alemayehu, 2004). Majority of the respondents reported that animals would be let free on the grazing land (private or communal) morning to evening. Comparable to the present finding, Zemene *et al*. (2016) reported that all respondents (99.5%) in Jimma area let their livestock to graze on either private or communal grazing land. A previous study conducted by Wondatir (2015) in Jeldu district of West Shewa was comparable to the present study and revealed natural pasture was the first and the most common feed resource used by livestock. Crop residues were the second feed resources next to grazing in terms of utilization by the farmers. In the dry period (in most cases from January to May), crop residues like maize stover, wheat straw, and *tef* straw were the main feed resources supplied either before letting the animals to graze or when animals come back home during the evening .

It is absolutely true that crop residues are abundant and important feed resources in the mixed farming systems of Ethiopia. However, these feed resources are characterized by low/ poor nutritional quality and inability to satisfy the nutrient requirement of a given animal (Tolera, *et al*. 2012). Of the crop residues, cereal crop by-products 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). Similarly, Solomon *et al.* (2008) also reported that crop residues are low in CP and *in vitro* DM digestibility, unless and otherwise some nutrient rich feed supplementations are given or some chemical/physical treatments are carried out to support satisfactory digestion and thereby, improve the livestock performance.

About (26.9%) of the respondents in this study also reported to use non-conventional feed resources such as local brewery residues commonly known as *Tela* and *katikala,* vegetable refusals and household leftovers. These feed resources are critically important to bridge the feed crisis encountered during dry period of the year. Higher proportion of respondents (29%) in Toke-kutaye district reported to feed non-conventional feeds as supplement because of high production of vegetable refusals as the area has access to irrigation for vegetable production.

About 12.3% of the sample respondents in the study areas reported that hay was conserved for livestock feeding. This was lower than the hay making and utilization experience of respondents in the central highlands of Ethiopia (Fekede, *et al*., 2013). In contrast to this study, hay making was uncommon in the central rift valley of Ethiopia (Zewdie and Yoseph, 2014). Hay from natural pasture is better in terms of its feeding value than crop residues so far harvested timely and proper handling and storage measures are applied (Yayneshet, 2010). Improved forage production and utilization was limited in the study areas. Moreover, the use of agro- industrial by-product as livestock feed supplement was very minimal. According to the key informants of the study areas, in addition to lack of awareness, unavailability and escalating cost of commercial/ agro-industrial by products in the local market was a challenge to use this resource as feed supplement. This agrees with the finding of Belay *et al.* (2012) who reported unavailability and high cost of concentrates/agro-industrial by products are the two important limiting factors to be used by the smallholder farmers in the rural animal production system. However, the utilization of concentrates/agro-industrial by products in urban dairy production system was higher by dairy producers (Belay and Greet, 2016). This might be mainly due to access to the resources and lack of grazing land. Green feed conservation in the form of silage and use of this resource when feed shortage becomes severe was rarely known in the study areas mainly due to lack of awareness.

Free grazing was the feeding system practiced by majority of the respondents (> 96%) in the study areas. This is consistent with the finding of Beyene *et al*. (2011) in Benishangul-Gumuz Region in western Ethiopia where grazing on natural pasture and stubbles after crop harvest account for dominant livestock feeding system. Similarly, Ketema (2014) reported that free grazing was the major feeding system in Kersa Malima district, South West Shawa Zone. However, semi-intensive and stall feeding/zero grazing were the common feeding systems in urban and peri-urban dairy production systems of southern Ethiopia (Girma *et al*. 2014). Emebet and Zeleke (2008) also identified the feeding system of Dire Dawa town to be intensive or zero-grazing system. The feeding system difference observed in different areas may be related to the difference in production system and/or grazing land area availability.

Feed conservation/ storage strategy is very critical to minimize the feed scarcity encountered during dry period. Proper feed conservation/storage strategy is very helpful to minimize nutrient losses. However, in the present study, the storage system was similar in all the study areas. About 81% of the respondents reported that roughage feeds/crop residues were stored in an open air and in a loose form with full exposure to direct sunlight and rainfall that could cause quality deterioration. Similar results were reported by Fekede *et al.* (2013) in which majority (77.5%) of the respondents in central highlands of Ethiopia store hay in a loose form in an open air. Similarly, Biratu and Haile (2017) also reported that crop residues were stacked at the farm in an open air and loose form. In contrast to the present finding, in west Hararghe, higher number of respondents stacked straws under shed to protect the feed from direct sun light and rainfall (Daniel, 2018).

5.6. Availability, Conservation and Feeding Practice of Maize Stover

The quantity of maize stover produced was estimated by multiplying the maize grain yield/household with the conversion factor of 2 (FAO, 1987). The overall average maize stover produced in this study was 6.12 tons /hh. This result is higher than the figure (4.3 tons /hh) reported in Adami Tullu Jidokombolcha and 5.2 tons/hh in Dugda Bora districts (Zewdie and Yoseph, 2014). From the study areas, the maize stover estimated in Bako-Tibe district was higher ($P<0.05$) than Toke-Kutaye and Ejere Districts. Similarly, the maize stover estimate at Toke-Kutaye district was also higher than that of Ejere district. The maize produced and consequently, the estimated stover may vary with location or may vary due to difference in variety and/or land size allotment. In line with the present finding, Berhanu *et al.* (2007) reported that maize production was different across districts ranging from 0.80 t/ha in Boricha to 3.18 t/ha in Kersa districts and consequently, the stover estimate /ha was different. The feed resources inventory report of FAO (2018) reported that Oromia Regional state ranked first in maize stover availability among regions.

The overall proportion of respondents who practice collection and storage of maize stover for later use were less than 50% in the study areas. However, relatively higher proportion (50.6%) of sample respondents in Toke Kutaye district were practiced collection and storage of dry maize stover for latter feeding. The least proportion (28.7%) was reported in Bako-Tibe district. On the contrary, according to Ashenafi (2010) reported farmers around Bako and Ambo areas didn’t conserve/store the stover after harvesting rather it was left on the field to be consumed by grazing animals believing that the manure deposited by the animals would restore the soil fertility.

In the present finding, however, higher number of respondents had collected and stored the dry maize stover. This could be due to increased awareness of the farmers and /or increased feed shortage of the areas.

In the study districts, utilization of maize stover starts soon after collection (38.5%), one month after collection (40.6%), and two months after collection (21%). The results of the current study was in line with the findings of Fekede *et al*. (2013) and Endale, (2015) who reported that feeding of stored hay and crop residue start soon after collection, one month after collection and two months after collection. But the proportion of sample respondents who feed their animals soon after collection was less and higher proportions of respondents start feeding just after one month. In the mixed farming system soon after crop harvest, farmers let their livestock to stubble grazing (Biratu and Haile, 2017). This might be the reason why greater numbers of respondents didn’t start feeding the collected stover soon after collection.

5.7. Conservation and Utilization of Green Maize Stover

Almost all respondents harvest green maize cob either for home consumption and/or selling to generate an income as elsewhere in the country. The attractive market price of the green cob is another reason for green cob harvesting (Berhanu *et al*., 2007). However, majority of the respondents (63.3%) in the study areas leave the green maize stover on the field to dry. Of the sample respondents who leave the maize stover on the field to dry, about 60.2% of them believed that the nutrient lost would be restored due to feces and urine excretion while animals are allowed to graze the stubble and residues on the crop land. This is comparable with Ashenafi (2010) who reported that farmers in Bako-Tibe and Ambo areas didn't collect and pile the maize stover rather let animals to graze the stubbles and crop residues with an assumption of restoring nutrients from the urine and excreta. About 30.1% of respondents reported that there were alternative forage sources while the green maize was harvested and was not an issue for them at this period. The rest of respondents (9.7%) had no any justifiable reason for not utilizing this resource.

About 36.69% of respondents reported that the fresh green maize stover was supplied to oxen and cows immediately after the removal of the ear/green cob. However, according to Berhanu *et al.* (2007) reported that higher number respondents (58%) had utilized green maize stover as feed in maize growing areas of Ethiopia, soon after harvesting the green cob. None of the respondents make silage from green maize stover in the study areas. Many researchers revealed that green feed conservation/preservation in the form of silage in general and green maize stover in particular was rarely practiced in Ethiopia (Berhanu *et al*. 2007: Adugna *et al*., 2012: Fiseha, 2018). In contrary to this finding, European countries like The Netherlands, Germany and Denmark, most of the forages (90%) locally produced are conserved in the form of silage. Moreover, in this continent, countries like France and Italy having good weather conditions for hay making also ensiles approximately 50% of the forages (Wilkinson *et al.,* 1996). Even though silage making is one of the best green feed conservation techniques in the world, majority of the respondents (74%) lack awareness in the study areas. Few respondents (10%) had the awareness of the technology, but lack enough money to buy the required tools. This indicates that the extension service given to farmers in the study areas is weak.

5.8. Seasonal Availability of Feed Resources

Seasonal fluctuation of feed resources both in terms of quantity and quality is a major concern in feed resources planning. In the study areas, natural pasture, crop residues, aftermath grazing, harvested hay, and to a limited extent improved forages and non-conventional feeds (vegetable refusals, residues of local liquors) constitute the major feeds for livestock. Natural pasture was the main feed resources starting from the onset of main rain season (June to November), however, its availability declines progressively as the dry season extends. In agreement to the current results, natural pastures were the main feed resources during the main rain season (July to September) in central rift valley of Ethiopia (Zewdie and Yoseph, 2014). Weeds, maize thinning and stripping, green maize stalk after the green ear has been harvested were also used as livestock feeds (August to October). According to Mengistu *et al.*(2016) (as cited in Fiseha, 2018), maize thinning (green) and weeds from cultivated fields are also used as important feed resources from June–September in addition to natural pasture. As elsewhere in Ethiopia, stubble grazing contributes significant role in the study areas during dry season of the year (November to February). In line with the present finding, stubble grazing was used from October to December in the central rift valley of Ethiopia (Zewdie and Yoseph, 2014). The grazing length might be varied to the type of crop grown and/or agro-ecological difference of different areas. In the dry period (in most cases from January to June) the sample respondents reported that stack of crop residues like maize stover, wheat straw, *tef* straw, barley straw and pulse straws were utilized along with the limited grazing/browsing of natural pastures. In line with the present finding, Berihu *et al.* (2014) described that crop residues including wheat, maize, barley, bean, and peas as well as "atella" were utilized in dry season in Ganta Afeshum district, Eastern Tigray. Vegetable refusals were also important feed resources in the study areas mainly at Toke kutaye district, as the district was accessible for irrigation. Hay making and utilization experience of the study areas was limited. Of the sample respondents, only few of them had conserved hay for the dry period utilization when feed shortage becomes serious (December to May). In contrast to this finding, hay making from natural pasture is a very common practice in the greater Addis Ababa milk shed, central highlands of Ethiopia (Fekede *et al.*, 2013). In these areas, hay is a major feed source and could be used for an average of 8 months and it is also source of income to those farmers who produced and sales to their neighbors/dairymen.

5.9. Estimation of the feed balance

The data of total grazing and browsing land, areas of aftermath grazing, forest, grain yield and livestock population of the study districts were taken from 2016/17 annual report of respective Agricultural offices in the study areas for estimation of feed quantity and feed gaps. The major feed resources contributing to the dry matter production in the study districts were crop residues, natural pasture and crop stubbles accounting for the largest share. The report of Zewdie and Yoseph(2014) in rift valley areas of Ethiopia was similar to the present finding. Though the dry matter production of crop residues is so high, the high lignin content and low nutritive value limits its intake/utilization by ruminant animals (Adugna *et al*., 2012). Among crop residues, maize stover represented the largest share of dry matter production in Bako Tibe while wheat straw was dominant at Toke kutaye and Ejere districts. The largest share of maize stover observed at Bako Tibe district was related to high production of maize and high wheat straw to Toke-kutaye and Ejere districts was due to high production of wheat.

The average livestock population and the quantity of feed available in the study areas have been estimated to be 119,126.33 tropical livestock units (TLU) and 162,452.21 tons, respectively. The average available feed calculated per TLU was 1.36 tons or 3.73 kg/d/TLU which was less than the maintenance DM requirement of 4.6 kg/d/TLU (Kearl, 1982). Therefore, average available feed supply satisfies only 81% of the maintenance requirement of livestock population. The energy and protein requirement of a steer weighing 250 kg (1TLU) is 7.4 Mcal (30.96MJ) and 337g/day, respectively (Kearl, 1982). The mean metabolizable energy (ME/kg) and CP% taken from the previous researchers 8.05MJ/kg and 63g/kg DM, respectively, was used to estimate the balance of the two nutrients. The ME and CP supply of all feeds could be about 30.0 MJ and 235 gram per day, respectively. This indicates a protein deficiency and a marginal supply of energy for maintenance. In general, the available feed supplied satisfies only about 81% of the feed and 69.7% of the protein maintenance requirements. According to Dirsha *et al*. (2018) reported the annual feed supply in Gurage Zone, Southern Ethiopia, satisfies only 76.81% of the maintenance DM requirement and was relatively lower than the present study. Though the feed available in Bako-Tibe district seems quite enough to satisfy the maintenance requirement of the total livestock feed per annum, most of the crop residues contain less than 7% CP, which is the minimum crude protein required for maintenance or rumen microbial functioning. The negative balance for DM requirement observed in the current study agrees with earlier works of scholars in different areas (Adugna and Said, 1994; Tessema *et al*., 2003: Zewdie and Yoseph, 2014; Selamawit *et al*., 2017). However, the feed supply that meets the DM requirement by 39.59% which was reported by Mohammed *et al.* (2016) in Jimma areas was far less than the present study; this might be due to agro-ecological difference or high human and livestock population.

5.10. Livestock Water Source and Watering Frequency in the Study Areas

Shortage of water was a critical problem in the study areas particularly during the dry season. Rivers (75%) and spring water (17.65%) were the two main water sources for livestock during dry season in the study areas. It was also noted that farmers had to travel a long distance to find these water sources. However, the overall contribution of rivers was reduced to 32% during wet season as the contribution of other water sources like spring water (20.17%), rain (27.17%) and pond (13%) increased to certain extents. A study conducted in Kafta Humera district, Western Tigray was comparable to the present study as rivers were the major water sources during the dry season (Mulugeta, 2015). The author further stated that the use of rivers as water source was decreased from 65.4% (dry season) to 35.6 %(rainy season) as other water sources are available nearby. Similarly, rivers were the main sources of water during dry season in kersa Malima district (Ketema, 2014).

Water requirement and watering frequency of animals varied with season, types of feed supplied, physiological status of the animals and/or the ecological zones in which animals are reared. In other words, water requirements can be influenced by many different factors. For instance, milking cows require 4-5 kg of water for each kg of milk produced (Banerjee, 2009). From the interviewed sample respondents, about 43.7% of them watered their livestock once per day during the dry season. In line with the present finding, majority of the respondents watered their animals once per day during dry season in kersa Malima district (Ketema, 2014). On the other hand, relatively less number of respondents (38.66%) watered their livestock once per day during the wet season. Generally, in wet/rainy season water consumption rate and watering frequency decreases mainly due to cold weather condition and less DM contents of the feed supplied. During dry season, the number of respondents (39.22%) who watered their animals two times per day was higher in contrast to wet season (18.21%). More respondents (30.81%) watered their livestock once per two days during the wet season; however, this was rarely practiced during dry season. Majority of the respondents stated that watering frequency was not an issue for farmers during wet season, as water is available anywhere and animals have access to many natural water sources. In general, according to Kassahun *et al*. (2008), watering frequency decreases with an increase in distance to the water point and vice versa. Similarly, Azage *et al*. (2013) also reported that the watering frequency of dairy cattle depends on access to water sources, the age structure of the dairy herd, physiological stage of animals and season. In line with the present finding, animals would travel longer distance to the watering points during the dry season, however, in wet season animals could be watered in a nearby water sources (Tessema *et al*. 2003).

5.11. Constraints of Livestock Production in the Study Areas

On the basis of index value, shortage of feeds and diseases were identified to be the most important constraints of livestock production in the study areas. This is in line with Mulugeta (2015) who reported that feed shortage was the most important constraint in Kafta Humera district, Western Tigray. Similarly, Belay *et al*. (2012) also reported that inadequate quantity and poor quality feed ingredients were the major limiting factor to the development of dairy production in rural, peri-urban and urban dairy systems. Inadequate feed supply is the major bottleneck affecting livestock production in Ethiopia (Yisehak and Geert, 2014). Of the constraints that could limit livestock production, feed scarcity took the first rank in dry season regardless of agro-ecological variation (Fiseha, 2018). Livestock diseases (ticks) were the second critical problem reported in the study areas. However, in contrast to this study Ketema (2014) reported that livestock disease (95.5%) was the most important constraint followed by scarcity of improved genotype

(94.15) and feed shortage (82.15%) in Kersa Malima, south- west Shewa. The overall index indicated that water shortage and low performance of indigenous animals were reported to be the third and fourth constraints, respectively. Generally, feed shortage, animal diseases, water scarcity during the dry season, poor genetic potential of local breeds, and market problems were identified to be the major challenges of livestock production in the study areas. The interaction of these constraints affects the overall production or resulted in lower milk yield, weight loss, high mortality and/or absence of heat (Fiseha, 2018).

5.12. Physical Characteristics of Silage

The physical characteristics of GMS silages treated with additives showed certain improvements in terms of colour, aroma and texture as compared to the control. The degree of mold coverage also reduced due to the application of additives. The results of the present study are consistent with previous study of (Bilal, 2009).that silage which was treated with molasses showed better results in terms of colour and flavor than the control(without additive). Similarly, Getahun *et al*. (2018) and Mulugeta (2015) reported that the addition of molasses and EM to sugar cane top and crop residues, respectively, resulted in a pronounced alcoholic odor or strong sweet smell, as compared to the control. Obviously, alcoholic odor or strong sweet smell is an indicator for quality silage. In line with the present finding, the sensory evaluation scores of silage made from elephant grass treated with 3% molasses showed better physical characteristics (smell, texture) than silage made from the same forage crop of un-chopped and untreated with molasses (Mtengeti *et al.* 2014). As ensiling period progressed, increased mold coverage was observed on the control group. The mold coverage of green maize stover in the control group was relatively high as compared to silage treated with additives at fermentation period of eight weeks; which could be attributed to low concentration of lactic acid to arrest proliferation of micro-organisms. The better anaerobic fermentative property of additives might probably be attributed to the presence of lactate and acetate producing microbes and water soluble carbohydrate in adequate quantities (Winters *et al*., 1998).

5.13. Silage pH, Temperature and Dry Matter Loss

The pH value records were higher in the control groups than silages that were treated with additives. The pH values of the silages varied from 3.96 – 4.53, indicating that the GMS silage was properly fermented. This pH value range is within the acceptable range for good silage in the tropics (Bilal, 2009; Nhan *et al.,* 2009; McDonald *et al*., 2010). In the present study, pH values showed a decreasing trend in GMS silage treated with additives with prolonged fermentation periods up to six week. Comparable to the present study, elephant grass silage which was chopped and treated with 3% molasses resulted pH value of 3.99 (Mtengeti *et al.* 2014). Similarly, Bilal (2009) also reported that Mott dwarf elephant grass ensiled with additives showed a decreased pH value with the level of molasses increased from 0% to 3% and fermentation periods from 30 to 35 days. The relatively high pH values of GMS silage in the control group/silage without additive may be attributed to low concentration of fermentable carbohydrates. However, this pH value was within an acceptable range for quality silage. This probably indicates that GMS had the threshold soluble carbohydrate that could trigger lactic acid production.

Temperature is another important parameter used to measure the physical quality of the silage. The temperature of the silage above 120°F (48.9^{0}C), can lead to an undesirable high temperature reaction that causes heat-damage-browning or the Maillard reactions, and decreased silage digestibility (Jones *et al*., 2004; Bolsen *et al.,* 1996). The temperature of the silages in this study was closer to the ambient temperature of the laboratory where the silos were kept regardless of the additive types and incubation periods. According to Kung (2014), silage temperature in small silos is expected to be similar to the ambient temperature or just a few degrees warmer than normal while the fermentation is completed. Elevated temperatures above ambient temperature suggest oxidative respiration by molds and fungi and feed instability (Wren, 2000). On the farm, warm silage is not always an absolute indicator of spoilage because large silos often retain relatively high temperatures even in the winter, silage temperatures as high as 32-33 °C was recorded in some silos kept for three months (Olorunnisomo and Ibhaze, 2013). The slight increased temperature observed in silages that were treated with additive; however, might be due to higher fermentation rate resulted from the addition of additives.

The dry matter loss (7.55%) observed in the control group at the fermentation period of eight weeks was higher as compared to the green maize stover silage treated with additives for the same and different ensiling periods. The lower DM loss in GMS silages that were treated with additives could be related to fast fermentation processes of the silage material leading to lower pH values. In line with the present result, maximum DM loss was observed in grass silage produced without applying additives (Kung and Shaver, 2001). Similar results were also reported by Bilal (2009) where the DM recovery of grass silage was higher due to molasses addition as compared to the control/ grass silage without the addition of molasses. The DM loss of silage treated with EM and ensiled for eight weeks was higher ($P<0.05$) than the DM loss of all silages ensiled for four weeks. However, the DM loss was not significant ($P>0.05$) in all treatments at 4 weeks fermentation period. The relatively, less DM loss/more DM recovery was observed in silages treated with molasses and FJLB additives across all fermentation periods; which could be attributed to the addition of fermentation stimulants that would enhance the fermentation processes. High DM recovery was indirectly related to homolactic fermentation (Weinberg and Muck, 1996; Sharp *et al.,* 1994). However, total DM loss, up to 5% during the fermentation period is tolerable and considered normal, presumably due to the loss of soluble nutrients (McDonald *et al*., 2010).

5.14. Chemical Compositions and *In Vitro* Digestibility of Silage and Fresh Stover

The DM content of GMS silages ranged from 34.84 to 37.44 percent. The lower range was the control silage ensiled for eight weeks, and the higher range was silage treated with molasses and ensiled for six weeks. In agreement to the present finding, addition of molasses to Napier grass before ensiling enhanced the fermentation process and consequently avoided the DM loss (McDonald *et al*., 1991). Similarly, Bolsen *et al*. (1996) stated that the addition of molasses reduced nutrients loss by early stabilization of the medium. Moreover, Getahun *et al*. (2018) reported that addition of molasses alone to green SCT silage increased the DM content over the same forage treated with urea alone or 4% molasses + 1%urea. This indirectly implies molasses is an effective additive to recover high DM content. The crude protein content of the silage ranged from 4.85 to 5.9%. However, the CP content was improved due to the use of additives. The CP content of silage ensiled with additives was improved by 3.53 to 15.7% as compared to the fresh maize stover. In contrast, relatively lower CP content was recorded in the control/ silage ensiled without additive. Comparable with the present result, the findings of Bilal (2009) and Yonatan *et al.* (2014) resulted in higher CP content than the control due to the addition of molasses on grass before ensiling and EM inoculation on coffee husks, respectively. Similarly, Zhang (2003) as cited by (Gouri, 2012) also reported that ensiling green maize stover with additives improved CP contents by 25.51%.

Moreover, the CP content of sorghum stover treated with EM was improved from 2.93 to 5.33% or increased by 81.9 % from the untreated stover (Daniel, 2018).

In contrast to the present findings, the CP content of MGS (Mott grass silage) was not changed by the use additive (Nisa *et al*. 2005). This could be attributed to differences in variety and/ or additive type used. In general, the increased CP content in silage treated with additives might be attributed to the microbial growth/proliferation of lactic acid bacteria during the fermentation period and hence becoming part of the medium as the pH drops to 4.0. Bacteria are proteins in nature and contain more than 75% of their cell mass in the form of true protein (Yang *et al*., 2004 and Rusdy, 2015).

From the cell wall components, NDF was significantly lower ($P<0.05$) in silage treated with molasses and ensiled for six weeks than the control and FJLB treated silage across all fermentation periods. The ADF content of GMS silage treated with molasses and ensiled for six weeks was also lower than that of the control with fermentation period of four weeks. In this study, NDF and ADF contents were decreased by 1.46 and 6.35%, respectively, due to the addition of molasses and ensiling for six weeks as compared to fresh chopped GMS.

In line with the present finding, the NDF and ADF contents were decreased with the increasing level of molasses (Ofori and Nartey, 2018). Similarly, Gouri(2012) reported lower NDF when a fodder was treated with lactobacillus culture.

Moreover, Yonatan *et al.* (2014) reported that the use of EM as an additive resulted in lower NDF, ADF and lignin contents compared to the control in coffee husk. The decreased in NDF, ADF or lignin could be the result of hydrolysis of polysaccharides as ensiling to the pH values of less than 4.5 is believed to increase the chemical hydrolysis of fibrous feeds (Bolsen *et al.,* 1996). The IVOMD (*in vitro* organic matter digestibility) and ME (MJ/kg) content was higher in GMS silage treated with molasses and ensiled for six to eight weeks than the control during similar fermentation periods. The ash contents of GMS silages ranged from 7.5% (control) to 8.59 % (molasses) but the difference was non-significant across all the treatment groups. This is in agreement with Yonatan *et al*. (2014) who stated that coffee husk ensiled for 30 days with EM had higher ash (8.54%) content than coffee husk ensiled without EM addition for similar period (8.15%), but didn't show significant difference. In line with the present study, Nisa *et al.* (2005) also reported that the ash content of MGS (Mott grass silage) showed no significant difference across all the treatments due to the use of additive. This variation though not significant could be explained by the existence of minerals in the additive and/or higher recovery of DM due to fast fermentation processes when additives are applied.

5.15. Chemical Composition of Feed Ingredients in the Feeding Experiment

The chemical composition feed ingredients used in feeding trial were analyzed. The crude protein content of GMS silage which was treated with molasses and ensiled for six weeks in the laboratory trial was slightly higher than GMS silage prepared for the feeding trial. This variation could be related to seasonal difference (as frost was a problem), and/or soil factor. The crude protein content of the treatment feeds increased progressively when the concentrate proportion was increased from 30% to 50% in relation to the level of GMS silage. Similarly, the metabolisable energy (MJ/kg DM) was also increased from 9.83 MJ/kg DM to 10.14 MJ/kg DM as the proportion of concentrate mix increased from 30% to 50%, respectively. The *in vitro*-Organic matter digestibility values were negatively correlated with NDF, ADF and ADL content. In contrast, *in vitro*-Organic matter digestibility was positively correlated with HC (hemicelluloses). In agreement with the present results (Adugna and said, 1994) stated that the *in vitro*-DM digestibility values were negatively correlated with ADF (r = - 0.71), Lignin (r = -0.60), Cellulose(r = -0.48) and NDF(r = -0.36).

5.16. Daily Feed and Nutrient Intake

The daily total dry matter intake of cows fed on TMR diets with 40 and 50 % concentrate inclusion rate was higher than those cows fed with conventional diets (silage and concentrate separately). The total feed intake was in the order of T1< T2 < T3 < T4.
The CP, NDF and ADF intake of cows fed on GMS silage based TMR was significantly higher than cows fed on control (silage and concentrate, separately). This result conforms to the findings of Gupta *et al. (*2014), who reported that lactating crossbred cows fed TMR had 15.92% more intake than conventionally fed cows. The author further stated that crude protein and energy intakes were also increased in cows fed on TMR as compared to cows fed roughage and concentrate separately. A previous study conducted by Dejene *et al*. (2017) also revealed that cows fed natural pasture hay based TMR had higher DM intake than those cows fed hay and concentrate separately. According to Muya *et al*. (2011), the total daily DM and CP intake was improved for cows fed 100% TMR than cows fed on 75% TMR diet. Similarly, Khan *et al*. (2010) reported that crossbred cows fed pellet form of total mixed ration had higher dry matter and CP intake. Moreover, a research conducted by Pachauri *et al*. (2010) on wheat straw based TMR showed increased energy, DCP and TDN intake. This may be explained by the fact that the feeding of GMS silage based TMR eliminates dietary fluctuations. The constant supply of TMR diet creates stable rumen environment and makes the ruminant system more efficient. However, in conventional feeding, concentrate and roughage will be provided separately and thereby, the rumen environment will be disturbed intermittently as the feed is changed and thus, may resulted digestive upset (Maekawa *et al*., 2002).

The metabolizable energy of the present finding ranged from 96.7 to 127.13 MJ per day from T1 toT4, respectively. This is in line with the energy range of 62.94 to 147.81 MJ per day described by (paul *et al*., 2004).

5.17. Apparent Digestibility of Dry Matter and Nutrients

The apparent digestibility of dry matter and nutrients was higher ($P<0.05$) for cows fed TMR diet with the concentrate inclusion rate of 40 and 50% than the conventional feeding system. In agreement with the present finding, Hundal *et al*. (2004) revealed that TMR of Oat hay based diet showed higher DM, OM and NDF digestibility than feeding Oat hay and concentrate separately. The digestibility of CP increased in the order of T1=T2< T3 <T4, this indicates, as the level of concentrate mix increased from 30-50%, the CP content increased simultaneously. Except in the conventional diet, the digestibility percentage of the fibers (NDF and ADF) didn't show statistical difference among TMR treatments. In line with this study Khan *et al.* (2010) stated that the DM and CP digestibility was higher in lactating cows fed complete ration in pelleted form and un-pelleted form than the conventional feeding. Moreover, a study conducted by Pachauri et *al*. (2010), showed that the digestibility of DM, CF, EE and NFE was higher in wheat straw based TMR than conventional feeding method (feeding of wheat straw and concentrate separately). Furthermore, Geberemariyam, (2018) revealed that heifers fed natural pasture hay based TMR showed better apparent digestibility in terms of organic matter, NDF, ADF and ADL than heifers fed roughage and concentrate separately. This could also be associated to rumen environment as feeding TMR diet creates stable rumen environments that would favor microbial proliferation and thus, facilitates digestion and absorption of nutrients.

5.18. Milk Yield and Composition

The milk yield of cows fed TMR diets was higher by 2.4 to 22.15% per day from T2 to T4, respectively, than cows fed conventional diet. Of the experimental cows, cows fed TMR diets with 40 and 50 percent concentrate inclusion showed statistically higher milk yield over 30 percent concentrate inclusion and the conventional feeding method. As a result, the extra daily milk yield was 1.2 and 1.39kg and 1.55 and 1.75kg, above those cows maintained under silage based TMR with 30% concentrate and cows fed conventionally, respectively. According to Gupta *et al*. (2014), cows fed TMR had higher milk yield than those fed conventionally. The overall milk production was increased by 16.96 and 19.49 % in cows fed TMR during rainy and dry season, respectively, which was closer to the current result.

Moreover, Cows fed straw based TMR gave 15-20% more milk and had longer lactation period over cows fed conventional feeding system (Walli, 2009). In agreement with the present findings, Hundal *et al*. (2004) reported that cows fed TMR diet showed higher milk yield (0.41kg) than cows fed roughage and concentrate separately. The milk yield increased by 3.34kg/cow/day for cows fed pasture hay based TMR over those fed conventionally was higher than the present results (Dejene *et al*. 2017). Similarly, the milk yield of cows fed TMR feed was higher (44.1 vs 29.6kg/d).over cows kept on quality pasture cows (Kolver and Muller, 1998) and this figure was also higher than the present findings; this difference might be due to the difference in stage of lactation and/or due blending nature of the TMR diet. In this experiment, however, the extra daily milk yield produced by cows fed TMR diet with 40 and 50% concentrate over T2 and T1 may be explained by the relatively larger daily DM intake and thus, protein and energy intake per head. Moreover, the mode of feeding also would have an impact on the feed intake and digestion and thereby, would influence the milk production.

Generally, in order to speculate the best treatment and set recommendations, it is better to look in to the economics of the feeding regimes. Based on both the biological and economic response of the cows the best treatment would be suggested. Therefore, in order estimate the profit obtained from each treatment milk price and cost of feeds comparison was made and thus, TMR diet with 40% concentrate was suggested to be more economical or profitable among treatments.

The milk composition (fat, protein, lactose ash and SNF) didn't show significant difference among treatments. This result is in line with the reports of Dejene *et al*., (2017) who reported that the milk composition of cows fed on pasture based hay TMR and cows fed hay and concentrate separately didn't show significant variation.

6. CONCLUSION AND RECOMMENDATIONS

In this chapter the overview of research objectives, methods followed, major findings and the recommendations emanated from the research findings are briefly presented.

6.1. Conclusion

The present study comprised of three interrelated sections i.e survey and two experiments. The survey study was aimed at assessing the feed resource availability, feeding system and maize stover utilization/conservation practices in three selected districts of West Shewa Zone so as to generate baseline information and design intervention strategies. This was followed by two sets of experiments; the first was a laboratory (silage) experiment conducted to evaluate different additives and incubation periods to make quality silage from GMS. The second experiment was on station feeding trial aimed at evaluating the response of Jersey cows fed on GMS silage based TMR graded with different levels of concentrate and compare TMR form of feeding with the conventional feeding method (concentrate and roughage supplied separately). In the survey, primary data was collected by interviewing 357 farm households randomly selected from the three districts. Supplementary data (information) was collected from the respective district agricultural offices, extension agents and key informants.

In the silage experiment 12 treatment combinations were set (3 incubation periods: 4, 6 and 8 weeks) and 4 additives (no additive or control, 3% molasses, 1% EM and 1% FJLB). Each treatment combination was replicated 5 times. In order to speculate the best additive and fermentation period, the physico -chemical characteristics of the silages were evaluated.

The feeding experiment was conducted on-station using eight mid-lactating pure Jersey cows with more or less similar milk yield and parity range of (one through four) in order to determine the optimum proportion of concentrate and GMS silage mix and also compare TMR form of feeding with the conventional feeding method (concentrate and roughage separately). The formulated concentrate used was wheat bran 69%, *noug* cake

30% and salt 1% and was assumed to fully meet the protein and energy requirement of cows fed grass hay, with milk yield of 8-10 liter/day and a butter fat content of 4.4% when supplemented at the rate of 0.5 kg/liter of milk. The formulated concentrate was blended with GMS silage in a graded manner of 30%, 40%, and 50% on the basis of daily dry matter allowance except the control diet, where cows received formulated concentrate of 0.5kg/liter of milk.

The survey result revealed that different feed resources were used by smallholder farmers. The major feeds resources identified were natural pasture, crop residues and aftermath grazing, grass hay harvested from private grazing land and non-conventional feeds (local brewery by-products, vegetable refusals), and to some extent improved forages.

The land area (0.45ha) allocated for grazing was far less than the land used for crop production (1.83 ha). From the crop land, land allotted for maize production was higher (42.62%) than the rest of the crops. The major crop residues used across the study areas include stover (maize and sorghum) and straws of teff, wheat and barley. The average net utilizable crop residue in the study areas was estimated to be about 130820.74 tons. The total livestock population and feed resource available in the study areas has been estimated to be 119,126.63 tropical livestock units (TLU) and 162,452.2 tons, respectively.

Thus, the average annual quantity of feed available per TLU would be 1.36 tons (3.73kg/day/TLU) which is less the maintenance DM requirement of 1.68 tons/TLU/year or 4.6kg/day/ TLU i.e. feed supply satisfies only 81% of the maintenance requirement of livestock population. Moreover, the nutrients supplied by these feed resources was 235 g protein and 30.0MJ metabolizable energy per day/TLU which is less than 337g CP and 7.4Mcal(30.96MJ) metabolizable energy required for a steer weighing 250 kg(1TLU). On the other hand, though most of the interviewed farmers use green maize (cob) either for consumption and/or selling to generate cash, only few of respondents (36.69%) provide the green maize stover immediately to their animals. The majority of the respondents (63.3%) leave the green stover on the field to dry. None of the respondents conserve green maize stover in the form of silage for latter use mainly due to lack of awareness.

Free grazing with some supplementation when animals came back to home was the most common feeding system in the study areas. The most important constraints in the study areas were feed shortage and diseases (tick) in that order of importance.

In the laboratory (silage) experiment, based up on the physico- chemical characteristics of GMS silage evaluations, GMS silage which was treated with 3% molasses and incubated for six weeks exhibited relatively the best quality silage characteristics.

In the feeding experiment, the DM and nutrient intake, apparent digestibility and milk yield and milk composition responses were evaluated in order to determine the optimum proportion of GMS silage and concentrate level and also compare the mode of feedings. The daily total DM intake was higher for cows fed TMR with concentrate level of 40 and 50% inclusion than those cows fed GMS silage and concentrate separately. Similarly, the OM, CP, NDF and ADF intake of cows fed on TMR with 40 and 50% concentrate inclusion rate was higher than the conventional feeding method. The total DM intake of T2 was higher than T1. On the contrary, the concentrate intake level of T2 was relatively lower than T1. The apparent digestibility of DM and nutrients were also higher in T3 and T4. The digestibility percentage of CP was increasing order T1 = T2<T3<T4. However, there were no significant variations among the TMR diets for NDF and ADF contents. .

In general, the daily milk yield of cows fed on TMR containing 40 and 50% concentrate mix was better than cows fed on conventional diet and silage with 30% concentrate inclusion rate. The milk yield of T1 and T2 didn’t differ significantly even though T1 was lower than T2 numerically. The economic analysis made by using the cost of production (mainly the feed cost) and price of milk/lt indicated that cows fed on TMR diet with 40% concentrate are more profitable.

Thus, TMR graded with 40% concentrate inclusion seemed more economical and TMR diet also showed better response against conventional feeding system in terms of milk production. The GMS silage treated with 3% molasses and ensiled for 6 weeks period is resulted better quality silage than silage treated with 1%EM and 1%FJLB.

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6.2. Recommendations

- In general, in order to tackle the feed scarcity encountered during dry season, implementing new technologies and wise use of the feed resources available is imperative. Of the technologies, feed conservation in the form of silage when feeds like green maize stover and other forages are available is very vital.

- The green maize stover silage can be used as a complementary livestock feed when feed crisis become serious as it contains reasonable crude protein and metabolizable energy.

- Appropriate feed conservation and storage, improved forage production and proper utilization practices should be applied to ensure a year round feed supply to livestock.

- Farmers should be provided all rounded extension support by stakeholders/concerned bodies

- Limiting the number of animals kept per household could also be important in order to balance the feed supply and their requirement

- Use of 3% molasses in fresh weight basis as an additive and ensiling period of six weeks is quite enough for quality silage production from green maize stover.

- TMR feeding is a more promising type of mode feeding than conventional feeding (supplying roughage and concentrate separately) as it was reflected on the production response.

- GMS silage based TMR with 40% concentrate inclusion seemed more economical as the economic analysis made by using feed cost/kg and price of milk/lt indicated.

Future Research Areas

- GMS silage making with plastic bag /pit and conducting feeding experiment on local cows under farmers' condition.
- A comparative study between GMS silage and natural pasture hay or GMS silage –pasture hay substitution experiment need to be conducted in the future.
- A comparative study on harvesting matured green cob and consequently drying the grain in order to use the green maize stover as livestock feed source and harvesting the grain when dried need further research in terms of grain quality, quantity and profitability.
- The quality (nutrient content) of the feeds available in the study areas should be further studied.
- Maize breeders should work not only to maximize the yield of a specific variety but also should consider stover quality and quantity as well.
- The silage based feeding system should be also evaluated on growth and meat quality of cattle and small ruminant.

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7. REFERENCES

Abdisa G., Girma A., Verkuijl H. and Mwangi W. (2001). Farmers' Maize Seed Systems in Western Oromia, Ethiopia. Mexico, D.F: International Maize and Wheat Improvement Center (CIMMYT) and Ethiopian Agricultural Research Organization (EARO).

Abedo A. A., Hafez Y. H. , Khalifa E. I., Bahera, Mohamed K. and El-Zolaky O. A. (2013). Milk Yield and Composition of Dairy Zaraibi Goats Fed Microbial Inoculated Corn Silage. *Egyptian Journal of Sheep and Goat Sciences,* Vol. 8 (1), Pp: 141-151

Adebabay K. (2009). Characterization of Milk Production Systems, Marketing and On-Farm Evaluation of the Effect of Feed Supplementation on Milk Yield and Milk Composition of Cows at Bure District. Bahir Dar University. Ethiopia.

Adugna T. (2007). Feed Resources for Producing Export Quality Meat and Livestock in Ethiopia Examples from Selected Woredas in Oromia and SNNP Regional States. *Ethiopia sanitary and phytosanitary standards and livestock and meat marketing program (SPS-LMM).* Texas Agricultural experiment station (TAES)/Texas A & M University system

Adugna T. (2008). Feed resources and feeding management: A manual for feedlot operators and development worker.38p.

Adugna T., Getnet A., Driba G., Lemma G. and Alemayehu M. (2012). Feed resources availability and quality. In: Adugna T., Alemu Y. and Dawit A. (ed.) Livestock Feed Resouces in Ethiopia: Challenges, Opportunities and the need for transformation. Pp. 5-35.

Adugna Tolera and said.A.N.(1994). Adugna T. and Said A.N. (1994). Assessment of feed resources in Walayta Sodo and laboratory evaluation. *Ethiopian Journal of Agricultural Science.* 14: 69-87

Aemiro K., Getnet A., Dereje F., Getu K. and Mesfin D. (2010)**.** Milk Yield and Quality of Crossbred Dairy Cows Fed with Different Levels of Vetch (Vicia dasycarpa) Hay and Concentrate on a Basal Diet of Fresh Cut Napier Grass (Penissetium purpureum). *Ethiopian Journal of Agricultural Sciences 20:161-167*

Aemiro K.., Getu k.., Getnet A., Dereje F. & Zewdie W. (2014). Growth Performance of F1 Friesian X Boran Crossbred Dairy Calves Supplemented with Effective Micro Organism (EM) Fermented Wheat Bran (Bokashi) in the Central Highlands of Ethiopia. *Global Journal of Science Frontier Research*: Agriculture and Veterinary Volume 14 Issue 9

AFIA (Australian Fodder Industry Association), (2011). Laboratory Methods Manual. Version 7: 80-81. http://www.afia.org.au.

Alemayehu A., Afework H., Habtamu A. and Mulisa F. (2018). Determinants of adoption of improved forages in selected districts of Benishangul-Gumuz, Western Ethiopia. *Tropical Grasslands-Forrajes Tropicales.* Vol. 6(2):104–110

Alemayehu M. (2004) Pasture and Forage Resource profiles of Ethiopia. Ethiopia/FAO; Addis Ababa, Ethiopia, pp 19.

Alemayehu M. and Getnet A. (2012). The evaluation of forage seed production in Ethiopia. In: Getnet Assefa, Mesfin Dejene, Jean Hanson, Getachew Anemut, Solomon Mengistu and Alemayehu Mengistu (eds), Forage seed research and development in Ethiopia. Ethiopia institute of agricultural research, Addis Ababa, Ethiopia. Pp 15-32.

Alemayehu M., Gezahagn K. and Fekede F. (2018). Status of Ethiopian Rangelands: with Special Reference to Southern Rangelands. Review: *International Journal of Agriculture and Biosciences*. P-ISSN: 2305-6622; E-ISSN: 2306-3599

Amanullah S.M., Kim D.H., Lee H.J., Joo Y.H., Kim S.B., Kim S.C. (2014). Effects of microbial additives on chemical composition and fermentation characteristics of barley silage. Asian-Australas *Journal of Animalscience,* 27(4):511-7.

Assaminew S. (2014). Assessment of feed formulation and feeding practices for Urban and Peri-urban dairy cows, around Holetta, Ethiopia. MSC. Thesis submitted to the College of Veterinary Medicine and Agriculture, Addis Ababa University, Ethiopia.

Ashenafi M. (2010). Comparative Analysis of Maize-Livestock Innovation Systems in Awassa, Bako and Ambo Areas of Ethiopia. PhD dissertation submitted to Haramaya University, Ethiopia

Association of Official Analytical Chemists (AOAC). (1990). Official Methods of Analysis. 15th Edition. Arlington, Verginia, USA. Pp 12-98.

Auldist M. J., O'Brien G. C. D., Macmillan K. L. & Grainger C. (2007). Effects of varying lactation length on milk production capacity of cows in pasture-based dairying systems. *Journal of Dairy Science*. 90:3234-3241

Azage T., Berhanu G., Dirk H., Berhanu B. and Yoseph M. (2013): Smallholder dairy production and marketing systems in Ethiopia: IPMS experiences and opportunities for market-oriented development. Improving Productivity and Market Success of Ethiopian Farmers Project (IPMS) working paper 31. International Livestock Research Institute (ILRI), Addis Ababa, Ethiopia.

Bainesagn W. (2016). Smallholder Cattle Production Systems and Husbandry Management in West Shewa Zone of Oromia Regional State, Central Ethiopia. *World scientific News*. WSN, 53(3) 178-188.

Bal M.A., Coors J.G., Shaver, R.D. (1997). Impact of the maturity of corn for use as silage in the diets of dairy cows on intake, digestion, and milk production. *Journal of Dairy Science 80*: 2497-2503

Banerjee G.C. (2009): A textbook of animal husbandry. 8th edition. Oxford and IBH publishing Co. Pvt. Ltd. New Dehli.

Bargo F., Muller L.D., Delahoy J.E., Cassidy T.W. (2002). Performance of high producing dairy cows with three different feeding systems combining pasture and total mixed rations. *Journal of Dairy Science*, 85: 2948-2963.

Bedasa E., 2012. Study of Smallholder Farms Livestock Feed Sourcing and Feeding Strategies and their Implication on Livestock Water Productivity in Mixed Crop-Livestock Ssystems in the Highlands of the Blue Nile Basin, Ethiopia. MSc. thesis Submitted to the School of Graduate Studies. Haramaya University.139p.

Bekele S. (1991). Crop livestock interactions in the Ethiopian highlands and effects on sustainability of mixed farming: a case study from Ada district, Debrezeit. An MSc. Thesis Agricultural University of Norway, Oslow, Norway.163p.

Belay D., Azage T. and Hegde B.P. (2012). Smallholder Livestock Production System in Dandi District, Oromia Regional State, Central Ethiopia. *Global Veterinaria* 8 (5): 472-479, 2012

Belay D. & Geert P. J. J. (2016). Assessment of feed resources, feeding practices and coping strategies to feed scarcity by smallholder urban dairy producers in Jimma town, Ethiopia. *Journal of Springer open Research*, 5, 717.

Berhanu G., Fernandez-Rivera S., Mohammed H., Mwangi W. and Seid A. (2007). Maize and livestock: Their iner-linked roles in meeting human needs in Ethiopia. Research report 6. ILRI (international livestock research institute), Nairobi, Kenya, Pp 103

Berhane M. (2012). Effect of feeding pulse hulls in concentrate mixture on nutrient utilization and performance of dairy cows**.** A PhD dissertation submitted to the national dairy research institute, karnal (deemed university) in partial fulfillment of the requirements for the award of the degree of doctor of philosophy in livestock production management, India.

Berihu H., Aleme A. and Mulata H. (2014). Assessment on Major Production System and Constraints of Livestock Development in Eastern Zone of Tigray; The case of "Ganta Afeshum Woreda" Northern Ethiopia. *Agricultural Science, Engineering and Technology Research*, 2(1): 01- 09.

Beyene T. Tegene N. and Ayana A. (2011). Effect of farming systems on livestock feed resources and feeding systems in Benishangul-Gumuz Region, Western Ethiopia. *International Research Journal of Agricultural Science and Soil Science* Vol. 1(1) pp. 020-028 March 2011.

Bilal M.Q. (2009). Effect of Molasses and Corn as Silage Additives on the Characteristics of Mott Dwarf Elephant Grass Silage at different fermentation periods. Pakistan, *Veterinary Journal.* 29(1): 19-23.

Biratu K. and Haile S. (2017). Assessment of livestock feed availability, conservation mechanism and utilization practices in South Western Ethiopia. *Academic research Journal of agricultural science and research,* Vol. 5(7), DOI: 10.14662/ARJASR2017.074

Bolsen K.K., Ashbell G., Weinberg Z.G. (1996). Silage fermentation and silage additives. Review. *Asian-Aust*. *Journal of Animal science 9:483-493*. Bureau of Animal Production and Health (BAPH). Criteria for evaluation of maize stover silage. BAPH, Ministry of Agriculture, Bejing, China. FAO, publication.

Borreani G. and Tabacco E. (2010). The relationship of silage temperature with the microbiological status of the face of corn silage bunkers. *Journal of Dairy Science* 93:2620-2629

Brännäng E. and Persson S. (1990): Ethiopian animal husbandry. A Handbook. of South Eastern Agricultural Development Zone. Uppsala. Sweden. 127p.

Bureenok S., Namihira T., Tamaki M., Mizumachi S., Kawamoto Y. and Nakada T. (2005). Fermentative Quality of Guineagrass Silage by Using Fermented Juice of the Epiphytic Lactic Acid Bacteria (FJLB) as a Silage Additive. *Asian-Aust. Journal of animal science*. Vol. 18, No. 6: pp 807-811

Calsamiglia S., Ferret A. and Devant M. (2002). Effects of pH and pH fluctuations on microbial fermentation and nutrient flow from a dual-flow continuous culture system. *Journal of Dairy Science.* 85, Pp: 574–579.

Collar C. and Aksland G. (2001). Harvest stage effects on yield and quality of winter forage. Proceedings, 31st California Alfalfa and Forage Symposium: Modesto, CA, UC Cooperative Extension University of California, Davis.

CSA (2016). The Federal Democratic Republic of Ethiopia Central Statistical Agency Agricultural Sample Survey 2015/2016 (2008 E.C.) Volume I Report on Area and Production of Major Crops (Private Peasant Holdings, Meher Season), Statistical Bulletin 584.

CSA (2017). Agricultural sample survey: Report on livestock and livestock characterstics (private peasant holdings) Ethiopia: Statistical bulletin 585, Vol. II. Addis Ababa, Ethiopia.

CSA (2018). The Federal Democratic Republic of Ethiopia Central Statistical Agency Agricultural Sample Survey 2017/18 (2010 E.C.). Volume I Report on area and production of major crops (Private Peasant Holdings, Meher Season), Statistical Bulletin, 586

Daniel T. W. (2018). Characterization of Cattle Fattening and Marketing Systems and Nutritional Quality of Sorghum Stover Ensiled with Effective Mico-organisms (EM) and Urea in West Hararghe, Ethiopia; PhD Dissertation submitted to Addis Ababa University, College of Veterinary Medicine and Agriculture Department of Animal Production Studies, Ethiopia.

Dejene T., Lemma F., Fekede F., Getu K. and Zewudie W. (2017). Effect of Total Mixed Ration on Dry Matter Intake, Milk Yield and Composition of Early Lactating Jersey Cows. *Journal of Biology, Agriculture and Healthcare*. ISSN 2224-3208 (Paper) ISSN 2225-093X (Online) Vol.7, No.9.

Dessalegn G., Birhan T. and Gebreyohannes B. (2016). Study of reproductive and production performance of cross breed dairy cattle under smallholder's management system in Bishoftu and Akaki towns. *International journal of advanced research and biological science* 3: 118-123

Dirsha D.W.Ashenafi M. W. and Gebeyehu G. N. (2018). Feed resources assessment, laboratory evaluation of chemical composition of feeds and livestock feed balance in enset (Ensete ventricosum)-based mixed production systems of Gurage zone, southern Ethiopia. *International Journal of Livestock Production.* Vol. 9(6), pp. 112-130,

Donna M., Jose R. and Larry W.T. (2002). Managing the total mixed ration to prevent problems in dairy cows. University of Kentucky, pp.1-4.

Driehuis F., Elferink S. and Van W. (2001). Fermentation characteristics and aerobic stability of grass silage inoculated with *Lactobacillus buchheri*, with or without homofermentative lactic acid bacteria. Grass and Forage Sciences. 56: 330–343.

Emama B., Mohammed H. and Mohammed S. (2015). A situational analysis of agricultural production and marketing, and natural resource management systems in the Ethiopian highlands. ILRI/Humidtropics Project Report. Nairobi, Kenya: International Livestock Research Institute (ILRI).

Emebet M. and Zeleke M. (2008): Characteristics and constraints of crossbred dairy cattle production in lowland areas of Eastern Ethiopia. *Livestock Research for Rural Development*. 20(4).Available at http://www.lrrd.org/lrrd20/4/mure20057.htm

Endale Y., (2015). Assessment Of Feed Resources And Determination Of Mineral Status Of Livestock Feed In Meta Robi District,West Shewa Zone, Oromia Regional State, Ethiopia. Msc. Thesis Ambo University

Endale Y., Abule E., Lemma F. and Getnet A. (2016). Livestock feed production and feed balance in metaRobi District, West Shewa Zone, Oromiya Regional State, Ethiopia

Academic Research Journal of Agricultural Science and Research. Vol. 4(2), Pp. 45-54 DOI: 10.14662/ARJASR2016.072

Fanos M. (2014). Maize stover: A potential green fodder in Ethiopia. In: livestock and irrigation value chain for Ethiopia smallholders. ILRI

Food and Agriculture Organization of the United Nations (FAO), (1987). Land use, production regions and farming systems inventory. Technical report 3 vol. 1. FAO project ETH/78/003, Addis Ababa, Ethiopia, pp: 98

Food and Agriculture Organization of the United Nations (FAO), (2002). Animal production based on crop residues; China's experiences. FAO Animal Production and Health Paper.

Food and Agriculture Organization of the United Nations (FAO) (2012). Balanced feeding for improving livestock productivity – Increase in milk production and nutrient use efficiency and decrease in methane emission, by M.R. Garg. FAO Animal Production and Health Paper No. 173. Rome, Italy.

Food and Agriculture Organization of the United Nations (FAO), (2018). Ethiopia: Report on feed inventory and feed balance, 2018. Rome, Italy. Page 160 . Licence: CC BY-NC-SA 3.0 IGO

Fekede F., Shiv P., Getnet A., Getu K. and Seyoum B. (2013).The status of production, conservation and utilization of natural pasture hay for feeding dairy cattle in the greater Addis milk shed, central highlands of Ethiopia. *Journal of Agricultural Research and Development*, 3(6): 082-093.

Fikru S. (2015). Assessment of Cattle Fattening and Marketing Practice in Harshin District of Somali Regional State, Ethiopia. *Journal of advanced Dairy Res*earch, 3: 137. doi:10.4172/2329-888X.1000137

Fiseha T. W. (2018). Feed Resources, Feeding Practices And Nutrient Balance of Dairy Cattle in Kedida Gamela Woreda of Kambata Tambaro Zone, South Central Ethiopia. Msc. Thesis Submitted to Arba -Minch University, Ethiopia

Fröberg, S., Aspegren-Güldorff A., Olsson I., Marin B., Berg C., Hernández C., Galina C.S., Lidfors L. & Svennersten-Sjaunja K. (2007). Effect of restricted suckling on milk yield, milk composition and udder health in cows and behaviour and weight 71 gains, in dual purpose cattle in the tropics. Tropical Animal Health and Production 39, 71-81.

Geberemariyam T. (2018). Comparative Evaluation of Total Mixed Ration and Conventional Feeding for Post Weaned Jersey Calves in the Central Highlands of Ethiopia. Msc Thesis Submitted to Hawassa University College Of Agriculture, Hawassa, Ethiopia

Gebremariam S., Amare S., Derek B. and Solomon A. (2010). Diagnostic study on live cattle and beef production and marketing: constraints and opportunities for enhancing the system, Addis Ababa, Ethiopia. 46p.

Gebrewold A., Alemayehu M., Demeke S., Dediye S. and Tadesse A. (2000). Status of Dairy Research in Ethiopia. In The Role of Village Dairy Co-operatives in Dairy Development. Smallholder Dairy Development Project (SDDP) Proceeding, Ministry of Agriculture (MOA). Addis Ababa, Ethiopia.

Getachew A., Hailu B., Workneh N. and Gezahegn, A. (1993). A survey of the farming systems of Vertisol areas of the Ethiopian highlands. In: Improved Management of Vertisols for Sustainable Crop-livestock Production in the Ethiopian Highlands: Synthesis report. Addis Ababa, Ethiopia.

Getachew M., Tsehay R., Zelalem L., Gerba L., Duncan, A.J. 2 and Yeshambel M. (2015). Assessment of livestock production systems, the potential of feed availability, farming system and livestock production problems in Fogera District, Amhara Region, Ethiopia. *Conference paper*, March 2015. ILRI

Getahun K., Ashenafi M., Getnet A. and Getachew A. (2018). Nutritional and fermentative quality of sugarcane (*Saccharum officinarum*) top ensiled with or without urea and molasses. *African Journal of Agricultural Research*. 13(20), pp. 1010-1017.

Getnet A. (2012). Retrospects and prospects of forage and pasture crop research in Ethiopia. In: Getnet Assefa, Mesfin Dejene, Jean Hanson, Getachew Anemut, Solomon Mengistu and Alemayehu Mengistu (eds), Forage seed research and development in Ethiopia. Ethiopia Institute of Agricultural Research, Addis Ababa, Ethiopia. Pp 7-14.

Girma C., Yoseph M. and Mengistu U. (2014). Feed resources quality and feeding practices in urban and peri-urban dairy production of southern Ethiopia. *Tropical and Subtropical Agroecosystems*, 17: 539 – 546

Girma C., Yoseph M. and Mengistu U. (2014). Performance of crossbred dairy cows under small and medium scale farmers' management in and around Shashamane city, Southern Ethiopia. *Global Journal of Scientific Research*. volume 2(1).

Gouri M. (2012). Effect of Drying Versus Ensiling of Maize Stover on Chemical Composition and Feeding Value to Lactating Crossbred Cows. PhD Dissertation submitted to the Karnataka Veterinary, Animal and Fisheries Sciences University, Bidar.

Guim A., Andrade P., Iturrlno-Schocken R.P.,Malheiros E.B. (1998). Aerobic Stability of Wilted Grass Silages (*Pennisetum purpureum*, Schum) Treated with Microbial Inoculant Fundacao Moki'ti Okada and Universidade Estadual Paulista, Jaboticabal Campus, Sao Paulo, Brazil.

Guim A. P., Andrade D. and Malheiros E.B. (1999). Effect of EM on the Consumption, Nutritive Value and Digestibility of Elephant Grass Silage by Ruminant Animals. FCAVJ, UNESP Jaboticabal SP Brazil.

Gupta J.J., Dey A., Bhatt B.P., Chakrabarti A., Dayal S., Kumari R. and Barari S.K. (2014). Performance of lactating crossbred cows fed on forage based total mixed ration. *Livestock Research International Journal* Vol (2) Issue 2 Pp. 30-32

Guyer Q. P. (1986). Feeding Corn and Sorghum Silages to Beef Cattle. Published by cooperative extension, institute of agriculture and natural resource. University of Nebraska Lincoln

Gryseels G. (1988). Role of Livestock on a Mixed Smallholder Farms in Debre Berhan, PhD Dissertation, Agricultural University of Wageningen, The Netherlands. 249p.

Henderson N. *(*1993). Silage Additives. *Animal Feed Science Technology*, 45 (1): 35-56

Higa T. (1994). Effective Microorganisms: A New Dimension for Nature Farming. pp. 20-22. InJ.F. Parr, S.B. Hornick, and M.E. Simpson (eds). *Proceedings of the 2nd International Conference on Kyusei Nature Farming.* U.S.Department of Agriculture, Washington, D.C, USA.

Hiwet G., Girmay G., Nigussie A., Mengsteab H. , Kassa T., and Shimbahri M.(2017). Conversion of communal grazing land into arable land and its impacts on soil properties and vegetation cover. *Arid land research and management.* .https://doi.org/10.1080/15324982.2017.1406412

Hundal J.S., Gupta R.P., Wadhwa M., Bakshi M.P.S. (2004). Effect of feeding total mixed ration on the productive performance of dairy cattle. *Animal Nutrition and Feed Technology*, 4: 179-186.

Indetie D. (2009): Effects of nutritional supplementation and genotype on milk production and fertility of lactating dairy cattle under tropical conditions.Pp.29- 30. International

Symposium on Sustainable Improvement of Animal Production and Health.Vienna, Austria, 8-11 June 2009.

Jabbar M., Negassa A. and Gidyelew T. (2007). Improving Market Opportunities. In *Geographic distribution of cattle and shoats populations and their market supply sheds in Ethiopia*. ILRI (International Livestock Research Institute), Discussion Paper No. 2. Nairobi, Kenya; 54.

Jahnke H. E. (1982). Livestock Production Systems and Livestock Development in Tropical Africa. Kieler Wissenschaftsverlag Vauk. Kiel, Germany.

John M. (2005). Making quality silage: Tropical dairy farming; feeding management for smallholder dairy farmers in the humid tropics, p. 312, land links press.

Jones C. M., Heinrichs A. J., Roth G. W. and Ishler V. A. (2004). Understanding Silage Management. From Harvest to Feed: Penn State College of Agricultural Sciences research and extension programs are funded in part by Pennsylvania counties, the Commonwealth of Pennsylvania, and the U.S. Department of Agriculture.

Kamstra L.D., Luther R.M. and McGuffey R.K. (1979). Silage making and silage additives. South Dakota Cattle Feeders Field Day Proceedings and Research Reports, 1979. Paper 4. http://openprairie.sdstate.edu/sd_cattlefeed_1979/4

Kassahun A., Synman H.A. and Smit G.N. (2008): Impact of rangeland degradation on the pastoral production systems, livelihoods and perceptions of the Somali pastoralists in Eastern Ethiopia. *Journal of Arid Environments*, 72(7): 1265-1281.

Kassahun G., Tolemariam T. Tolera A., Beyene F. and Demeke S. (2015). Feed resources and livestock production situation in the Highland and Mid altitude areas of Horro and Guduru district of Oromia regional state, western Ethiopia. *Science of Technical Arts Research Journal 4(3):* 111-116.

Keady T.W.J. (1996). A Review of the Effects of Molasses Treatment of Unwilted Grass at Ensiling on Silage Fermentation, Digestibility and Intake, and on Animal Performance. *Irish Journal of Agricultural and Food Research*, 35, 141.

Kearl L. C. (1982). Nutrient requirements of ruminants in developing countries. International Feed Stuffs Institute, UTAH State University, Logan, 381pp.

Ketema W. (2014). Assessment of Dairy Cattle Feed Resources and Milk Yields under Smallholder Farmers in Kersa Malima Woreda. Msc. Thesis Submitted to Addis Ababa University, CVMA, Ethiopia.

Khan A. M., Nisa M.U.and Sarwar, M. (2003). Techniques of measuring digestibility for the nutritional evaluation of feeds. *International Journal of Agriculture and Biology*, 05(1): 91 -94. Faisalabad, Pakistan.

Khan S.R., singh S.K and Mudgal V. (2010.) Effect of feeding complete rations on the performance of lactating crossbred cow .*Indian Journal of Animal Nutrition;* 27(3):261-264.

Kitaba A. and Tamir B. (2007). Effect of harvesting stage and nutrient levels on nutritive values of natural pasture in central highlands of Ethiopia. *Agricultura tropica et subtropica*. Vol. 40 (1) 2007

Knický M. and Spörndly R. (2014). Silage additives - assessment of their efficiency to improve aerobic stability of silages. *Proceeding conference of 16th International Symposium Forage Conservation.* Brno, The Czech Republic, p 55.

Kolver E.S. and Muller L. D (1998). Performance and Nutrient Intake of High Producing Holstein Cows Consuming Pasture or a Total Mixed Ration. *Journal of Dairy Sci*ence 81:1403–1411

Kossila, V., 1984. Location and potential feed use. In: Sundstøl, F. and Owen, E. (Eds.). pp. 4-24.

Kung L. and Shaver R. (2001). Interpretation and use of silage fermentation analysis reports. Focus on Forage 3(13):1-5

Kung L. (2014). Managing the aerobic stability of silages. Proceeding conference of 16th International Symposium Forage Conservation. Brno, The Czech Republic, pp 47

LeroyJ.L.M.R., Langbeen A., Hoeck V. and Bols P.E.J. (2010). Effect of energy balance on oocyte and embryo quality in modern dairy cows. WCDS *Advanced Dairy Technolology* .,22: 71-79.

Lukuyu B., Gachuiri C.K., Lukuyu M.N., Lusweti C. and Mwendia S. (2012.): Feeding dairy cattle in East Africa. East Africa Dairy Development Project, Nairobi, Kenya. Pp. 63-79.

Maekawa M., Beauchemin K.A. and Christensen D.A. (2002). Effect of concentrates level and feeding management on chewing activities, saliva production and ruminal pH of lactating dairy cows. *Journal of Dairy Science*. 85:1165-1175.

Malede B. and Takele A. (2014). Livestock Feed Resources Assessment, Constraints and Improvement Strategies in Ethiopia. *Middle-East Journal of Scientific Research.* 21 (4): 616-622, 2014

Mannetje L. T. (2000). The future of silage making in the tropics. In: Mannetje, L. (ed.) Silage making in the tropics with particular emphasis on smallholders. Plant Production and Protection Paper No. 161. pp. 169–171. (FAO: Rome).

McDonald P., Edwards R. A., Greenhalgh J. F. D., Morgan C. A., Sinclair L. A., Wilkinson R. G. (2010). Animal Nutrition. 7th ed. Pearson educational materials, 499 p.

McDonald P., Edwards R. A., Greenhalgh J. F. D. and Morgan C. A. (1995). Systems for expressing the energy value of foods; Animal Nutrition (5th edition) Longman group Ltd Singapore, page 244-259.

McDonald P., Henderson A. R. and Heron S. J. (1991). The Biochemistry of silage. (2nd ed). Cambrian Printers Ltd. Aberystwyth. pp. 184-236.

Melkamu B. Y.and Birhan T.(2014). Silage Additives: *Open Journal of Applied Sciences*, 4, 258-274. http://dx.doi.org/10.4236/ojapps.2014.45026

Misgana D., Gebeyehu G. and Gebreyohannes B. (2015): Characterization of Smallholder Dairy Cattle Production Systems in Selected Districts of East Wollega Zone, Ethiopia. *World Journal of Dairy and Food Sciences*, 10(2): 95-109.

Mohammed H., Yisehak K. and Meseret M. (2016). Assessment of Livestock Feed Resources Utilization in Jimma Zone, Southwest Ethiopia. *Academic Journal of Nutrition,* 5 (1) DOI: 10.5829/idosi.ajn.2016.01.17

Mtengeti E. J., Maeda F. H. and Urio N. A. (2014). Effects of Chopping, Additive and Silo Type on the Quality of Elephant Grass (*Pennisetum Purpureum*) Silage**.** *Livestock Research for Rural Development* 26 (4) 2014

Mulualem T. and Molla M. (2013). Production Constraints, Farmers Preferences and Participatory on Farm Evaluation of Improved Forage Technologies in Selected Districts of Southern Ethiopia. *Greener Journal of Agricultural Sciences,* 3 (9):628-635.

Mulugeta A. (2015). Evaluation of Effective Microbes (EM) Treatment on Chemical Composition of Crop Residues and Performance of Crossbred Dairy Cows. Msc. Thesis Submitted to Haramaya University, Haramaya, Ethiopia.

Mulugeta F. (2015). Production System and Phenotypic Characterization of Begait Cattle and Effects of Supplementation with Concentrate Feeds on Milk Yield and Composition of Begait Cows, In Humera Ranch, Western Tigray, Ethiopia. PhD Dissertation, Addis Ababa University, College of Veterinary Medicine and Agriculture. Debre Zeit, Ethiopia.

Muya M.C., Nhrerera F.V., Khekana T. and Ramapuptla (2011). Lactataion Performance of Mutli- parous Cows Fed a restricted Total Mixed Ration plus Legume and Grass Hay Mixture. *Journal of Animal and Veterinary Advances,* 10 (14): 1779-1784

Nhan N.T.H., Hon N.V. and Preston T.R. (2009). Ensiling with or without additives to preserve pineapple residue and reduce pollution of the environment. *Livestock Research for Rural Development.* Volume 21, Article 96.

Nisa M.u., Touqir N. A., Sarwar M. , Khan M. A. and Akhtar M. (2005). Effect of Additives and Fermentation Periods on Chemical Composition and In situ Digestion Kinetics of Mott Grass (*Pennisetum purpureum*) Silage. *Asian-Aust. Journal of Animal Sciences*. Vol 18, No. 6 : 812- 815)

NRC (2001). Nutrient Requirements of Dairy Cattle. 7th Revised Edition. National Research Council, National Academy Press, Washington, D.C., 406p.

O'Connor, C.B. 1994. Rural dairy technology. ILRI training manual No. 1. *International Livestock Research Institute (ILRI)*, Addis Ababa, Ethiopia. p133.

O'Callaghan T. F., Hennessy D., McAuliffe S., Kilcawley K. N., O'Donovan M., Dillon P., Ross R. P. and Stanton C. (2016). Effect of pasture versus indoor feeding systems on raw milk composition and quality over an entire lactation. *Journal of Dairy Sci.ences 99:9424–9440* http://dx.doi.org/10.3168/jds.2016-10985

Ofori A. D. and Nartey M. A. (2018). Nutritive Value of Napier Grass Ensiled Using Molasses as an Additive. *International Journal of Engineering and Science,* V 7. Issue 9 PP 45-50

Ohshima M., Kimura E. and Yokota H. (1996). A method of making good quality silage from direct cut alfalfa by spraying previously fermented juice. *Animal Feed Science Technology,* 66:129-137.

Ohshima M., Cao L. M., Yokota E., Kimura Y., Ohshima and Yokota H. (1997). Influence of addition of fermented green juice to alfalfa ensiled at different moisture contents, *Journal of Grassland Science.* (Japan), 43:56-68.

Olorunnisomo O. A. and Adesina M. A. (2014).Silage Characteristics, Nutritive Value and Preference of Zebu Cows for Moringa Leaf Ensiled with different levels of Cassava Peel. *Journal Of Applied Agricultural Research*, 6(1): 191-196 Issue 2006-750x

Olorunnisomo O. A. and Ibhaze G. A. (2013). Milk Yield and Feed Conversion of Sokoto Gudali Cows Fed Elephant Grass Ensiled with Cassava Peel. *Agricultural tropica et subtropica*, 46/4, 123-128, 2013

O'Mahony F. (1988). Rural dairy technology experiences in Ethiopia. ILCA Manual No.3 Dairy Technology Unit. ILCA, Addis Ababa, Ethiopia. p 64

Ososanya T. O. and Olorunnisomo O. A . (2015). Silage characteristics and preference of sheep for wet brewer's grain ensiled with maize cob. *Livestock Research for Rural Development Volume 27(1)*

Pachauri S.K, Singh S.K. and Mudgal V. (2010). Effect of Feeding Wheat Straw and Urea Ammoniated Wheat Straw Based Total Mixed Rations on the performance of Female Crossbred Calves. *Indian journal of Animal nutrition,* 27 (1): 73-76

Paul S. S., Mandal A. B., Mandal G. P., Kannan A. and Pathak N. N. (2004). Deriving Nutrient Requirements of Lactating Indian Cattle under Tropical Condition Using Performance and Intake Data Emanated from Feeding Trials Conducted in Different Research Institutes. *Asian-Aust. Journal of Animal science;* Vol 17, No. 6 : 769-776

Pedroso A. F., Nussio L.G., Loures D.R.S. (2008). Fermentation, losses, and aerobic stability of sugarcane silages treated with chemical and bacterial additives. *Scientia Agricola*. 65:567-691.

Pedroso A.F., Rodrigues A.A., Júnior W.B.and Souza G.B. (2011). Fermentation parameters, quality and losses in sugarcane silages treated with chemical additives and bacterial inoculants. *Revista Brasileira de Zootecnia.* 40(11):2318-2322

Peyrat J., Baumont R. A., Morvan L., Nozière P. (2016). Effect of maturity and hybrid on ruminal and intestinal digestion of corn silage in dry cows; *Journal of Dairy Science*, 2016, 99, Safalaoh A. C. L. (2006). Body weight gain, dressing percentage, abdominal fat and serum cholesterol of broilers supplemented with a microbial preparation. *African Journal of Food Agriculture Nutrition and Development,* 6(1)

Samson L. and Frehiwot M. (2014). Spatial analysis of cattle and shoat population in Ethiopia: growth trend, distribution and market access. *Springer open. D*OI: 10.1186/2193-1801-3-310.

Statistical Analysis System (SAS), (2004). Version 9.1. SAS Institute. Inc., Cary, NC, USA.

Schingoethe D.J. (2017). A 100-Year Review: Total mixed ration feeding of dairy cows. *Journal of Dairy Science.* 100(12):10143-10150. DOI: 10.3168/jds.2017-12967

Selamawit D., Yeshambel M. and Bimrew A. (2017). Assessment of livestock production system and feed balance in watersheds of North Achefer District, Ethiopia. *Journal of Agriculture and Environment for International Development* - JAEID 2017, 111 (1): 175-190

Senthilkumar S., Suganya T., Deepa K., Muralidharan J. and Sasikala K. (2016). Supplementation of molasses in livestock feed. *International Journal of Sciences and environmental technology,* 5(3):1243–1250.

Seyoum B., Zinash S., Tadesse T. and Liyusew A. (1997). Evaluation of Napier (Pennisetum purpureum) and Pennisetum hybrids (*Pennisetum purpureum X Pennisetum typhoides*) in the central highlands of Ethiopia. In: Proceedings of the Fifth National Conference of the Ethiopian Society of Animal Production. 15-17 May, 1997, Addis Ababa, Ethiopia. pp. 194-202

Seyoum B., Getenet A., Abate T. and Dereje F. (2001). Present status and future direction in feed resources and nutrition research targeted for wheat based crop livestock production system in Ethiopia. In: P.C. Wall (ed.), Wheat and Weed, Food and Feed, Proceedings of two-stakeholder workshop, CIMMYT, Mexico City, pp 207-226.

Sharp R, Hooper P G and Armstrong D G (1994). The digestion of grass silages produced using inoculants of lactic acid bacteria. *Grass Forage Science* 49: 42-53.

Shimelis M. and Temesgen A. (2016). Training report on forage production, fee management and utilization for Africa RISING project farmers in Basona Worena Ethiopia**.** International Livestock

Shitahun M. (2009). Feed Resources Availability, Cattle Fattening Practices and Marketing System in Bure District, Amhara Region, Ethiopia. Msc. Thesis submitted to Mekelle University, Ethiopia.

Shuiep E. S., Eltaher H.A. and El Zubeir, I. E.M. (2016). Effect of Stage of Lactation and order of Parity on Milk Composition and Daily Milk Yield among Local and Crossbred Cows in South Darfur State, Sudan**.** *Journal of Agricultural and Veterinary Sciences* Vol. 17 No.(2) ISSN: 1858 6775

Silva M. S.J., Jobim C.C., Poppi E.C., Tres T. and Osmari M. P. (2015). Production technology and quality of corn silage for feeding dairy cattle in Southern Brazil. *Revista Brasileira de Zootecnia,* 44(9):pp. 303-313.

Solomon B., Solomon M. and Alemu Y. (2008). Matching livestock systems with available feed resources in the bale highlands of Ethiopia. Outlook on Agriculture. 37 (2):105-10.

Solomon M. (2011). Current status of dairy cow feeding in the Ethiopian Central Highlands and some recommendations for promising technologies. International livestock institute, ILR, SNV

Soriano F. D., Polan C.E., and Miller C.N. (2001). Supplementing pasture to lactating Holsteins fed a total mixed ration diet. *Journal of Dairy Science, 84*, pp: 2460–2468.

SPSS (Statistical Package for Social Science). (2002). SPSS, Ver. 20 for Windows. Inc. Chicago, Illinois. 109p

Streeter S. (2006): Feeding livestock in temporary holding facilities in the Northern Territory, Australia. No: J86. http://www.nt.gov.au/d/Content/File/p/Anim_Man/831.

Suttie J.M. (2000). Hay and straw conservation for small-scale farming and pastoral conditions. Plant Production and Protection Series No. 29. (FAO: Rome).

Tadesse B., Zelalem Y., Yohannes G. and Alemu G. (2003). Nutrient utilization efficiency of lactating crossbred dairy cows supplemented different levels of concentrate diets. Pp. 341-346. Proceedings of the 10th annual conference of Ethiopian Society of Animal production (ESAP). Ababa, Ethiopia, 22-24 August 2002, Ethiopian Society of Animal Production (ESAP)

Tessema Z., Aklilu A. and Ameha S. (2003). Assessment of the livestock production system, available feed resources and marketing situation in Belesa Woreda: A case study in drought prone areas of Amhara Region. PP. 165-175. In: Proceedings of the 10th annual conference of the Ethiopian Society of Animal Production (ESAP) held in Addis Ababa, Ethiopia, August 22-24, 2002.

Tilley J. M. A. and Terry R. A. (1963). A two-stage technique for the *in- vitro* digestion of forage crops. Grass and Forage Science, 18: 104–111.

Tolera A., Yami A. and Alemu D. (2012). Livestock feed resources in Ethiopia: Challenges, Opportunities and the need for transformation, Ethiopia Animal Feed Industry Association, Addis Ababa, Ethiopia.

Tsedeke A., Bekele S., Abebe M., Dagne W., Yilma K., Kindie T., Menale K., Gezahegn B., Berhanu T. and Tolera K. (2015). Factors that transformed maize productivity in Ethiopia. *Food Science*. DOI 10.1007/s12571-015-0488-z.

Ronaldo. (2006). Performance of Lactating Dairy Cows Fed Varying Levels of Total Mixed Ration and Pasture. PhD Thesis Presented to the School of Graduate Studies of North Carolina State University. 205p.

Rusdy M. (2015). Effects of additives on fermentation characteristics and chemical composition of ensiled *Chromolaena odorata* leaves. *Livestock Research for Rural Development.* Volume 27(4)

Van Soest P.J. and Robertson J. B. (1985). Analyses of Forage and Fibrous Foods. A laboratory Manual for Animal Science 613. Cornell University, Ithaca, New York, USA.

Walli T.K. (2009). Crop residue based densified feed block technology for improving ruminant productivity. In [Walli, T.K., ed]. Proceedings of the national symposium on fodder block technology, pp. 67–73. ILDEX India–2009, New Delhi

Weinberg Z. G. and Muck R. E. (1996). New trends and opportunities in the development and use of inoculants for silage. Microbial Rev., 19: 53-68.

Wilkinson J.M., Wadephul F. and Hill J. (1996). Silage in Europe, a survey of 33 countries. Chalcombe Publications, Welton, UK.

Wilkinson M. (1990). “Silage UK”, 6th edition. Chalcombe Publications, Marlow, UK

Winters A. L., Merry R. J., Muller M., Davies D. R., Pahlow G. and Muller T. (1998). Degradation of fructans by epiphytic and inoculant lactic acid bacteria during ensilage of grass. *Journal of Applied Microbiology*, 84:304-312.

Wondatir Z. (2015). Assessment of livestock production system and feed resources availability at Melka watershed of Nile Basin, Jeldu district, western Ethiopia. *Global Journal of Science Frontier Research*, 15(9): 7-20.

Woolford M. K. (1990). The detrimental effects of air on silage. *Journal of Applied Bacteriology.* 68:101-116.

Wren G. (2000). Evaluating silage problems. Bovine Veterinarian, May-June, pp. 4-8.

Yahaya M. S., Goto M., Yimiti W., Smerjai B. and Kawamoto Y. (2004). Additives effects of fermented juice of epiphytic lactic acid bacteria and acetic acid on silo fermentation and ruminal degradability of tropical elephant grass. *Journal of Animal Veterinary Advances.* ;3:115–121.

Yamane T. (1967). Statistics: An Introductory Analysis, 2nd Ed., New York: Harper and Row

Yang C. M., Haung J. S. C., Chang T., Cheng Y. H. and Chang C. Y. (2004). Fermentation acids, aerobic fungal growth, and intake of Napier grass ensiled with non-fiber carbohydrates, *Journal of Dairy Science,* 87: 630-636.

Yayneshet T. (2010). Ethiopia Sanitary & Phytosanitary Standards and Livestock and Meat Marketing Program (SPS-LMM) Texas A & M University System: Feed Resources Availability in Tigray Region, northern Ethiopia, for Production of Export Quality Meat and Livestock

Yeshitila A., Tessema Z. and Azage T. (2008). Availability of livestock feed resources in Alaba Woreda, Southern Ethiopia. In: Proceedings of the 16th annual conference of the Ethiopian Society of Animal Production (ESAP) held in Addis Ababa, Ethiopia, October 8 to 10, 2008.

Yihalem D., Berhan T. and Solomon M. (2006). Effect of harvesting date on composition and yield of natural pasture in north western Ethiopia. Tropical Science 45(1):19-22.

Yisehak K. & Geert P.J.J. (2014). The impact of Feed supply and Requirement on productivity of Free-Ranging Tropical Livestock Units: Links of multiple Factors. Laboratory of Animal nutrition, Faculty of Veterinary Medicine, Ghent University, Heidestraat 19,9820, Merebeke,Belgium.

Yonatan K., Solomon D., Taye T. and Yehenew G. (2014). Effect of Effective Microorganism (EM) on the nutritive quality of coffee husk silage. *International journal of scientific & technology research* volume 3, issue 7*,* ISSN 2277-8616

Yunus M., Ohba N., Tobisa M., Shimojo M. and Masuda Y. (2001). Effects of preheated additives on the fermentation quality of Napier grass silage. *Asian –Aust. Journal of Animal Science* vol. 14, No11:1564-156

Zemene W., Samuel T., Taye T. and Worku J. (2016). Assessment of the Prevailing Cattle Fattening Practices in Jimma Zone, South-Western Ethiopia. *Global Veterinaria* 17 (2): 105-113, 2016 ISSN 1992-6197

Zewdie W. (2010). Livestock production systems in relation with feed availability in the highlands and central rift valley of Ethiopia. MSc. Thesis submitted to Haramaya Univesity, Ethiopia.

Zewdie W. and Yoseph M. (2014). Feed resources availability and livestock production in the central rift valley of Ethiopia. *International Journal of livestock production*. Vol.5 (2), pp. 30-35.

Zhang W. (2003). Studies on the nutritive value and effective degradability of ensiled corn stover. China Herbivores. cnki:ISSN:1000-6443.0.2003-01-002

Zheng Y. (2013).Adoption of Total Mixed Ration Practice and Profitability: The Case of Ontario Dairy Farms A Thesis presented to The University of Guelph in partial fulfillment of requirements for the degree of Master of Science in Food, Agricultural and Resource Economics, Guelph, Ontario, Canada

Zimmermann I. and Kamukuenjandje R. T. (2008). Overview of A Variety of Trials on Agricultural Applications of Effective Microorganisms (EM). Agricola, Namibia, p. 17

Zinash S., Seyoum B., Lulseged G. and Tadesse T. (1995). Effect of Harvesting Stage on Yield and Quality of Natural Pasture in the Central High-Lands of Ethiopia. Addis Ababa, Ethiopia. In: Proceedings of the 3rd Annual Conference of the Ethiopian Society of Animal Production. 27-29 April 1995. pp. 316-322.

8. APPENDIX

Appendix 1. Structured questionnaire

I. Survey site (Location)

Region: _________ Zone__________ District_____________ Kebele / Mender _______

Altitude (m.a.s.l) _______________

II. Farming system characteristics

Household Characteristics

Date of interview__________________

1. Household head: Name ______________________________

1.1 Sex: Male/Females

1. 2. Age __________ years

1.3. Level of Education of head of the family (circle one):

1. Illiterate 2. Basic education (e.g. Religion based) 3. Primary (1-6)

4. Secondary (7-12) and above secondary

1.5. Family size: Male_________ Female _________ Total ____________

2. Land holding and Farm Characteristics (ha, 'Kert', m^2)

2.1. Land utilization pattern

1) Cultivable land___________
   1.1. Cultivated land _______________
   1.2. Fallow land___________
2) Grazing land______
3) Homestead ________
4) Others (specify)______________
5) Total land _______

2.2. Production and utilization of crops (In reference to last year)

S/No	Type of crop grown	Land size (kert/m^2/hectare	Yield/quintal

2.3. Do you have private grazing land? ( ) Yes ( ) No

If yes, what is the size of the grazing land allocated for it? _____

If no, where and how you graze your animals?

2.4. Is there any communal grazing land in your locality? ( ) Yes ( ) No

If yes, what is the size/status of this grazing land? _____

A. Decreasing B. Increasing C. No change

2.5. Is the grazing resource adequate to your animals? (A) Yes (B) No

If no, what measures do you take to alleviate feed shortage? (A) Purchase concentrates (B) Purchase forage (rent grazing land) (C) Use crop residues (D) Preserve any feed during high production season (E) Undergo destocking (F) others (specify) ---

3. Livestock holdings and herd structure

S/No	Type of animal	Local breeds	Crossbred	Total
1	Cows			
2	Oxen			
3	Heifers			
4	Young bulls			
5	Calves (<6months)			
6	Sheep			
7	Goats			
8	Horse		*******	
9	Donkeys		*******	
10	Mule		*******	
11	Chicken			

4. **Feed resources and feeding system**

4.1. What are the major feed resources in dry season (November- May) and wet season (June-October)? (Rank 1-5 in the order of importance)

Period	Natural pasture	Crop residues	Hay	Non-conventional feeds (Household wastes/left over)	Cultivated forages	Others (specify)
Dry						
Wet						

5.1. How do you store hay or crop residues? (A) Stacked outside (B) stacked under shade (C) Baled outside (D) baled under shade (E) other (specify) ------------------------------

5.2. When do you start feeding crop residues for your animals?

(A) Soon after collection (B) One month after (C) Two months later (D) Over two months (E) Other (specify) -----------------------------------

5.3. In what form do you feed your crop residue? (A) Whole (B) chopped (C) treated (D) Mixed with other feeds (E) other (specify) -----------------

4.5. Do you use crop residues for other purposes other than livestock feeding?

A. yes B. no

If yes, for which purpose?

4.6. Livestock feeding system (Tick "√")

1) Free grazing alone 3) Grazing and stall feeding 2) Stall feeding/Zero grazing 4) Tethered grazing

5. Seasonal distribution of different feed resources

Types of feed resource	Months ("√" if applicable)											
	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Pasture grazing												
Stubble grazing												
Road side grazing												
Fallow land grazing												
Grass hay												

Crop residue												
Improved fodder												
Tree leaves												
Concentrate (AIBP)												
Non-conventional feeds												
Others (Specify)												

6. How do you classify months of the year according to feed availability

Feed availability	Months "√" if applicable)											
	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Excess												
Adequate												
Shortage												

7. Do you apply any management technique to improve productivity of your pasture land?

(A) Yes (B) No

If yes, what management technique do you apply?

Management technique	"√" for the management you applied
Application of fertilizer	
Application of manure	
Over sowing of forage legume seeds	
Removal of weeds and unpalatable plants	
Others (specify)	

If not applying any management techniques why? ___________________

8. Improved forage and pasture crops

Do you have improved forages? (A) Yes (B) No

If yes, list their name and state their utilization

1.______________________ 4.________________________

2._______________________ 5. ___________________

3.________________________ 6. ___________________

If no, why?

d. Shortage of land b. Shortage of forage seed c. Lack of capital to buy seeds d. lack of awareness e Not interested in it f. Other (specify) -------------------------

9. Do you use purchased feeds for your cattle? (Circle one) ( )Yes ( ) No
If yes, what type of purchased feeds do you use**? --------------------------------------**
If no, what is the reason**?** (Circle one) a/Unavailable b/High cost c/Lack of money d/ Less understanding e/other (specify)
If yes, to which group of animals do you give priority?

Supplemented dairy cows	**Tick**	**Rank**		
Oxen				
Cows				
Heifers				
Young bulls				
calves				

9. Do you use any non-conventional feed resources like house wastes, banana leaves, brewery waste, and vegetable refusals)? (A) Yes (B) No

If yes list their name? 1. -------------------- 2. --------------------- 3. --------------------

10. Feed conservation/ collection and storage

Do you conserve/store Feeds for your animals? (A) Yes (B) No If yes, what is the form of conservation and feed types

Types of feed	Form of conservation Tick one or more ‘’√’’		
	hay	Silage	Other specify

11. Do you use green maize “eshet” for consumption and/or selling to generate cash income?

A. yes B. no

If yes, what is the fate of the green stover?

fate of the green maize stover	"√" the fate of green stover
Given to animals immediately	
Preserved in the form of silage	
Left on the field to dry	
Others (specify)	

12. Is silage making common in your area from green maize stover? A. Yes B. No

If no, why?

Reason for not making silage from green maize stover	"√" reason for not making silage
Lack of awareness	
Lack of money to buy necessary tools	
Both lack of awareness and capital	
Other (specify)	

13. Factors for not using green maize stover as livestock feed

Reason for not using fresh stover as livestock feed	"√" why didn't use green maize stover immediately after ear harvesting
Other feed resources are availability during green cob harvesting	
With an assumption to restore nutrients to the soil while animals fed on the farmland	
No reason	
Other (specify if any)	

14. Feed resources estimation in the study districts (information from woreda agri. Office in reference to last year)

Land allocation	**Land size in the district(ha)**	
Grazing and browsing land in the district(private and communal)		
Aftermath grazing		
Forest		
Other (specify if any)		
Crops grown in the district	Total area (Kert)	Total Yield in the district(Quintal)
Maize		
Sorghum		

Teff		
Wheat		
Barley		
Faba bean		
Field Pea		
Noug		
Linseed		

15. Livestock numbers in the study districts

Livestock spp.	Population	
	Local	Exotic
Cattle		
Cows		
Oxen		
Heifers		
Young bulls		
Calves		
Sheep		
Goats		
Horses		
Mules		
Donkeys		
Chickens		

16. What are the major water sources for your animals? (Tick one or more)

Season	Source of water						
	River	Dam/pond	Borehole	Spring	Pipe	Rain	Other
Dry season							
Wet season							

17. How far is the watering point for your animals from your home during dry and wet season? (Tick one)

Season	Distance					
	Watered at	<1km	1-3km	5-7km	7-10km	>10 km
Dry season						
Wet season						

18. What is the frequency of watering during dry season? (circle one) a/ Freely available b/ Once a day c/ Once in 2 days d/ Once in 3 days e/Other (specify) ----------

19. What is the quality of water given to your dairy cows during dry and wet season? (Tick one)

Season	Quality of water				
	Good/clear	Muddy	Salty	Smelly	Other Specify)
Dry season					
Wet season					

20. What are the major problems that affect your production activity? (Tick the problems and rank them)

Constraints/ problems	Tick here	Rank
Shortage of feed		
Health problem		
Water scarcity		
Low performance of the breed		
Market problem		
Specify (if any)		

What do you suggest any solutions to the above top five constraints?

----------- ------------- ---------------- ------------- ----------------------

21. Services provided by the government and non-governmental organizations

Do you get institutional support from any organization regarding to livestock production? (Circle one) ( ) Yes ( ) No

If yes, mention the institutions?

a/ ---------------------- b ---------------------- c/ ------------------------ d/-----------------------------

22. What is/are the support(s) given by the institution(s) mentioned above?

a/ Training on how to feed b/Training on how to maintain the health

c/ Provision of improved breeds d/Training on housing e/Credit services

f/ Others specify-------------------------------

Do you have any comment about the existing livestock extension system? ( ) Yes ( ) No

If yes, what are your comments?

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Appendix. 2

Table 1. Conversion factors of livestock number to Tropical Livestock Unit (TLU)

Livestock spp.	TLU
Local oxen/bull	1.1
Crossbred oxen/bull	1.9
Local cows	0.8
Crossbred cows	1.8
Local heifers	0.5
Crossbred heifers	0.7
Local calves	0.2
Crossbred calves	0.4
Sheep	0.1
Goats	0.1
Horses	0.8
mules	0.7
Donkeys	0.5
Chicken	0.01

Source: Gryseels (1988) and Bekele (1991), TLU=Total Livestock Unit.

Appendix 3. Crop Residue Estimation of the Study Districts

Bako Tibe district						
Crop type	Land cultivated/ha	Yield/ha	Total yield /Quintal	Conversion factor	Estimated straw/quintal	Estimated straw/tone
Teff	7936	18	142898	1.5	214347	21434.7
Wheat	1945	16.7	32475	1.5	48712.5	4871.25
Barley	733	16.39	12016	1.5	18024	1802.4
Maize	11612	61.49	713990	2	1427980	142798
Sorghum	1783	26.42	47098	2.5	117745	11774.5
Horse bean	1646	16.99	27962	1.2	33554.4	3355.44
Field pea	447	14	6285	1.2	7542	754.2
Haricot bean	26.42	24	634	1.2	760.8	76.08
Noug	1917	11.52	22094	4	88376	8837.6
			Total			**195704.17**

Toke Kutaye district						
Crop type	Land cultivated/ha	Yield/ha	Total yield /Quintal	Conversion factor	Estimated straw/quintal	Estimated straw/tone
Teff	6283	19.90	125059	1.5	187588.5	18758.85
Wheat	7447	26.76	199255	1.5	298882.5	29888.25
Barley	4419	28.20	124616	1.5	186924	18692.4
Maize	3298	46.56	153562	2	307124	30712.4
Sorghum	1382	24.95	34488	2.5	86220	8622
Horse bean	827	20.54	16988	1.2	20385.6	2038.56
Field pea	1214	13.25	16085.7	1.2	19302.84	1930.284
Lentil	214	8.44	1806.3	1.2	2167.56	216.756
Chick-pea	408	21.37	8719	1.2	10462.8	1046.28
Grass pea	427	22.00	9394	1.2	11272.8	1127.28
Haricot bean	115	14.25	1639	1.2	1966.8	196.68
Noug	1113	9.2	10240	4	40960	4096
Flax	735	11.36	8350	4	33400	3340
						120665.74

Ejere district						
Crop type	Land cultivated/ha	Yield/Qu/ha	Total yield /Quintal	Conversion factor	Estimated straw/quintal	Estimated straw/tone
Teff	6866.40	25.3	173720	1.5	260580	26058
Wheat	8731.53	35.5	309969.2	1.5	464953.8	46495.38
Barley	5908.69	29.7	175488	1.5	263232	26323.2
Barley (beer)	859.65	28.75	24715	1.5	37072.5	3707.25
Maize	335.58	39	13087.6	2	26175.2	2617.52
Sorghum	284.5	20.75	5904	2.5	14760	1476
Horse bean	763.6	20.65	15768.9	1.2	18922.68	1892.268
Field pea	178.5	10.71	1911.5	1.2	2293.8	229.38
Lentil	979	10.76	10535.6	1.2	12642.72	1264.272
Chick-pea	1867.6	25	46689	1.2	56026.8	5602.68
Grass pea	576	22.89	13186	1.2	15823.2	1582.32
Haricot bean	73	13.3	971.3	1.2	1165.56	116.556
Noug	48	9.46	454	4	1816	181.6
Flax	490	10.98	5382	4	21528	2152.8
Total						**119699.23**

The amount of feed estimated in 2016/2017 cropping year

Land use	Area/ha			Conversion Factor (tons)	Annual DM production(ton)			Average
	Bako-Tibe	Toke kutaye	Ejere		Bako-Tibe	Toke kutaye	Ejere	
Grazing and browsing	8346	8017	6791	2	16692	16034	13582	15436
Aftermath grazing	28100	27718	26302	0.5	14050	13859	13151	13,686
Forest, bush land	3470	2846	4436	0.7	2429	1992.2	3105.2	2508.8

Livestock population of the three districts in number and in tropical livestock units (TLU)

Species	Livestock numbers[1]			Conversion factor [2]	Tropical livestock unit(TLU)		
	Bako-Tibe	Toke kutaye	Ejere		Bako Tibe	Toke kutaye	Ejere
Cattle	137347	185596	97237	0.7	96142.9	129917.2	68065.9
Sheep	12502	47349	49152	0.1	1250.2	4734.9	4915.2
Goats	15381	34782	12778	0.1	1538.1	3478.2	1277.8
Horses	3685	10850	12031	0.8	2948	8680	9624.8
Donkeys	8415	10398	20721	0.5	4207.5	5199	10360.5
Mules	1023	2371	165	0.7	716.1	1659.7	115.5
Chicken	96742	84530	73058	0.01	967.42	845.3	730.58
		Total			107770.22	154514.3	95090.28

Source of data and conversion factors: [1] Woreda livestock production and health agency annual report (2017), [2] Janke(1982)

Land Size Used For Major Crops Grown/House Hold

Report

district		crop land	Maize	wheat	Teff	Barley	other
	Mean	1.9884	1.1783	.0895	.2829	.0407	.3620
Bako Tibe	N	129	129	129	129	129	129
	Std. Deviation	.52650	.43660	.19250	.25841	.12805	.27893
	Mean	1.8209	.4628	.4865	.4459	.2703	.1588
Ejere	N	74	74	74	74	74	74
	Std. Deviation	.62827	.25062	.26461	.24224	.24744	.22881
	Mean	1.6883	.5893	.3442	.3263	.2597	.1640
Toke Kutaye	N	154	154	154	154	154	154
	Std. Deviation	.42809	.27368	.22701	.19455	.20981	.21271
	Mean	1.8242	.7759	.2817	.3354	.1828	.2345
Total	N	357	357	357	357	357	357
	Std. Deviation	.52643	.45576	.27132	.23640	.22099	.25960

Appendix 4. Analysis of Variance (ANOVA)

Total Dry Matter Intake (TDMI)

Source	DF	Squares	Mean Square	F Value	Pr > F
Model	16	134.9755997	8.4359750	4.17	0.0042
Error	15	30.3152025	2.0210135		
Corrected Total	31	165.2908022			

R-Square	Coeff Var	Root MSE	intake Mean
0.816595	12.24157	1.421624	11.61308

Total Organic Matter Intake (TOMI)

Dependent Variable: TOMI

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	16	121.2502590	7.5781412	4.39	0.0032
Error	15	25.9198210	1.7279881		
Corrected Total	31		147.170080		

Crude Protein Intake (CPI)

Dependent Variable: CPI

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	16	3.71562065	0.23222629	9.67	<.0001
Error	15	0.36035185	0.02402346		
Corrected Total	31	4.07597250			

R-Square	Coeff Var	Root MSE	CPI Mean

0.911591	11.33988	0.154995	1.366813

Neutral Detergent Fibre Intake (NDFI)

Source	DF	Squares	Mean Square	F Value	Pr > F
Model	16	48.10455696	3.00653481	3.60	0.0086
Error	15	12.52118739	0.83474583		
Corrected Total	31	60.62574435			

R-Square	Coeff Var	Root MSE	NDFI Mean
0.793467	12.64376	0.913644	7.226049

Dependent Variable: TADFI

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	16	19.97075964	1.24817248	2.67	0.0320
Error	15	7.00659971	0.46710665		
Corrected Total	31	26.97735935			

R-Square	Coeff Var	Root MSE	TADFI Mean
0.740279	16.45577	0.683452	4.153267

Dependent Variable: TADLI

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	16	0.99440818	0.06215051	2.30	0.0576
Error	15	0.40596001	0.02706400		
Corrected Total	31	1.40036819			

R-Square	Coeff Var	Root MSE	TADLI Mean
0.710105	15.89891	0.164511	1.034734

Dependent Variable: ME

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	16	6.34415817	0.39650989	11.55	<.0001
Error	15	0.51507776	0.03433852		
Corrected Total	31	6.85923593			

R-Square	Coeff Var	Root MSE	ME Mean
0.924907	1.945383	0.185307	9.525452

Dependent Variable: Milk yield

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	16	36.57440300	2.28590019	5.54	0.0009
Error	15	6.19189547	0.41279303		
Corrected Total	31	42.76629847			

R-Square	Coeff Var	Root MSE	Milk Mean
0.855216	7.359799	0.642490	8.729719

Dependent Variable: FCM

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	16	60.15300873	3.75956305	4.33	0.0035
Error	15	13.03210528	0.86880702		
Corrected Total	31	73.18511401			

R-Square	Coeff Var	Root MSE	FCM Mean
0.821930	9.291819	0.932098	10.03139

Dependent Variable: fat

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	16	6.06388750	0.37899297	0.75	0.7166
Error	15	7.62111250	0.50807417		
Corrected Total	31	13.68500000			

R-Square	Coeff Var	Root MSE	fat Mean
0.443105	14.45828	0.712793	4.930000

Dependent Variable: protein

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	16	0.40290000	0.02518125	2.39	0.0499
Error	15	0.15828750	0.01055250		
Corrected Total	31	0.56118750			

R-Square	Coeff Var	Root MSE	protein Mean
0.717942	3.297103	0.102725	3.115625

Appendix 2. Dry maize stover left on the field after the removal of green cob, mode of conservation stover after grain harvesting and other uses of maize stalk.

Appendix 3. Chopping, ensiling and evaluations of GMS silages at different periods

Appendix 4. Removing green cob and harvesting green stover, and chopping and compacting the GMS to make quality silage

Appendix 5. Feeding out silage and mixing silage with concentrate to make TMR

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Appendix 6. Weighing and feeding according their body weight at the beginning of each experimental period.

Moisture level/stage of maturity of the maize crop can be estimated from its milk line progression