ASSESSMENT AND UTILIZATION PRACTICES OF OAT *(Avena sativa)* AS FEED AND FOOD RESOURCES, AND CHEMICAL EVALUATION OF ITS SILAGE IN KIMBIBIT WEREDA OF NORTH SHEWA ZONE, ETHIOPIA

MSc. Thesis

Teferi Megersa

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A Thesis Submitted to the Department of Animal Sciences, College of Agriculture and Natural Resource Sciences, College of Graduate Studies

DEBRE BERHAN UNIVERSITY

In Partial Fulfillment of the Requirements for the Degree of Master of science in Animal Nutrition

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Major advisor: Ahmed Hassen (Ph.D)

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DEBRE BERHAN, ETHIOPIA

COLLEGE OF GRADUATE STUDIES

COLLEGE OF AGRICULTURE AND NATURAL RESOURCE SCIENCES

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APPROVAL SHEET - I

This is to certify that the thesis entitled: **Assessment and utilization practices of oat *(Avena sativa)* as feed and food resources, and chemical evaluation of its silage in Kimbibit wereda of north Shewa zone, Ethiopia** submitted in partial fulfillment of the requirements for the degree of master of science with specialization in **Animal Nutrition** of the Graduate Program of the Department of **Animal Sciences**, College of Agriculture and Natural Resource Sciences, Debre Berhan University, is a record of original research carried out by **Teferi Megersa ID: Number PGRP 225/12**, under my supervision, and no part of the thesis has been submitted for any other degree of diploma.

The assistance and help received during this investigation have been duly acknowledged. Therefore, I recommend that it be accepted as fulfilling the thesis requirements.

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We, the under singed members of board of examiners of the final open defense by Teferi Megersa have read and evaluated his thesis entitled **Assessment and utilization practices of oat *(Avena sativa)* as feed and food resources, and chemical evaluation of its silage in Kimbibit Wereda of North Shewa Zone, Ethiopia** and examined the candidate. This is therefore to certify that the thesis has been accepted in partial fulfillment of the requirements for the degree of Master of science in **Animal Nutrition**.

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FINAL THESIS APPROVAL FORM

(Submission sheet-3)

As members of the Board of Examiners of the final Masters open defense, we certify that we have read and evaluated the thesis prepared by **Teferi Megersa** under the "**Assessment and utilization practices of oat (*Avena sativa)* as feed and food resources, and chemical evaluation of its silage in Kimbibit Wereda of North Shewa zone, Ethiopia"** and recommend that it be accepted as fulfilling the thesis requirement for the degree of Master of Science in **Animal Sciences** with Specialization in Animal Nutrition.

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Certification of the final Thesis

I hereby certify that all the corrections and recommendation suggested by the Board of Examiners are incorporated in to the final Thesis **Assessment and utilization practices of oat *(Avena sativa)* as feed and food resources, and chemical evaluation of its silage in Kimbibit Wereda of North Shewa zone, Ethiopia"**by Teferi Megersa.

Ahmed Hassen (Ph.D.)	____________________	______________
Name of major advisor	Signature	Date

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DEDICATION

Overall my works is dedicated to almighty God, than to my lovely wife and children and all my advisors.

STATEMENT OF THE AUTHOR

I declare that this thesis is my genuine work, and that all sources of materials used for this thesis have been profoundly acknowledged. This thesis has been submitted in partial fulfillment of the requirements for Master of Science (MSc) at Debre Berhan University and it is deposited at the University library to be made available for users under the rule of the library. I intensely 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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BIOGRAPHY

The author was born in March 17, 1978 in oromia regional state Aris zone Lemu and Bilbilo wereda Lemu kebele to his father Megersa Jote and his Mother Chaltu Degefa. He attended his primary education at Lemu primary school and secondary education at Bekoji secondary schools. He joined Debre Zeit College of veterinary medicine in 1998 and obtained certificate of Diploma in animal health. After that he started work in Dera Wereda North Shewa Zone. Then he obtained B.Sc. degree in animal science from Haramaya University. He was joined the school of graduate studies at Debre Berhan university to attend his MSc. in animal nutrition in November, 2019.

LIST OF ABBREVIATIONS AND ACRONYMS

ADF	Acid Detergent Fiber
ADL	Acid Detergent Lignin
AOAC	Association of Official Analytical Chemists
CIMMYT	International Maize and Wheat Improvement
Ca	Calcium
CAS	Central Statistics Agency
CF	Crud Fiber
CP	Crud Protein
DA	Development Agent
DBARC	Debre Berhan Agriculture Research Center
DCP	Digestible Crud Protein
DM	Dry Matter
DMI	Dry Matter Intake
EE	Ether Extract
FAO	Food and Agriculture Organization
Fe	Iron
FGD	Focus Group Discussion
GDP	Growth Domestic Product
GLM	General Linear Model
LAB	Lactic Acid Bacteria
M	Molasses
ME	Metabolizible Energy
Mg	Magnesium

LIST OF ABBREVIATIONS AND ACRONYMS

(*Continued*)

MOA	Ministry Of Agriculture
MOARD	Ministry Of Agriculture and Rural Development
N	Nitrogen
NDF	Neutral Detergent Fiber
NDS	Neutral Detergent Soluble
NGO	Non Government Organization
NPN	Non-Protein Nitrogen
P	Phosphorous
SAS	Statistical Analysis System
SPSS	Statistical Package for Social Science
TDN	Total Digestible Nutrient
TLU	Tropical Livestock Unit
U	Urea
WSC	Water Soluble Carbohydrates

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Assessment and utilization practices of oat as feed and food resources, and chemical evaluation of its silage in Kimbibit Wereda of North Shewa Zone, Ethiopia

ABSTRACT

A study with the objectives of assessing on the utilization practice of oat as feed and food resources and chemical evaluation of its silage was carried out in Kimbibit Wereda situated in North Shewa Zone of the Oromia regional state, Ethiopia. A total of 219 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 focus group discussion, key informant interview and field observations. Sample of oats seed were collected from the three study kebeles sow in different beds and grown using irrigations.The oats harvested at 105 days and chopped at 2mm size for silage preparation. The silage experiment was prepared in plastic container with the capacity of 2 kilogram. The treatments were combinations of nine additives (without additive, 0.5% U (urea), 1% U, 2% molasses (M), 4% M, (0.5% U+2% M), (0.5% U + 4%M), (1% U + 2% M), and (1% U +4% M) on fresh weight basis of oat crops with three replications four ensiling periods (21, 28,42 and 56 days). The collected survey data was managed, organized and analyzed using the statistical package of social science (SPSS) version 23. Software, whereas, the experimental data were subjected to analysis of variance using the General Liner Model (GLM) procedure of Statistical Analysis System Version (SAS), 2004 program. Results of the survey indicated that in the study kebeles cattle population were the largest position which was followed by sheep and goat population. The main challenge of local oats production in the study area was the competition of feed, food and wastage for roofing of house and firewood. There was no attention given for management and seed improvement practice of oats at wereda and zonal level. The main reasons for the production of local oats in the study area were because of its frost resistance capability and less production cost requirement. The competition between feed, food and other purpose affects animal productivity. Out of 219 interviewed participants only 85.8 % of the respondents know local oats were registered as animals feed by the ministry of agriculture. The laboratory result illustrated that the dry matter (DM) of treated local oats silage was different from the control sample in the level of molasses treated. Dry matter of

U at 0.5 and 1 % treated silage were also showed significant (P < 0.05) differences. The crude protein (CP) contents of oats silage treated without U (9.8%) was lower than 1% U treated (17%). The laboratory result depicted that oat silage made with the inclusion of molasses and 56 days ensiling period had lower CP content. Molasses treatement and ensiled dates difference had less effect to increase the CP content. Both M and ensiled date defference decreased the nutral detergent fiber (NDF) percentage. The U treated local oats silage had less effects to decrease the NDF content on prepared silage. In conclusion, silage making with a combination of 2% M and 1% U could improve the nutritive qualities and the efficiency of utilization of silage by ruminant animals in the highlands of Ethiopia.

Keywords:*Feed, Molasses, Oats, Silage, Urea*

1. INTRODUCTION

In Ethiopia, the livestock sub-sector has a significant contribution to the national income (Alemayehu *et al*., 2012) and for the livelihoods of rural and urban communities. Livestock production contributes up to 80 % of farmers' income in Ethiopia and about 20 % of agricultural growth domestic product (GDP) (Alemayehu *et al*., 2016). 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 systems (Jabbar *et al*., 2007). In addition, Hassen *et al.* (2010) reported that the productivity of animals remained at a low level due to inadequate feed in both quality and quantity. Similarly, Alemayehu *et al*. (2016); Denbela and Sintayehu (2020),also reported that the nutritional factors both in quantity and quality are the most limiting determinants to sustain livestock production in Ethiopia. The expansion of croplands as a result of increased human population pressure and shrinkage of grazing lands aggravated feed shortage, which is the main cause of poor productivity of animals (Getnet, 2012). In addition, climate change is playing a major role in challenging the development of feed resources (Dineshsingh *et al*., 2014).

A large proportion of livestock feed resources in Ethiopia come from natural pastures, crop residues and aftermath grazing (Amanuel *et al*., 2019), but such feed resources cannot promote increased animal productivity due to their nutritional limitations, lower intake and digestibility (Talore, 2015). In Ethiopia, green fodder (grazing) is the major type of feed resources (56.23 %) followed by crops residue (30.06 %) (CSA, 2015), and in highlands, crop residues provide on average about 50%, reach up to 80% during the dry seasons of the year of the total feed source for ruminant livestock (Gebremedhin *et al*., 2015). Moreover, hay, industrial by-products, improved feed and other feed types were also used as animal feed that comprise about 7.44, 1.21, 0.3, and 4.76 % of the total feeds, respectively (CSA, 2015). In the highlands of Ethiopia, high density of human and livestock population are found which ranges from 37-120 people and 27-130 Tropical Livestock Unit (TLU) per square kilometer (Gebremedhin *et al*., 2015).

The availability and choice of forage can warrant the quality and healthfulness of livestock production (Tewodros and Amare, 2016). Gezahagn *et al*. (2016) reported that in Ethiopia, the introduction of oat to the smallholders was for feed production. It has been realized that it is also being extensively grown as a food grain. However, it has been perceived that farmers have no awareness of the existence of different Oats varieties with different merits and consequently they grow the single-variety they own for multipurpose uses. The extent of horizontal expansion and utilization trend (forage and grain), socio-economic factors governing production and utilization of oats, available improvement opportunities and the overall prospect of oats have not been clearly understood (Gezahagn *et al*., 2016). Even though, oats are one of the major indigenous feed resources in the study area, their nutritional value and related farmer's preferences and evaluation of oats silage have not been adequately studied and documented (Deribe, 2015). Oat has fairly high concentrations of crude protein (CP) and crude fat (Qi *et al.,* 2017; Farhad *et al.,* 2019). Less emphasis was given to develop food oat varieties as compared to other small-seeded cereal crops like wheat and barley which are considered as major nutritious food crops (Fekadu *et al*., 2018).

In general, feed scarcity in terms of quantity and quality are the major ones in almost all parts of Ethiopia (Eshetie *et al*., 2018). FAO (2018), indicted that 21 % of dry matter (DM), 48 % of CP and 52 % of metabolizable energy (ME) is highly deficient for feeding animals. To overcome the feed shortage problem, some grasses species and fodder crops have been tested under rain-fed conditions without application of fertilizer at national level. Among the fodder crops, oat (*Avena sativa*) is the best adapted and productive forage with minimum input usage (Tewodros and Amare, 2016). It is also a well-adapted fodder crop used as energy source for livestock (Mengistu, 2008). Local oats silage no comparative study has been conducted in the study area. Moreover, efficient utilization of feed resources for animal production relies on the knowledge of the quantity and quality of the available feeds. Feeds for animals have been evaluated for their nutritional characteristics for balancing animal nutrients needs and hence improve animal performance.

This study hypothesized that 50 % flowering stage of local oats silage would increase the quality of DM compared to not ensiled oats at the same stage, applying additives urea (U) and molasses (M) would improve the feed quality of silage in comparison to that of untreated silage and local oats at 50 %flowering stage silage nutrient quality would be increased with the increments of ensiling date.

Objectives of this study:

General Objectives

The general objective of this study was to assess the utilization of local oat crops as feed and food and to evaluate the nutritive value of its silage at 50% flowering stage in the study area.

Specific Objectives:

- To assess the utilization practices of oat crops as feed and food and
- To evaluate the chemical composition of local oat fodder crops and its silage at 50% flowering stage in the study areas

2. LITERATURE REVIEW

2.1. Oat production and utilization

Oat (*Avena sativa*) seeds have been found in 4000-year-old remains in Egypt and its cultivation began much later than that of wheat and barley (Stevens *et al*., 2015). According to Gebremedhin *et al*. (2015) indicated that oats grain is the staple diet of human beings in some parts of the central high lands of Ethiopia. A well-distributed rainfall of 400mm and temperature range of 16-32^{o}c during the five months of its growing seasons is sufficient to meet its requirements as a fodder crop. Fekadu *et al.* (2018), also stated that the initial aim of oats introduce to the smallholders was for feed production. It has been realized that it is also being extensively grown as a food grain so that they grow the single-variety for multipurpose uses. It is ranked as sixth in the world's cereal production following wheat, maize, rice, barley and sorghum. However, it has been tested under irrigation conditions because rainfall was not reliable most of the years (Amanuel *et al*., 2019). According to the Ethiopia Ministry of agriculture and rural development, oats was registered as grass and used as forages (Getnet, 2012). It is one of the well-adapted and important fodder crops grown in the highlands of Ethiopia, mainly under rain-fed conditions (Amanuel *et al*., 2019). According to Gebremedhin *et al*. (2015), oat (*Avena Sativa*) was early maturing, palatable, succulent and energy-rich crop. It is mostly used as silage and is preferred by animals due to its high palatability and softness. Its grain is also a valuable feed for dairy cows, horses, young breeding animals and poultry. Many cultivars of oat have high feed value if cut at its 50 percent flowering stage which is the best time for the crop harvest for better yield and can meet the demand of the rapidly growing livestock industry of Ethiopia (Gebremedhin *et al*., 2015).It has been well accepted by the farming community because of its hardy nature which performs better under stressful conditions (poor soil fertility, water logging, and frost and disease outbreaks) with very minimal management inputs (Mengistu,2008).

Generally, it is possible to grow Oats under circumstances detrimental to growing other crops (Gezahagn *et al*., 2016), while the high yield of oat grains depends on a set of factors, such as technologies of management, climate and soil (Fontaneli *et al*., 2012). The use of cultivars that are more productive and responsive to nitrogen (N) fertilization is also important to increase yield (Silva *et al*., 2015). Since nitrogen is the most absorbed nutrients by cereals and inefficient amount is released by the soil, fertilization with N-fertilizer is necessary (Hawerroth *et al.*, 2015). However, the increment in N use combined with favorable climatic conditions stimulates vegetative growth and favoring plant lodging (Flores *et al.*, 2012). According to the study at Holetta average herbage DM yield of different oats varieties ranged from 11 to 17 t ha^{-1} while grain yield was ranged from 1.8 to 5.2 t ha^{-1} (Gezahagn *et al.*, 2016). Although oats is chiefly used as livestock feed, the white-colored grain type can also be processed for human food. Oats as a food grain has rapidly gained increasing popularity in recent years, as a result of their serum cholesterol-lowering properties thereby preventing heart-related problems. They are well adapted to a wide range of soil types and can perform better than other small-grain cereals on acid soils (Gebremedhin *et al*., 2015).

2.2. Introduced oat varieties to Ethiopia and the study area

Production of Oats by small holder farmers in different parts of Ethiopia dates back at least three decades as conventional research on the species was initiated in the early 1970's following introductions of about 9,054 lines of oats collected from over 55 countries of the world. About 40 additional dual-purpose (forage and/or grain) type oats varieties were also introduced from International Maize and wheat improvement (CIMMYT) in the mid 1980's (Fekadu *et al*., 2018). Since there has been no formal variety released mechanisms for forage crops in Ethiopia, Oats was informally distributed to the farming community by different livestock development projects of the Ministry of Agriculture (Gezahagn *et al*., 2016). Oats (*Avena Sativa*) is one of the most well-adapted fodder crops grown in the highlands of Ethiopia mainly under rain fed conditions (Gebremedhn *et al*., 2015). Oats varieties registered as grasses are *Avena sativa* varieties CI-8237, Bonsa, and Bona bas was registered in 1976, 2011 and 2011 respectively (MOARD, 2011). Fekadu *et al*. (2018) reported that among the different forage crops recommended for various agro ecological zones of Ethiopia, common oats (*Avena sativa*) is abundantly grown in the central highlands of Ethiopia, especially at Selale in North Shewa.

2.3. Animals feed resource

Natural pasture, after math grazing and crop residues are the major sources of roughage in most parts of Ethiopia (Getnet, 2012). It is obvious that the natural pasture based feeding system is greatly influenced by feed supply and nutritional dynamics of pasture forages (Denbela and Sintayehu, 2020). Getnet (2012), also indicted that the total annual feed produced from grazing lands and crop residues are not adequate to supply even maintenance level of feeding for the existing livestock population. This critical feed shortage among high demand for animal and animal products calls to look improving the supply and availability of feed. On the other hands, crop residues are low in protein, energy and other important micronutrients essential for animal production (Ramana *et al*., 2015). As a result, animals hardly meet their nutritional requirements and livestock productivity, in terms of meat and milk, is very low, draft power from oxen is minimal which thereby affects food crop production under smallholder crop and livestock farming systems (Tewodros and Amare (2016). According to Amanuel *et al*. (2019) indicated that, oat straw is soft and its grains are also valuable feeds for dairy cows, horses, young breeding animals and poultry. Tewodros and Amare (2016) also reported that integration of food and forage crops is a useful practice in area where both crop and livestock farming are simultaneously practiced.

Crop residues are plant by-products obtained from the cultivation of cereals, pulses, oil crops, roots and tubers. It is great to bridge the feed gaps observed during the dry period when other feed resources are scarce (Yayneshet, 2010). It contribute about 50% of the total feed supply in Ethiopia and this figure can be higher if the feedcrisis 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 (Ramana *et al*. 2015). 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) Oats (*Avena sativa*) straw composition of nutritive value DM, CP, Crud fiber (CF), ash, NDF and ADF 91, 3.4, 34.9, 7.5, 74.2, and 49.6 percent respectively (Ranjhnan, 2001). Similarly Dey et al. (2014) reported that the DM content of crop residues varied from 88 to 93 percent. During feed scarcity oxen and milking cows would be given priority access to hay and crop residues supplementation (Seyoum *et al*., 2001). 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)

2.4. Biomass of oats fodder Crop

Harvesting the forage crop at the proper stage of maturity and moisture content (both direct cut and field-cured crops) allow the maximum digestible yield, high palatability, and maximum potential animal intake (Borreani *et al*., 2017). Oats (*Avena sativa*) are cool-season annual grass that grows well in the cooler temperatures of the spring and fall as part of a double-cropping strategy to increase annual forage yield per unit area (Harper *et al*., 2017). The improved variety of oats have the potential to produce three-fold green fodder, that is 60-80 t ha^{-1} and could feed double the number of animals per unit area against the traditional fodder crops (Gebremedhin *et al*., 2015).

2.5. Nutritive values of oats fodder crop

Oats is a well-adapted, early maturing, palatable, succulent and energy rich crops for livestock (Mengistu, 2008).It is mostly used as silage or hay. It is liked by animals due to high palatability and softness. Its grain is also valuable feed for dairy cows, horses, young breeding animals, and poultry (Gebremedhin *et al*., 2015).According to Ranjhnan (2001), indicated that oats(*Avena sativa*) is a good fodder and is very much relished by the animals. It can conserved in the form of hay which can be baled. There are number of varieties of oats fodders and their nutritive value is variable depending upon the variety and its maturity (Table 1).

Forage intake is dependent upon the cell wall content, while forage digestibility is dependent on the cell wall (neutral detergent fiber) content and its availability determined by lignification (Van Soest, 1986). Information was limited on agronomic practices, biomass production, and nutritive value of various improved forage varieties, including oat crop at the farmer's level (Amanuel *et al.*, 2019). Variation in concentration of minerals might be affected by factors like varieties (Gezahegn *et al*., 2014), growth stage, morphological fractions, climatic conditions, soil characteristics, seasonal conditions (McDonald *et al.*, 2002). Oat grains have high content of proteins, which is relatively better in quality, compared to other cereals. The contents of Magnesium (Mg), Iron (Fe), Phosphorous (P), Calcium (Ca), and vitamin E and B_1 are also higher in oats compared with other cereals (Amanuel *et al*., 2019). According to Fekadu *et al.* (2018), reported that oats are one of the most nutritious cereals, high in protein and fiber.

Acid detergent fiber (ADF) is the percentage of indigestible and slowly digestible material in a feed or forage (McDonald *et al*., 2002). This fraction includes cellulose, lignin and pectin. Acid detergent fiber has a positive relationship with the ages of the plant and the neutral detergent fiber (NDF) contents above the critical value of 60% results in decreased voluntary feed intake, feed conversion efficiency and longer rumination time (Amanuel *et al*., 2019). Decortication increased the concentration of CP, starch, and crude fat of DM, and it decreased the NDF concentration. Total amino acid concentration was highest in decorticated oat, and the Lysine amino acid (Lys) proportion of total amino acid was lower for decorticated oat than untreated oat (Farhad *et al*., 2019). Toasted oat had lower solubility of CP and lower crude fat concentration. The composition of the removed hull mirrored the difference between oat and decorticated hull, with lower CP and starch and higher NDF concentration in hulls than in oat (Farhad *et al*., 2019). The hull of oat (*Avena sativa*) constitutes 28 to 32% of the grain DM due to the presence of lignin-carbohydrate/phenolic-carbohydrate complexes (Decker *et al*., 2014).

Table 1. Chemical composition of Oats (*Avena sativa*)

Stages of Oats				**%**						**Mcal**
	DM	**CP**	**CF**	**N-Free extract**	**EE**	**Ash**	**DCP**	**TDN**	**DE**	**ME**
Fresh, early vegetative	13	18.8	18	37.5	3.6	22.1				
Fresh, late vegetative	15	14.6	32.9	36.4	2.1	13.9				
Fresh early blooming	17	10.8	31	45.9	1.8	10.4				
Late blooming	19	9.2	34.8	44.8	1.8	9.4				
Fresh, milk stage	22	6.4	28.7	53.2	2.3	9.3	2.9	52.4	2.9	2.4
Fresh, ripe	25	5.3	34.2	47.1	2.5	10.9				
Silage, early blooming		8.1	39.8	39.6	3	9.5				
Silage, late blooming		7.3	48.8	40.6	1.6	9.7				
Grains	100	9.3	15.5	69.4	1.9	8.5	7.2	79	3.5	2.8

Source: (Ranjhnan, 2001).

CF = Crud Fiber, CP = Crud Protein, DCP = Digestable Crud Protein, DE = Digestable Energy, DM = Dry Matter, EE = Ether Extract, ME = Metabolizable Energy, TDN = Total Digestable Nutreint,

2.6. Feed conservation through 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 the conservation of excess forages available during the rainy season as hay or silage for feeding livestock when feed shortage is more serious during the dry season of the year. Silage making has great potential to solve seasonal feed shortages 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 a 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). The production of well-preserved, high-quality silages depends mainly on the composition of the forage at ensiling and the application of appropriate silage-making practices (Driehuis *et al.*, 2017). Ensiling is based on spontaneous solid-state fermentation whereby lactic acid bacteria (LAB) convert water-soluble carbohydrates (WSC) into organic acids, mainly lactic acid (Moselhy *et al*., 2015). Microbial silage inoculants such as (LAB) are used to improve silage fermentation and prevent spoilage of ryegrass and maize silages through increased organic acid production, mainly lactic acid (LA) and acetic acid, and a more rapid pH decline (Muck, 2013).

Crops such as oats, sorghum, 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 (Jones *et al*., 2004). As a result, the pH decreases, and the forage is preserved (Wang *et al*., 2017). The principles of ensilage are well known. The first essential objective is to achieve anaerobic conditions under which natural fermentation can take place. In practice this is achieved by consolidating and compacting the material and the sealing of the silo to prevent re-entry of air (Yibarek and Tamir, 2014).Where oxygen is in contact with herbage for some time, aerobic microbial activity occurs and yeast and mould will grow. This causes the material into decay to a useless, inedible and frequently toxic product (McDonald *et al.,* 1991). Finer chopping of plant material results in improved compaction and fermentation of silage. This then improves palatability and intake of silage (Yibarek and Tamir, 2014). Crops rich in soluble carbohydrate like oats are most suitable for ensiling whereas protein-rich crops like berseem, lucerne, etc are not good for silage making as they are deficient in soluble carbohydrates (Ranjhnan, 2001). Whole crop silage may give high DM yields from one single cut, and maximum DM yield is obtained at the dough stages of maturity (Randby, *et al*., 2019).

Silage is a high moisture feed (James, 1987). It is green material produced by controlled fermentation of green fodder crops retaining the high moisture content. Fresh fodders when packed in a container and allowed to ferment under anaerobic condition, produce some volatile fatty acid which preserve the forage material for a long time, with minimum loss of nutrients (Ranjhnan, 2001). To produce good quality silage, the crops should contain 25-35% dry matter at the time of ensiling (James, 1987; Ranjhnan, 2001).

A sufficient amount of fermentable carbohydrates in plant material is necessary for lactic acid production which reduces fermentation pH and guarantees good quality silage (McDonald *et al.*, 2011). But low water-soluble carbohydrate content may be the main cause of low-quality silage (Kang *et al*., 2018). Similarly Rafiuddin *et al*. (2016) indicted that as the plant matures, the water-soluble carbohydrates decrease, thereby decreasing the fermentation activity of bacteria. Too early or too late harvesting stage not only impairs the energy density of the whole plant but also affects the optimum moisture level required for good silage preservation. Therefore, optimum stage of maturity is important to harvest maximum nutrients for livestock feeding. An anaerobic environment and a fermentation of plant sugars to lactic acid-producing a low pH. An anaerobic environment is essential to prevent the growth of aerobic spoilage microorganisms (including molds, yeasts, and bacteria) because many of these microorganisms can grow at low pH (less than 4.0) but require oxygen. Thus the sealing of a silo is critical to achieving and maintaining an anaerobic environment. Any oxygen remaining in the silo after sealing is usually used up by plant respiration within a few hours. A low pH reduces the activity of plant enzymes and inhibits the growth of undesirable anaerobic bacteria (Richard and Limin, 2015).

Molasses is often added to silage as a sugar additive increasing fermentation and feed quality. The faster the fermentation is completed, the more nutrients will be present in the silage. Adding U is a common and cheap method of increasing nitrogen supply; however, U decreases the fermentation quality of silage by increasing pH with the release of ammonia. So, it is considered that the addition of different combinations of U and M may improve both the protein content and fermentation quality of the silage (Kang *et al*., 2018). However, as Yibarek and Tamir (2014) molasses is the most common additive used in experiments to provide a fast fermentable carbohydrate for the ensilation of tropical forages. Usually cane molasses has 75% DM and is applied up to 10%. For tropical forages at rates of 4-5% molasses have been added. It is a viscous additive and should be mixed with a small volume of water to be easily spread and to minimize seepage loss. Forages fed as silage remain popular for dairy farms because they minimize the loss of nutrients from harvest through storage, allow for easier feeding, and often allow greater efficiency and timeliness of feed mixing and handling on the farm than dry forages. Measuring the chemical composition and physical properties of silages is important for proper ration formulation and troubleshooting silage quality problems (Grant and Ferraretto, 2018). The content and ferment ability of silage fiber, starch, and protein, together with fermentation end products, influence dairy cattle feeding behavior and dry matter intake (DMI) (Oliveira *et al*., 2017).

Table 2: Nutritive value of cereal crops silage.

% at DM basis	**Feed type**		
	Oats silage (Milk stage)	**Barley silage**	**Triticale silage**
pH	4.46	4.32	4.42
DM	38.5	35.6	43.7
CP	11.5	13.1	11.6
NDF	53.5	58.2	57.9
ADF	34.2	30.4	39.1
Lignin	4.2	6.4	4.6
Ash	14.9	17.3	14.6

Source: (Saman, 2004)

ADF=Acid Detergent Fiber, CP=Crud Protein, DM=Dry Matter, NDF=Nuteral Detergent Fiber

2.6.1. Factors affecting silage quality

The fermentation proceses reaches the greatest stage a few hours after the material is 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 are 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.

2.6.2. Moisture content of silage

The moisture content of the crop at ensiling affects the rate and extent of fermentation. A drier crop has a higher concentration of solutes dissolved in the residual plant moisture, raising osmotic pressure. Higher osmotic pressure reduces microbial growth rate, raises the critical pH that is inhibitory to microbial growth, and thus reduces the quantity of sugar needed to be fermented for anaerobically stable silage. Beyond fermentation effects, crops ensiled too wet may produce effluent. Crops ensiled too dry are more prone to heating and spoilage (Richard and Limin, 2015). Similarly it should be noted that molasses under high temperature can help Clostridial microorganisms proliferate. Molasses has been proven in most experiments to promote lactic acid fermentation, reduce pH, and hinder Clostridial fermentation and proteolysis and to some extent decreases organic matter losses (Yibarek and Tamir, 2014).

2.6.3. Chopping of plants for silage making

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). At ensiling, chopped forage is still metabolically active and respires while oxygen is available. Plant tissue respiration is the primary driver for removing oxygen from the silo and producing heat, although respiration by aerobic microorganisms can contribute (Borreani *et al*., 2017).

2.6.4. Silage silos

The silos may be below or above the ground. It should be characterized by air-tight wall, smooth wall and balanced depth of silos. The silos should have air-tight wall without any cracks whether the silos are below or above the ground. The wall of the silos should be smooth and strong. Care should be taken to avoid the corners in constructions. If the silos is blow the ground the deeper the silos, proportionately there will be a less loss of silage, but the depth depends up on the water table in the soil. The depth of silos should be above the water table (Ranjhan, 2001).

2.6.5. The temperature and gas of silage

An option to measure temperature at the silo face is to use a probe or "spike" thermometer (Borreani *et al*., 2017). In addition heat-sensing digital cameras can capture in a single picture all temperatures of the working face, and may reduce costs associated with personnel and chemical reagents used for conventional assessment of silage aerobic stability (Addah *et al*., 2012). Heat production is normal during the ensiling process and a rise up to 12°concerning silage temperature at harvesting is common even in a well-managed silo (Adesogan and Newman, 2014). Prolonged temperatures above 40°C can cause protein damage (denaturation), affecting the availability of amino acid at feeding of most legume and grass forages (Borreani *et al*., 2017). Growth rates of the LAB essential to the initial ensiling fermentation are also affected by temperature, among other parameters like availability of sugars, degree of anaerobiosis, and moisture levels. Lactic acid bacteria grow most rapidly at temperatures between 27 and 38°C. Below 27°C, their growth is slower, but most fermentations should be complete between 7 to 10 days at these temperatures (Yamamoto *et al*., 2011). In some instances, silages may be relatively hot (>30–35°C) even after 4 to 6 wk (or more) in the silo. This finding may be more common in silages that have been harvested dry (>40–45% DM) and poorly packed (Limin *et al*., 2018).

Various forms of nitrogen oxide are formed during fermentation, primarily by enterobacteria using nitrate as an electron acceptor in place of oxygen. These nitrogen oxides are collectively referred to as silo gas. Inhalation of even small quantities of nitrogen dioxide (NO_2) and nitrogen tetraoxide (NO_2O_4) can lead to chronic pulmonary problems and be fatal. Formation of silo gas occurs within 4-6 h of silo filling and may continue for a 2 to 3-week period. To avoid silo gas, stay away from silos for at least 3 weeks or more after filling. Ventilate upright silos before entering and use a chemical detector to ensure safety (Richard and Limin, 2015).

2.6.6. Silage pH and volatile fatty acid

With increased pH, bacilli and other aerobic bacteria grow, increasing temperature further. Finally, molds complete the silage deterioration (Borreani *et al*., 2017). The chemical changes which occur in the green crop when it is ensiled, leads ultimately to the preservation of fodder. After ensiling sugars are oxidized to carbon dioxide and water; considerable amount of heat is also produced. Within five hours practically all oxygen present in the mass is utilized. Due to the production of carbon dioxide, which gives rise to carbonic acid, acid-forming bacteria multiply in the silage enormously. After aerobic respiration ceased microbial changes continue till a pH of 4.0 to 4.2 is reached and lactic acid producing bacteria remain in the silage (Ranjhan, 2001). The decrease in silage pH generally is more rapid in whole-plant corn than in legume silage because the latter has a higher buffering capacity. Within legume silages, the decrease in silage pH is more rapid in forages with low DM (<30%) compared with those with high DM (>40%) because more metabolic water is available in the former (Limin *et al*., 2018).

When the fermented silage pH is 4.3 or even below, the limitation of proteolytic bacteria activities is possible, and so it is the most preferred silage process for protein loss prevention (Kang *et al*., 2018). Lactic acid is produced from soluble carbohydrates. Hemicellulose are also break down during ensiling and pentose sugars are produced which may further be fermented to lactic and acetic acids. In well preserved silage, about 0.7 to 4% of acetic acid is present. The volatile fatty acid like formic, acetic, propionic and butyric are also produced. Acetic acid is predominant among volatile fatty acid in a good silage. Butyric acid is in trace. In bad silage butyric acid content is higher (Ranjhan, 2001).

2.6.7. Quality of silage

It has been noted that there was a positive correlation between silage fermentation quality and quality class of silage (Bakici and Demirel, 2004). High-quality silage is the result of several management practices. The silo type affects the physical and chemical properties of silages. Different types of silos are in practice for silage making including bunker, pile, upright, pit or trench silo and plastic bag systems. The increased DM losses during ensiling period are often due to exposure to oxygen. The pile and bunker silos have higher risk of oxygen exposure as compared to bag silos due to increased surface area (Rafiuddin *et al*., 2017). Silage quality and nutritional values are influenced by numerous biological and technological factors, when the proper ensilage techniques are used silage will have a high nutritive value and hygienic quality (Zehra and Unal, 2009). However, the results in practice indicated that the quality of silage is often poor or even unsatisfactory. These results are usually achieved when the fermentation condition is difficult. Factors that influence fermentation includes the degree of green fodder wilting, length of cut, ensiling technology type, and amount of additive used (Yibarek and Tamir, 2014). The exact nutrient status of the silage will depend on many factors that can only be controlled via management. It is important to remember that silage additives will not make poor quality forage into good silage but they can help make top quality forage into excellent quality silage (Kenilworth and Warwickshire, 2012).

Before the active fermentation phase can begin, oxygen trapped in the packed forage allows biological and chemical processes that consume nutrients and energy, leading to the production of water, carbon dioxide, heat and free ammonia. This increases silage temperature and negatively affects the silage, both in terms of DM and quality losses (Borreani *et al*., 2017).

Some silage sources also contain a significant starch fraction with the potential to substantially influence feed intake and meal patterns. Starch content varies by hybrid, growing conditions, and time of harvest. Several factors influence starch digestibility in silage, including maturity at harvest, processing method, and duration of silage fermentation (Grant and Ferraretto, 2018). Silage additives have been used to address a wide variety of silage management issues. These issues include ensuring a rapid production of lactic acid and a lowering of pH, avoiding clostridial fermentation, reducing yeast populations to make silages more aerobically stable, and improving animal performance (Muck *et al*., 2018). The lower pH is usually an indicative of increased lactic acid concentration thereby implying better fermentation of silages during ensiling period (Rafiuddin *et al*., 2017). Similarly, Muck *et al*. (2018) indicted that good silage management can minimize or prevent mycotoxin production in the silo. The potential for production in the silo can be further reduced through the chemical and microbial additives (Muck *et al*., 2018).

About 50-60% of the proteins are broken down to amino acids in well preserved silage. In badly preserved silage the amino acids are further broken down to produce various amines like tryptamine, phenylethylamine and histamine. The main products of putrefaction are betaine, adenine, and pentamethylene diamine. Some of the minerals like sodium, potassium, calcium and magnesium present in the green fodder may form salts with lactic and volatile acids. The amount of alcohol formed, which combines with acids and gives a characteristics aroma to the silage (Ranjhan, 2001).

Clostridia are present on crops and in the soil in the form of spores. Clostridia multiply under anaerobic conditions, produce butyric acid and break down amino acids resulting in silage with a poor palatability and lower nutritional value. The enterobacteria are no-spore forming, facultative anaerobes, which ferment sugars to acetic acid and other products. Enterobacteria also can degrade amino acids. The growth of clostridia and enterobacteria can be inhibited by lactic acid fermentation. Lactic acid bacteria are normally present on harvested crops and these organisms ferment naturally occurring sugars like glucose and fructose to mainly lactic acid. The lactic acid produced increases the hydrogen ion concentration and un-dissociated acids to a level at which undesirable organisms are inhibited (McDonald *et al.,* 1991). The critical pH at which growth of clostridia and enterobacteria are inhibited depends on the moisture content and the temperature. The wetter the material the lower the critical pH will be (Yibarek and Tamir 2014).

Aerobic deterioration of silages during the feed-out phase is a significant problem for farm profitability and feed quality worldwide. So, it is now recognized that the changes during the feed-out phase are equally as important as those in the closed silo from the viewpoint of preserving nutrients and maintaining good hygienic quality of the silage (Borreani and Tabacco, 2010). On-farm silages, most microbial deterioration is invisible initially and may only be detected by a temperature rise in the forage (Borreani *et al*., 2017).

Table 3. Description of physical characteristics and quality assessment of silage

Scores	**Smell**	**Color**	**Texture**	**Moldiness**	**pH**
Bad	Rancid and musty smell /pungent/	Dark/deep brown	Putrefactive and agglutinative	Highly moldy	>5.0
Moderate	Irritative/offensive; alcohol, acidic	Brown (Medium)	Slightly viscous /slimy	Medium	4.4-5.0
Good	Light acidic (pleasant)	Brown yellow	Medium (loose and soft, firm)	Slightly moldy	4.1-4.3
Excellent	Pleasant and sweet-acidic (very pleasant)	Light /greenish yellow/Olive green	Loose and soft, Firm	Without mold	<4.0

Source: (Getahun *et al*., 2018).

2.6.8. Development of organisms in silage

Lactic acid bacteria, which are the most important species during ensiling, are usually present on grass in numbers 1000 times lower than their main competitors, fungi and enterobacteria. After ensiling, the microorganisms capable of anaerobic growth namely, lactic acid bacteria, enterobacteria, clostridia, some Bacillus spp. and yeasts begin to grow and compete for available nutrients. The first few days of ensiling are critical to the success or failure of the subsequent fermentation. Under favourable conditions lactic acid bacteria will quickly acidify the environment to such an extent that the competing organisms will not be able to survive and the end result will be a stable, low pH silage. If, however, the pH is not lowered quickly enough the undesirable microorganisms, mainly enterobacteria, clostridia and yeasts will be able to compete for nutrients. This will reduce the chances of obtaining a stable silage (McDonald *et al.*, 1991; Yibarek and Tamir 2014). In addition lactate-utilizing yeasts are the primary microorganisms responsible for initiating aerobic deterioration in most silages. It is possible to delay aerobic deterioration when oxygen is present by inhibiting yeasts through the use of specific silage additives like propionic, acetic, sorbic, and benzoic acids (Borreani *et al*., 2017).

The clostridial species of highest concern in dairy cow feeding is *Clostridium tyrobutyricum* due to its spores creating large economic impact in the dairy industry through late blowing of hard cheese (Cecilia, 2018) and the major concern of the presence of clostridia in silage for horses is the species *Clostridium botulinum*. This species can produce the lethal neurotoxin botulin under certain conditions (Stratford *et a*l., 2014) and very small amounts of the toxin cause equine death (Cecilia, 2018). The same author reviewed that the silage has been reported as being badly fermented with a high pH and a strong smell of ammonia. Enterobacteria found in silages are Gram-negative bacteria which are facultatively anaerobic and have both catalase activity and NO_3 reducing ability. Enterobacteria can ferment glucose to acetic and formic acid, ethanol and butanediol and can also produce ammonia in anaerobic environments, depending on the species. As ethanol, butanediol and ammonia do not contribute to a decrease in pH, they are not desired fermentation products. In general, the reduction of the effects of some bacteria like *Listeria* contamination in silage by removal of obviously spoiled forage material before feeding and by avoiding feeding silage with high pH and signs of aerobic deterioration (Cecilia, 2018).

2.6.9. Type of additives applied on silage

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 main nutrient additives used in the silage making process are ammonia and urea. Molasses ammonia mixes have been commonly used in the silage making process. The advantages of using ammonia positively resulted in an enhanced CP source, aerobic stability of silages, less heating and moulding during ensiling and decreased protein degradation in the silo (Yibarek and Tamir, 2014). To increase the quality of silage it is possible to apply additives. Possible additives are lactic acid stimulant like molasses and sugar, whey, over fermentable ingredients and bacteria culture and microorganisms, direct acidification by mineral and organic acids, applying sterilizing agents like sodium metabisulphite and antibiotics and urea limestone treatment (Ranjhan, 2001).

Yibarek and Tamir (2014) has reviewed that there are five types of silage additives such as:

1. Fermentation stimulants:
    - A. Fermentable carbohydrates Sugar sources such as Molasses, sucrose, glucose, citrus pulp, pineapple pulp, and sugar beet pulp
    - B. Enzymes: like Cellulases, hemicellulases, amylases
    - C. Inoculants such as Lactic acid bacteria
2. Fermentation inhibitors:
    - A. Acids and organic acid salts such as Mineral acids (e.g. hydrochloric), formic acid, acetic acid, lactic acid, acrylic acid, calcium formate, propionic acid, propionates
    - B. Other chemical inhibitors such as Formaldehyde, sodium nitrite, sodium metabisulphite
3. Aerobic spoilage inhibitors: Like Propionic acid, propionates, acetic acid, caproic acid, ammonia, some inoculants

4. Nutrients: Like Urea, ammonia, grain, minerals, sugar beet pulp
5. Absorbents: like grain, straw, bentonite, sugar beet pulp, polyacrylamide

2.6.10. Effects of additives on silage

The main functions of additives are to either increase the nutritional value of silage or improve fermentation so that storage losses are reduced (Yibarek and Tamir, 2014). Many different silage additives are available and are used for different reasons. It includes fermentation stimulants, fermentation inhibitors, aerobic deterioration inhibitors, nutrients and absorbents (McDonald *et al*., 1991). The NDF and ADF contents in sorghum silages with the addition of urea plus molasses decreased. Researchers have suggested two reasons for this decrease. First, the addition of molasses to silages increases the number of aerobic bacteria, including the lactic acid bacterium; therefore, the NDF and ADF degradation of silages increases. Second, a decrease takes place because of the lower ADF content of the additives (Bilal and Brahim, 2005).

Lukkananukool *et al*. (2013) stated that it was difficult to make a good quality silage from forages in low water-soluble carbohydrates and high buffering capacity. Adesogan and Newman (2010) reported that using a fermentable starch source such as molasses can have positive results on increasing the organic acid production and lowering the pH of silage. Molasses is a viscous additive that needs water to mix with samples (Yibarek and Tamir, 2014). It is a by-product of the sugar beet and sugarcane industries were one of the earliest silage additives to be used as a source of sugars (McDonald *et al.,* 2011). It is feed available to provide energy in livestock rations. All of the molasses are concentrated water solutions of sugars, hemicellulose, and minerals. Cane molasses is the most commonly used of the various types of molasses available. It is used in the ration for cattle, sheep, and horses but seldom used in swine rations because it may cause scoring. Molasses is usually limited to not more than 10-15% of ration (James, 1987).

Overfeeding CP to lactating cows also increases milk urea nitrogen and milk non-protein nitrogen concentrations, increases urine volume, increases urinary nitrogen output (Ernst and Alexander, 2005) and may decrease milk protein content (Leonardi *et al.,* 2003). The decrease in milk protein concentrations is most common when the additional protein that is being supplied is rumen un-degradable protein and the rumen un-degradable protein has a poor amino acid balance. In cows fed grass silage-based diets feeding additional protein increased milk protein concentration, but this increase was mainly associated with increased milk urea nitrogen concentration (Ernst and Alexander, 2005).

When cattle are fed low-quality forages, several experiments indicate that significant amounts of urea (up to 1.9% to 2.5% of diet DM) can replace true protein (Ernst and Alexander, 2005). Urea is a NPN compound in the crystalline form, white, odor-less and contains 45% nitrogen. It has a protein equivalent of 281% (45% N x 6.25). It contains carbon, oxygen, nitrogen and hydrogen. It is the most common of the NPN sources used in ruminant ration and use should be limited to not more than one-third of the total protein in the ration. It is generally not used in non-ruminant animal rations, but can be used in ruminant rations because the rumen microbes can utilize the nitrogen in urea, forming amino acids needed by the bacteria. Mixing urea with molasses increases its palatability (James, 1987). The potential of microorganisms to utilize non-protein nitrogen is not restricted to urea as a feed additive it is also relevant for urea synthesized in the liver of their host animal (Ernst and Alexander, 2005). Silage additives can be useful tools to improve silage quality (increase nutritional content) and animal performance (milk /quantity and composition/, gain, body condition, reproduction), or decrease heating and molding during storage (Yibarek and Tamir, 2014).

2.6.11. Effects of fermentation period on silage

Quality silage is achieved when the fermentation process is completed well. It occurs when lactic acid is the predominant acid produced, and thus will drop the silage pH quickly. The fermentation period is a crucial parameter in producing good silage (Mohd-Setapar *et al.*, 2012). An anaerobic environment is essential to prevent the growth of aerobic spoilage microorganisms (including molds, yeasts, and bacteria) because many of these microorganisms can grow at low pH (less than 4.0) but require oxygen (Richard and Limin, 2015). Thus the sealing of a silo is critical to achieving and maintaining an anaerobic environment. Any oxygen remaining in the silo after sealing is usually used up by plant respiration within a few hours.

2.6.12. Silage as animal feed resources

The use of conserved forages, mainly maize silage as a supplement to milking cows, is seen as a good option for small-scale dairy systems (Mugabe *et al*., 2016). Supplementing oat silage to small-scale dairy systems is useful when grazing conditions are limiting, and to conserve pasture during the dry season (Victor *et al*., 2018). In addition as Valter *et al*. (2019) indicted that the inclusion of legumes in triticale provided better silage fermentation, a lower concentration of structural components and better digestibility of organic matter, producing a higher intake of DM and enhanced milk production by cows. The CP content of silages increased according to the proportion of legumes present in the silage.

In well-covered silages, the feed-out removal rate of silage from the silo face represents one of the most important factors to prevent aerobic spoilage (Borreani *et al*., 2017). Hay and pasture have been the major forage types used in equine feed rations. However, wrapped forages in bales, such as silage and haylage, have partially replaced hay in equine diets in different countries (Cecilia, 2018). Feeding cannulated horses the same grass crop conserved as silage, haylage or hay for 21 days each resulted in similar biochemical and microbial composition in right ventral colon content and faeces (Muhonen *et al*. 2009), except for counts of *Streptococci* which were higher in right ventral colon and faeces when hay was fed, compared to when silage or haylage was used. Fermentation kinetics in the right ventral colon was also similar when silage, haylage and hay were fed (Muller *et al*., 2012). Miyaji *et al*. (2008) also reported that no differences were found among hay or silage diets in total VFA concentration in any segment of the hindgut, and apparent digestibility of DM, organic matter and NDF and ADF were similar among hay and silage in all hindgut segments. Cecilia, (2018) reported that maize silage is a suitable feed for horses and mules if the animals were given time to adapt to the feed. But if silage fermentation is not dominated by lactic acid production and the silage contains other fermentation products, especially when the noticeable smell of butyric acid horses may refuse or reject to eat the forage. Although the species of enterobacteria most frequently found in silages are considered to be non-pathogenic, they may contain endotoxins in the outer cell membrane, which may potentially be associated with digestive disorders in horses.

3. MATERIALS AND METHODS

3.1. Description of the Study Areas

The study was conducted in *Kimbibit Woreda* of North Showa Zone, Oromia National Regional State, Ethiopia at a distance of 78 km from Addis Ababa. *Kimbibit wereda* is located at 9^0 20' North, 39^0 18' East has 29 rural and 2 urban *kebeles*. The total human population of the *Woreda* is about 109,933, of which 54,425 are women (CSA, 2005). The total land area of the *Wereda* is estimated to be 861.26 square kilometers, it has an estimated population density of 127.6 people per square kilometer. The altitude ranging from 2620 to 3020 m.a.s.l. (Seblewengel, 2018). The *Wereda* falls under the highland (100% *dega)* agro-ecological zone. The rainfall distribution is bimodal, with short and long rainy seasons from March to April and June to September, respectively. It received an average annual rainfall of about 1013mm with a temperature ranging from 17 to 23 ^oC. Most of the land is used for crop production which is entirely rain-fed and a few parts as pasture (grazing) lands. The majority of the community members of the *Wereda* are dependent on subsistence agriculture and the farming system of the *Wereda* is characterized by a mixed crop-livestock production system. As a result, there is close interdependence between crop and livestock sub-systems in the study area. It is best known for barley, wild oats, wheat, horse beans, linseed and lentils. Cattle, sheep and equines are the dominant types of livestock (Seblewengel, 2018).

The total land coverage of the *wereda* is 65,885 hectares, out of which, crop cultivation covers 33,401 hectares, private grazing land takes up 29,168 hectare and communal, degraded, road, and rives covers 900, 500, 400 and 400 hectares, respectively. Moreover, 1116 hectares of land were covered by *sheno* town (*Kimbibit weread* agricultural and land management office). Vertisoil, red brown soil and abolse soils are the dominant soil types. Vertisoils are found on flat areas and characterized by poor drainage, difficult to plough when dry and too much moisture. It is less productive compared to red brown soil. The red brown soils found mostly on sloppy areas of the *Wereda* and has good drainage and moderately exposed to erosion. This type of soil is productive and suitable for crops such as wheat, barley, beans and peans. Abolse soil is poorly fertile and mostly used for grazing (*Kimbibit wereda* Agricultur and Investiment offices).

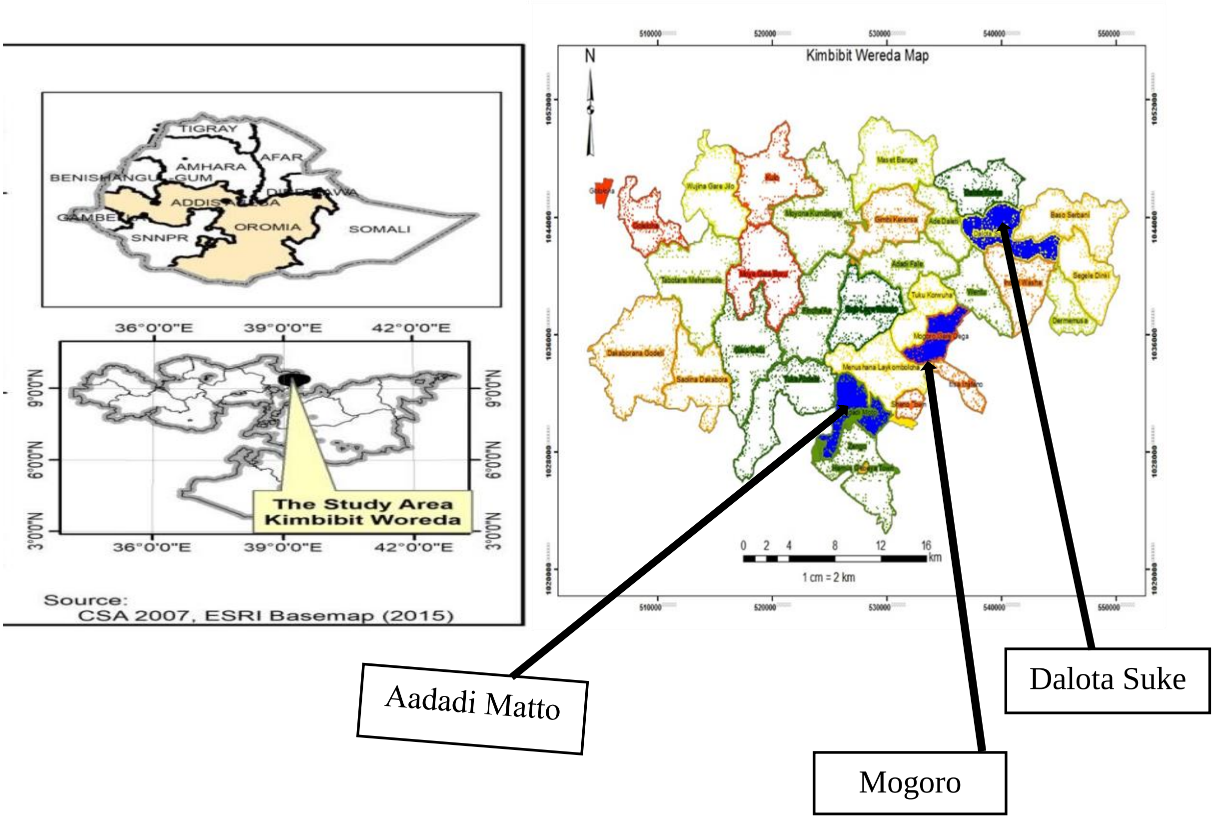

Figure 1. Map of *Kimbibit Wereda* and study *kebeles*

3.1.1. Sampling procedures for household survey

Multistage sampling procedure was used to select *kebeles* and household heads. In the first stage, three representative *kebeles* namely *Dalota suke*, *Adadi matto* and *Mogoro* were purposively selected based on high cattle population, oat production and accessibility with the help of the *Wereda* livestock production and health agent experts, Agricultural development office expert and development agents (DA). A total of 219 households were randomly selected for interview from the three *kebeles* (Table 4). The sample size was determined according to the following formula (Yamane, 1967).

$$n = N/1+N (e2)$$

Where, n = the sample size; N = the population size; e = the acceptable sampling error/margin of error (level of precision at 10%).

Table 4. Total sample size selected from the study *Wereda*

Kebeles	**Household heads**	**Sampled proportion (%)**	**Sample size**
Dalota suke	307	34	75
Adadi matto	244	32	71
Mogoro	269	33	73
Total		**100.0**	**219**

3.1.2. Data collection and sources

The overall data set considered in the current study was included both primary and secondary data sources. The primary data was collected using a pretested semi-structured questionnaires via a face to-face interview. The questionnaire was pre-tested to check the clarity and appropriateness of the questions.

Data were collected on demographic characteristics of the households such as family size, educational status, landholding, herd size and structure. In addition, data related to feed resources availability and feeding system, oats crop availability and utilization practices, storage and feeding practices and constraints of livestock production were collected. Checklist were also prepared for key informant interviews and group discussions.

Field observations and focus group discussions (FGD) were conducted at each of the selected *kebele*. Focus group discussion grouped in the three *kebeles* with the member of 15 persons composed of both gender and different age groups have participated (Figure 2) (Bryan, 2013). Key informants' interviews were undertaken with the Zonal and *Wereda* level livestock production experts, local development agents, knowledgeable farmers, and community leaders in the selected *kebele*. Field observations were also done to observe what is happening on the ground.

Secondary data were collected from the Oromia North Shewa Zone agriculture office, *Kimbibit Wereda* agriculture office, K*imbibit Wereda* animals and fishery production office, *Kimbibit Wereda* revenue office, *Kimbibit Wereda* land resource management office, DA at *kebele* level, *kebele* management group and Jida *Wereda* which is the neighbor of *Kimbibit*

Wereda. Data were collected using enumerators (agricultural development agents), who were trained to assist in primary data collection during face to-face interviews.

Figure 2. Focus group discussion (*Dalota Suke, Adadi Matto and Mogoro*) left to right.

3.2. Sowing and management of local oats

About 19.25m^2 of land was prepared for the study and plowed two times before sowing. It was sown on 22nd November, 2020 (Staff, 2019) and grown using irrigation and harvested greater than 75 kilograms of green fodder (Gebremedhin *et al*., 2015). The seed was collected from the three selected *kebeles* and had sown on different three beds, where each replication measured about 6.42m^2. The seeding rates were 100kg ha^{-1} (Amanuel *et al*., 2019) (Figure 3). The beds were uniformly irrigated starting from the sowing date up to maturity. Water was applied once a day in the afternoon up to the emergency period. After emergency of the seed, the application of water was decreased and applied every two days at the same time. Moreover, fertilizers (either natural or artificial) and other management practice (weed control, pest control) were not applied to the sown local oats.

Figure 3. Growth stage of local oats sown

3.3. Preparation of silage additives and experimental feeds

Urea and molasses are widely used to increase nutrient content, digestibility and consequently feed value of silages (Sibel *et al*., 2009). Molasses was purchased from *Wonj*

Sugar factory. It is the byproducts of sugar cane (Appendix figure 5). It was diluted with water at the ratio of 1:1.5 to sprinkle uniformly (Kang *et al*. 2018). In addition, U was diluted with the same ratio of water (1:1.5) when used as a sole additive. When U and M were mixed, the amount of water used for dilution equaled the amount of mentioned ratio of M used by weight (Suárez *et al*., 2011). On the 2 kilogram chopped oats, its 2% weight was 40 gram and 4% weight was 80 gram, the amount of M according to the set ratio were 60 and 120 milliliter mixed with 2 kilogram chopped oats at 2mm length. The M and water was stirred together in graduated cylinder until mixed each other then the mixture were added to the chopped oats mixed all each other and put to the mini silos.

Urea was purchased from local farmers cooperative (Appendix figure 4). Urea can be used to increase nitrogen concentration of the forage (Zafari *et al*., 2014). The amount of U 0.5% (10 gram) and 1% (20 gram) of 2 kilogram chopped oats were measured. Water at the ratio of 1:1.5 was 15 and 30 milliliters mixed with 10 and 20 gram U, respectively. Then the prepared U and water was mixed with the 2 kilogram chopped oats and put to the mini silos. Water was not applied for the 0% treatment of U and M.

The local oats sown was harvested after 105 days at 50% flowering stages. The flowering stage of this crop was best stage to harvest (Gebremedhin *et al*., 2015) and it reached flowering stage at 99 days to 150 (Usman *et al*., 2018). It was harvested by the leftover height of the crops approximately 2 to 5 centimeters on the farmland. Hand sickle was used to harvest the oats. The irrigated oats were harvested at 50% flowering stage where the moisture contents of this fodder were 72.86 % which was suitable for silage making (James, 1987; Ranjhan, 2001). During field practical work the materials used were hand sickle for harvesting oats, a local axe for chopping, thirty-six plastic containers with the capacity of five liters as mini silos, transparent plastic bags for sample collection, icebox for sample transportion to the laboratory, graduated cylinder for measuring liquid additives and water, and sensitive balance for measuring chopped oats and additives. Urea and M with different proportions were used also in the prepared silage.

The oats were harvested at 50% flowering stage from the three beds and chopped mechanically at the length of 2cm (appendix figure 3) (Rafiuddin *et al*., 2017). These chopped oats were mixed with U and M treatments. For each treatment oats were ensiled either untreated or with one of the two additives. Before packing into mini silos, the chopped oat samples were mixed with U and M with the ratio of 0%, 0.5%. 1% (Yibarek and Tamir, 2014) and 0%, 2%, 4% (Khan *et al.*, 2006), respectively. The treatments were combinations of nine additives; without additive, (0.5% U), (1% U), (2%M), (4% M), (0.5% U+2%M), (0.5%U + 4%M), (1% U + 2%M), and (1% U + 4% M) on fresh weight basis of oat crops with three replications. Urea and M were diluted with water at a ratio of 1:1.5 (Getahun *et al.,* 2018) which water was applied at the same rate as the additives carrier (Jacobs *et al*., 2009). Twenty-seven mini silos were prepared and placed under shade which allowed at room temperature (Getahun *et al,* 2018; Habte, *et al*., 2020) and the other nine mini silos were prepared without additives.

After treatments, mini silos with five liters of plastic container were prepared for silage making. The container was prepared with a packing weight of two kilogram and the chopped local oat samples were inserted to the containers. To remove gas from the container, packing with hand and periodically tamping with a wooden stick and tightly closed the containers were practiced (Figure 4). The mini silos were covered with plastic materials to decrease the DM lost. Moreover, the containers (mini silos) were protected from rodents, birds and livestock damage to prevent the plastic containers from aerobic spoilage.

Figure 4. Min silos for silage preparation with its replications

3.3.1. Treatments and experimental design

The factorial arrangement was applied for both the main effects of U and M treatments. The three replications were arranged using a random table (Kwanchai and Arturo, 1984). The raw and column for U and M for the repilication 1(12 and 13), 2(4 and 26) and 3(8 and 46) and for ensiling duration replication 1(14 and 16), 2(16 and 36) and 3(25 and 11) were used. The starting points for the arrangements were used finger touch on the random table. The random tables were used for both the replications treated silage and the date difference prepared silage (Appendix table 9).

3.4. Chemical composition of oat fodder and silage

3.4.1. Chemical composition of fodder

Local oats fodder samples at 50% flowering (before ensiling) were collected. After collection, the triplicate samples were weighed immediately, transferred into bags and taken to *Debre Berhan* agricultural research centre laboratory shortly after harvesting, and then the samples was weighed and put into a properly labeled paper bag and oven-dried at 60^{o}c for 72 hours. After drying the samples were ground in a Wiley mill to pass through 1-mm sieve for chemical analysis. Then after DM evaluation the three samples were mixed each other and representative samples were prepared for other chemical composition analyses.

3.4.2. Chemical composition of silage

After 21, 28, 42, and 56 days of the fermentation period, the mini silos were opened and samples were taken for physical and chemical analysis. Observation for mold formation was done starting from the silo opening time, while color, smell and texture were evaluated after silo content extraction. For physical analysis, the quality of silages were determined by color and smell. The color of the silage was measured using the four parameters: dark/deep brown, medium brown, yellow-brown, and greenish-yellow, and the smell was measured with the parameter of rancid/pungent smell, irritative/alcoholic, lightly acidic and very pleasant and sweet acidic (Getahun *et al*., 2018). To determine the chemical composition for DM, CP, NDF, ADF, acid detergent lignin (ADL), ash, and pH, the silage samples on average 228.75gm were collected from each mini silo (Appendix figure 6).

Silage samples collected from each mini silos was kept in an ice box until sending to *Debre Berhan* agricultural research institute laboratory. The collected samples were coded with the same as that of mini silos and a total of 36 samples were prepared for chemical analysis. Dried samples were ground to pass at a 1mm screen. Silage chemical evaluation was done after 21, 28, 42, and 56 days (Imsya *et al*., 2018; Habte, *et al*., 2020). Dry Matter, Nitrogen, and ash were analyzed using standard procedures of AOAC, (1990). Nitrogen content was determined using Kjeldhal method and then CP content was calculated as N x 6.25. Fibers such as NDF, ADF and ADL contents were determined following the standard procedures of Van Soest and Robertson (1985).

3.5. Statistical analysis

3.5.1. Statistical analysis of oats survey as feed and food

The collected data was managed using Microsoft excel version 2010. The survey of local oats as feed and food was analyzed using the SPSS version 23 software. Preliminary data analysis like homogeneity test, normality test and screening of outliers were employed before conducting the main data analysis. The data were presented using descriptive statistics like frequency, percentage, standard division, and variances.

3.5.2. Statistics of chemical analysis of silage

Experimental data were subjected to analysis of variance using the General Linear Model (GLM) procedure of the SAS program (SAS, 2004). Mean separation was done using Duncan's multiple rang test at 5% probability.

The following statistical model were used.

For U and M treatment

$Yijk = \mu + Ci + Pj + CPij + Eijk$. Where:

$Yijk$ = the dependent variable,

μ = overall mean,

Ci = effects of urea and molasses levels,

Pj = effect of duration of fermentation,

$CPij$= interaction effect,

$Eijkm$, = experimental error.

For ensiling duration

$Yij = \mu + Di + Eij$. Where

Yij = the dependent variable

μ = over all mean

Di = effects of ensiling duration

Eij = experimental error

4. RESULTS AND DISCUSSION

4.1. Socio-economic characteristics of the household

4.1.1. Demographic characteristics of the household

The details of results of the demographic characteristics of the respondents are presented in table 5. The results of the study indicated that the respondents age from 28-45 (49.3%). The adult age above 61 years old (7.76%) was the least age group participated in this survey. Similar to the current studies, CSA (2017) also reported that for both sexs the percentage of the population in each age group steadily decreases as age increases. Overall, 80.2% and 19.18% of the respondents were male and female-headed households, respectively. The percentage of female-headed households in the present study was lower than the values reported by Seblewengel (2018) for *Kimbibit* (50%), Sisay (2006) for *Debark* (51.6%), *Layarmachiho* (50.6%) and *Metema* (50%) *Woredas*.This could be due to cultural issues that forces females to get married and/or for economic reason. The result of the present study was also in agreement with the findings of previous studies (Azage Tegegne, 2004) (5.6%) for Addis Ababa who reported lower percentage of female headed-households.

The educational status of the respondents in the study areas ranges from illiterate to grade nine (Table 5). From the sampled households in the study area, about 47.03% were illiterate. These findings were in agreement with Dawit Assefa *et al.* (2013), who reported that large number of the respondents were illiterate at from *Adami Tulu Jiddo Kombolcha Woreda* of Oromiya. This will have a negative effect on the development of the livestock sector. Similar to the current study, CSA (2017) also indicted that about 48% of women and 28% of men at the age of 15-49 years have no formal education. Three percent of women and 5% of men have completed primary school, while 1% of women and men had secondary education. Six percent of women and 9% of men have more than a secondary education. In general, education is a basic tool for understanding and adopting new technologies to improve livestock production and productivity.

Table 5. Household characteristics of the respondents in the study areas

Characteristics	Kebele						Over all mean (N=219)	
	Dalota suke (n=75)		*Adaadi matto* (n= 71)		*Mogoro* (n=73)			
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
Age (years)								
28 – 45	41	54.6	36	50.7	31	42.7	108	49.3
46 – 60	30	40.0	31	43.6	33	45.2	94	42.9
Above 61	4	5.3	4	5.6	9	12.3	17	7.7
Family size								
HH head	67	89.3	65	91.5	69	94.5	201	91.7
Son of HH	5	6.7	3	4.2	3	4.1	11	5.0
Daughter of HH	3	4.0	3	4.2	1	1.4	7	3.
Sex of households								
Male	57	76.0	56	78.9	64	87.7	177	80.8
Female	18	24.0	15	21.1	9	12.3	42	19.2
Educational status								
Illiterate	37	49.3	31	43.7	35	47.9	103	47.0
Basic education	6	8.0	5	7.0	8	11.0	19	8.7
1 – 4	19	25.3	25	35.2	20	27.4	64	29.2
5 – 9	13	17.3	10	14.1	10	13.7	33	15.1

HH = Household, n/N = number of interviewed

4.1.2. Landholding and land use pattern of the households

Appendix table 1 and Table 6 shows the total land holding and land use pattern of the sample respondents in the study areas. In the current survey the maximum land holding per household for food crops, local oats and grazing were 5.3, 3 and 2 hectares, respectively (Table 6).The respondents land use pattern for oats were with the range of 0.4 to 1.5 ha (71%) and for other crops 0.75 to 2 ha (57%). The size of land allocated for crop production was higher than the other land use which was agreed with the finding of Seblewengel (2018), who reported that in *Kimbibit* wereda much of the land is used for crop production. In addition, Alemayehu *et al*. (2013) also reported that the increase in crop production in the past decade has been due to increases in area cultivated and little suitable uncultivated land remains in the highlands, apart from pasture land. Similarly, CSA (2019) indicted that in Ethiopia, cereal production is a dominant form of agricultural practice over other types of crop production. The average grazing landholding size in the study area 0.93ha was higher than the values reported by Mekete (2017) (0.52 ha) and 0.46 ha reported by Hassen *et al.* (2010) in the central highlands of Ethiopia.

Table 6. Land holding and use patterns of the sample households in the study areas (Mean±SD)

Land use (hec.)	**Kebeles**			**Overall**
	***Dalota suke* (n=75)**	***Adadi matto* (n=71)**	***Mogoro* (n=73)**	**N=219**
Crops land out of oats crops	2.23±0.77	1.87±0.78	2.22±1.09	2.11±0.90
Land holding for oats crops	1.21±0.051	1.17±0.54	1.18±0.61	1.19±0.55
Grazing land	1.02±0.42	0.84±0.25	0.92±0.27	0.93±0.33
Land for others (Housed and planted area)	0.05±0.06	0.05±0.06	0.05±0.07	0.05±0.06

hec = hectare, n/N = number of interviewed, SD = Standard deviation

4.1.3. Livestock holding per households

In the study area from the total herd size cattle were the largest position followed by sheep and goat population showed in (Table 7 and Appendix table 2). The current result agreed with CSA (2015) reported that in Ethiopia cattle population was the highest (54 million), followed by sheep (25.5) and goats (24.06 million). Similar results were observed by Seblewengel (2018), cattle, sheep and equines were the main livestock type in *Kimbibit Wereda*. According to Metaferia *et al.* (2011), cattle, sheep and goats are the three most important livestock species that have a considerable importance to the GDP of Ethiopia. Samson and Frehiwot (2014) also concluded that the Ethiopian highlands and areas which have a better infrastructure account for the largest share of the livestock population. In the current study, some of the interviewed candidates do not own poultry, equines, sheep and goat. In *Dalota suke kebele*, for instance, 49.3% of the respondent's didnot have poultry, equines (42.7%), and sheep and goat (25.3%).

Table 7. Livestock population in the study area

Animals type	Dalota Suke	Adad Matto	Mogro	Total of study area
Cattle	494	483	473	1450
Sheep and goat	345	430	446	1221
Equines	127	123	118	368
Poultry	202	148	145	495

4.2. Local oats in the study area

4.2.1. Introduction of local oats in to Kimbibit Wereda

Oats was first introduced in North *Shewa*, Salale areas by a man called San George in 1960 for animal feed (Gezahagn *et al*., 2016). *Jida* is known to be the first place where Oats was initially introduced. On the otherhand, Oats informally was introduced to the study area in 1977 by a person called "*Boke Wesenu*" and it was gradually distributed to the near *kebeles* and throughout the *Wereda* (Table 8). This finding was in agreement with the results obtained by Gezahagn *et al*. (2016). Respondents of survey and FGD, specially aged person has known how and when the local oats was first introduced in the *kebele*. A similar result was observed by Haile (2005), who reported that older people have relatively richer experiences of the social and physical environments as well as greater experience of farming activities. Even though, Oats was introduced earlier, it did not get much attention in improving it productivity. Similar findings were reported by Deribe (2015) and Gezahagn *et al*. (2016) who observed that no attention was given from the Zonal, *Wereda* and *kebele* level to oat crops. In the study *kebeles,* 38.3, 45.1 and 30.1 % of the respondents had the knowledge on the time of local oats introduction to *Dalota suke*, *Adadi matto*, and *Mogoro,* respectively. Generally, about 37 % of the total respondents had the knowledge when it was first introduced to their areas.

4.2.2. Reasons for local oats introduction to Kimbibit Wereda

The primary reason for the production of local oats in the study areas was because of its frost resistance capacity, requires less production cost and high demand (Table 8). In the study *kebele's*, about 82.6% of the respondents indicated that oats had the capacity to resist frost. In addition, the majority of respondents (82.2%) reported that oats was required low production cost as compared to other cereal crops. Gezahagn *et al*. (2016) also reported that, farmers prefer oats production for its ability to grow on the wider range of soil types, water logging area and resistance to biotic and abiotic stresses. Wani *et al*. (2014) reported that oats are generally regarded as a minor cereal crop when considered in terms of grain produced annually and used as animal feed.

Table 8. Response of household for the introduction and engaged of oat.

Description (%)	Kebele							
	***Dalota* (n=75)**		***Adadi Matto* (n=71)**		***Mogoro* (n=73)**		**Overall mean (N=219)**	
	Frequency	**%**	**Frequency**	**%**	**Frequency**	**%**	**Frequency**	**%**
Time of local oats introduced								
Yes	29	38.7	32	45.1	22	30.1	83	37.9
No	46	61.3	39	54.9	51	69.9	136	62.1
Reason for local oats engaged								
High demand								
Yes	55	73.3	56	78.9	59	80.8	170	77.6
No	12	16	11	15.5	6	8.2	29	13.2
No idea	8	10.7	4	5.6	8	11	20	9.1
Diseases resistant								
Yes	53	70.7	52	73.2	49	67.1	154	70.3
No	14	18.7	15	21.1	16	21.9	45	20.5
No idea	8	10.7	4	5.6	8	11	20	9.1
High price								
Yes	17	22.7	16	22.5	6	8.2	39	17.8
No	50	66.7	51	71.8	59	80.8	160	73.1
No idea	8	10.7	4	5.6	8	11	20	9.1

n/N = number of interviewed

Table 8. Response of household for the introduction and engaged of oat (***continued***)

Being in contract farming								
Yes	7	9.3	9	12.7	0	0	16	7.3
No	60	80	58	81.7	65	89	183	83.6
No idea	8	10.7	4	5.6	8	10.7	20	27.4
Frost resistant								
Yes	67	89.3	61	85.9	53	72.6	181	82.6
No	0	0	6	8.5	12	16.4	18	8.2
No idea	8	10.7	4	5.6	8	11	20	9.1
Less cost for production								
Yes	63	84	61	85.9	56	76.7	180	82.2
No	4	5.3	6	8.5	9	12.3	19	8.7
No idea	8	10.7	4	5.6	8	11	20	9.1
Do not engaged								
Yes	8	10.7	4	5.6	8	11	20	9.1
No	67	89.3	67	94.4	65	89	199	90.9
No idea	0	0	0	0	0	0	0	0

n/N = number of interviewed

4.2.3. Local oats variety in the study *kebeles*

The information related to local oats varieties are presented in Table 9. In the three study *kebeles*, from the total survey households, 44.7% of the households responded that there was only one variety of local oats in the study areas and did not know the name of the variety. Similar result was also reported by Gezahagn *et al*. (2016) who noted that the variety produced in the North shewa zone was not known by the respondents. The respondents commented that no one taking responsibility for the distributed local oats in the study *kebeles*. Moreover, both the *Wereda* agricultural office and zonal agricultural offices also indicated that no government and non-governmental organization was responsible for distributed local oats in the study areas. Similar results were indicated by Fikadu *et al*. (2018), who reported that without the indication of varieties' common oats (*Avena sativa*) were distributed in Selale in *North Shewa* Zone, Oromia regional state. Similar result was noted by Gezahagn *et al*. (2016) who also reported that *Injera* from oats were prepared mixing with other crops such as teff and barely. Moreover, oats powder was also utilized for soup making.

Table 9. Local variety information in the study area.

Variety	**Kebele**						**Overall mean**	
	Dalota Suke		***Adadi Matto***		***Mogoro***			
	Freq.	**%**	**Freq.**	**%**	**Freq.**	**%**	**Freq.**	**%**
One variety	34	45.3	37	52.1	27	37.0	98	44.7
I don't know	41	54.7	34	47.9	46	63.0	121	55.3
Total	75	100.0	71	100.0	73	100.0	219	100.0

Freq. = Frequency

4.2.4. Local oats seed source, seeding rates, growth, biomass and grain production in the study area

The survey study have revealed that neither the government nor the non-governmental organization take responsibility for the distribution of oats crop. On the other hand, Fekadu *et al*. (2018) reported that about 40 dual-purpose (forage and/or grain) type oats varieties were introduced from CIMMYT in the mid 1980's. In addition, Gezahagn *et al*. (2016) also reported that oats was informally distributed to the farming community by different livestock development projects of the Ministry of Agriculture. In general, the main seed sources of the study areas were from previously engaged farmers (58.4%) and (27.9 %) of respondents didn't know the sources (Table 10). Furthermore, broadcast sowing was the major sowing system in the study areas. Almost all of the respondents were practiced broadcasting sowing systems. The seeding rate of local oats was 90 to 100 kilograms per hectare, however, Dawit and Teklu (2014) reported that the fodder DM value (15.0 t/ha) was obtained at seed rate of 80 kg/ha at the higher fertilizer level, because fertilizer contribute for the increment of leaf area of fodder oats. Some of the respondents sowed at the rate of 101 to 110 kilogram per hectare. Only 8.7% of the interviewed participants indicted that they didn't know the seeding rates of local oats per ha (Appendix Table 3).

The growth stage of local oats varies based on the environment and rain fall amount in the study areas. When the rain fall was enough the seed emerged earlier and the crops matured with in short period as compared to less rain fall. The seed was emerging with the ranges of 7 to 15 days, which was agreed with Usman *et al*. (2018) and Duda *et al.* (2021), who reported that the emergence of spring oats was 10 days after sowing.

The flowering stage required between 90 to 105 days, rarely delayed up to 115 days, which was agreed with the findings of Dawit and Teklu (2011) who reported different varieties of oat have different yield performance and adaptation to specific situation, so the *Bonsa* oats variety reached 50% flowering and matured stage on day 106 and 149, respectively. Most of the respondents utilized local oats as a feed source at its flowering stage. The matured local oats harvested as food and straw needed 151 to 210 days, which was comparable with the finding of Usman *et al*. (2018) (177 to 215 days). The harvesting date was also influenced by the amount of rain fall in the study areas (Appendix Table 4), which was similar to the findings of Gezahagn *et al*. (2016).

In the study areas, the local straw biomass mostly depended on the sowed months of the year, as a result, local oats sowed in April had high biomass straw. In the study *kebeles*, the biomass of straw was approximately ranged between 500 to 1500 kilograms per hectare because of low mangment practice to oat production. Similarly, Gebremedhin *et al*. (2015) also reported that the green fodder for whole crop of improved variety of oats bio-mass was 60-80 ton per hectare. From the interviewed respondents 14.2 % participants did not know the biomass of local oats straw per hectare (Appendix Table 3).

Table 10. Local oats seed source in the study area

Descriptions	Kebele						Overall mean	
	Dalota		*Adaadi Matto*		*Mogoro*			
	Freq.	**%**	**Freq.**	**%**	**Freq.**	**%**	**Freq.**	**%**
Previously engage farmers	41	54.7	40	56.3	47.0	64.0	128	58.4
Government distributed	0	0	0	0	0	0	0	0
NGO distributed	0	0	0	0	0	0	0	0
Did not know the sources	34	35.3	31	43.7	26.0	35.6	91	41.6
Total	75		71		73		219	

Freq = Frequency

4.2.5. Sowing time of local oats in Kimbibit Wereda

Local oats in the study *kebeles* were sown for both feed and food. The survey and FGD respondents indicated that the quantity of grain and the fodder biomass depended on sow months. Local oats sow in April produced good biomass of fodder and straw and lower amount of grain. Moreover, oats sown in May produced higher grain yield, large grain size and less biomass of fodder and straw. This difference might be due to variation in rainfall distribution. There was less sowing practices in the other months. Even though more grain was produced in May sown oats, respondents in the study areas did not sow local oats in May due to shortage of rainfall (Table 11). Some of the respondent's sowed oats in June for cut and carry system (Table 12). The results of the current study was in line with the findings of Duda *et al*. (2021) who reported that spring sawing oat is preferable. However, oat performs better than other cereals on clay soils, tolerating also acid and low fertile soils, growing well between 4.5 to 8.6 pH (Duda *et al*., 2021). In contrast, Staff (2019) reported that November is the most suitable time for sowing of oats to get more production, but depending on the conditions and supply of fodder, its sowing can be done till December first week for irrigated oats.

Table 11. Sowing period of local oats in the study areas

Months	Responses	
	Freq.	%
March	41	18.7
April	147	67.1
May	22	10.1
June	4	1.8
I don't know	5	2.3
Total	219	100.0

Freq = Frequency

Table 12. Sowing month's difference of local oats as feed and food

Discriptions	Responses	
	Freq.	%
Sow at same months	145	66.2
Sow at different months	43	19.6
no idea	31	14.2
Total	219	100.0

Freq = Frequency

4.3. Management practices of local oats production as feed and food in the study area

4.3.1. Land preparation to local oats concerning other grain crops

The results from table13 indicated that the agronomic practices of local oats in the study areas were less than other cereal crops. The respondents in this study reported that local oats was less managed than wheat and barley. In the study area, the majority of households (66.7%) were plowed their oat lands two times, whereas, for wheat and barley minimum of four times, indicating less attention was given for oat production. In general, less attention was given to local oats production (Table 13). However, according to Staff (2019) reported that to get a good germination of oat crop, it is necessary to prepare the field properly.

Table 13. Land preparation for the production of fodder crop and cerial grains.

Land preparation	N	Discriptions	Freq.	%
Local oats				
		Plough once during sowing	54	24.7
	219	Plough two times including sow time	146	66.7
		Did not produce	19	8.7
Wheat				
		Plough four times including sow time	115	52.5
	219	Plough five times including sow time	85	38.8
		Did not produce	19	8.7
Barley				
		Plough three times including sow time	80	36.5
	219	Plough four times including sow time	120	54.8
		Did not produce	19	8.7

Freq = Frequency, N = number of respondents

4.3.2. Fertilizers application to local oats production

Natural and artificial fertilizers support the increment of crop productivity. All the respondents in the study areas were not practiced fertilizer application for oats production. Similar results were noted by Gezahagn *et al*. (2016) who reported that oats have grown without any input. In other words, Flores *et al*. (2012), Hawerroth *et al.* (2015), Silva *et al*. (2015), and Duda *et al*. (2021) observed that oat crop was more productive and responsive to nitrogen fertilizer. The majority of the respondents stated that the fertility of the soil was an issue for farmers. Due to this in the near future local oats land must be also needed fertilizer application. The management practice especially the application of nitrogen fertilizer expected to increase the biomass and nutrient contents of local oats as feed and food. Similarly, Seblewengel (2018) also reported that any farm input including use of fertilizer that augments agricultural productivity is expected to boost the overall production. In the study area, farmers sowed local oats in water logged areas, less productive soil and some of them on fertile soils without fertilizers. On the other hand, respondents were applied both natural and artificial fertilizer for wheat and barley on any type of farm land (Appendix table 5). Similarly, Alemayehu *et al*. (2013) also reported that in 2007/08 the fertilizer applications for wheat and barley in relation to total area cultivated 62.1 and 30.5 % covered, respectively. But in the study area, there was no such practice that result in low quality and quantity of oat production.

4.3.3. Others management practice to local oats

The management practice to any crops determined its productivity. Controlling of weed by hand and application of chemicals, both natural and artificial fertilizers were included on other management practice to any crop. Even though, the respondents were utilized oats as food in the study area, there was less/near to no management practices (91.3%) to increase its productivity, which was related to the report of Fekadu *et al*. (2018). On the other hand, weeds compete with crop plants for essential growth factors like light, moisture, nutrients and space (Bekele *et al*., 2018). Alemayehu *et al*. (2013) also that improved seed and fertilizer improve the productivity of wheat and barley. Moreover, uncontrolled weed growth throughout the crop growth could cause a yield reduction of 57.6 to 73.2% (Tesfaye *et al*., 2014).

4.4. Local oats grain production

The grain production of local oats was affected by the amount of rain and sowing time which was agreed with Fontaneli *et al*., (2012) who reported that the high yield of oat grains depends on a set of factors, such as technologies, management, climate, and soil. In the study areas, local oats were sown in May and its grain size was large. This finding was agreed with Duda *et al*. (2021), who reported that the sowing date had a great effect on oats production. The total production of grain per hectare was ranged from 1000 to 3000 kilogram (Table 14), which was lower than the findings of Usman *et al*. (2018) (2346 to 5693 kilogram), and higher than the findings of Gezahagn *et al*. (2016) who reported 395 kilograms per hectare in *Kimbibit Wereda.*

4.5. Special Feature of Local Oats

Respondents in the three study *kebeles* were identified the special feature of local oats which include; resistance to water logging, frost tolerant, disease resistance, and tolerant to drought with the percentage of 34.4, 32.6, 27.7, and 1.8, respectively (Table 14). This is in line with Gezahagn *et al*. (2016) and Usman *et al.* (2018) who observed that oats was well adapted to wide range of soils and relatively tolerant to moisture stress, water logging, and frost. Similarly, Dawit and Teklu (2011) also reported that as compared to other cereal crops such as barley and wheat, oats are adapted to a wide range of soils, resistant to moisture stress, and relatively tolerant to water-logging and frost. Similarly, Tewodros and Amare, (2016) also reported that among the forage grasses, oat is the best adapted and productive forage with minimum input usage and best during feed shortage. Moreover, according to the respondents, environmental change, less soil fertility, high costs of fertilizer and chemicals, and other management practices make other cereal crops production more tedious than Oats. Similar results were noted by Seblewengel (2018) who reported that land degradation, frost, deforestation, irregularities of rain pattern, water logging, and financial inability to use improved seeds, fertilizers, pesticides, and herbicides were leading to huge crop loss. Similarly, Alemayehu *et al*. (2013) also observed that the overall production of crop yield is highly susceptible to weather shocks, particularly droughts.

The survey respondents indicated that due to the challenge of food crops production and the good feature of local oats crops, farmers produced and utilized oats grain as food. Even though 85.8% of the respondents knew that local oats were registered as animal feed by the ministry of agriculture (MOAG, 2011), they were used as food sources due to the high production cost of other grain crops (Table 14).

Table 14. Special feature and reason of Local oats in the study kebeles

Discription	Freq.	%
Drought tolerance	4	1.8
Frost tolerance	71	32.6
Tolerate water logging	75	34.4
Disease tolerance	61	27.7
I don't know	8	3.6
Because other grain crops decreased productivity	34	15.6
Less management to Local oats no cost to produce	86	39.0
High quality nutrient in oats	4	2.0
High productive cost to other crops	95	43.4

Freq = Frequency

4.6. Utilization practices of local oats in Kimbibit Wereda

4.6.1. Utilization practices of oats as feed

Early introduction of local oats in the study areas was for animal feeding which was similar to Gezahagn *et al*. (2016) findings. Local oats straw, its green fodder, and also its grain was utilized as animal feed. Amanuel *et al*. (2019) and Eshetie *et al.* (2018) also reported its well adaptability and use as an energy source for livestock. Focus group discussion and questionnaire survey of the study areas indicated that during the time of introduction local oats were the best feed to all animals especially its grain was used for horse feed (Table 16). Getaneh *et al*. (2021) also indicted that Oats (*Avena sativa*) has been grown for thousands of years, mainly as animal feed. All respondents in the study areas agreed with the use of oats for both feed and food (Table 17). They utilized oats in the form of straw, after math, hull, grazing (Appendix figure 2), hay, cut and carry system, and grain feeding. Similar findings were also observed by Ghulam *et al*. (2014) who observed that oats were utilized in the form of direct grazing, cut and carry, grazed before stem elongation, and for grain. The majority of respondents used oats in the form of straw as a source feed followed by after math feeding (Appendix table 6 and Table 15). Some of the respondents fed local oats straw after treatment or addition of additives like molasses, salt, and oil by-products (Appendix table 7 and 8).

Table 15. Feeding time of local oats straw

Discription	**Freq.**	**%**
soon after collection	135	61.7
two months after collection	39	17.8
three months after collection	25	11.4
throughout the year	13	5.9
available time	7	3.2

Freq = Frequency

Table 16 . Purpose of local oats during the introduced time in the study area.

Discription	**Freq.**	**%**
As animals feed	96	43.8
I don't know	123	56.2
Total	219	100.0

Freq = Frequency

4.6.2. Utilization practice as food

The result indicated that oats were also accepted for human food (Table 17). All the respondents of the three *kebeles* explained that oats crop was used for making *Injera* after being mixed with other food crops with different ratio, which was agreed with Gezahagn *et al*. (2016) findings. Similarly, Wani *et al*. (2014) reported that oats for food use are first dehulled, because hulls are not suitable for humans' without processing, although readily digested by ruminants. Peterson (2001) also reported that oat has recently attracted its research and commercial attention mainly due to its high nutritional value.

In the study area, the color and odor of local oats mixed with barley and wheat were more acceptable than that of only barley and wheat *Injera*. Gezahagn *et al*. (2016) and Fikadu *et* *al*. (2018) were reported that oats mixed with different ratio of cereals like tef, wheat, and barley, its *Injera* was excellent acceptance with good quality parameters like texture, color, odor, and test. It was possible to conclude that mixing local oats grain with other cereal grains could be utilized as human food, which was similar to the findings of Gebremedhin *et al*. (2015).

Table 17 . Participant responses local oats as feed and food

Measured chatacters	**N**	**Freq.**	**%**
Local oats only animals feed	219	0	0.0
Local oats only human food	219	0	0.0
Local oats both as feed and food	219	219	100.0

Freq = Frequency, N = number of respondents

4.6.3. Utilization trend of local oats as feed and food

The trend of local oats straw utilization practices in the study area was increasing. From the total respondents, 85.8% indicated that the utilization trend of oats straw was increasing. Generally, in the study areas, the utilization of oats straw was increasing as compared to other cereals straw except for barley straw (Table 18). Local oats straw was used to cope with feed shortage especially during the dry season, which agreed with the previous study (Eshetie *et al*., 2018). Similarly, Getaneh *et al*. (2021) also indicted that Oats have been grown mainly as animal feed.

Most of the respondents (61.6%) were started feeding local oats straw soon after collection (Table 15). On the other hand, from the total interviewed respondents, 59.9 % were fed their animals using local oats grain. But due to different reasons, no one was prepared local oats as silage in any growth stage (Table 19). In the study areas, local oats grain as a source feed was decreased while, as a source food was increased, which agreed with the study of Gebremedhin *et al*. (2015) who reported that oats grain is the staple diet of human beings in some parts of the central high lands of Ethiopia. Similarly, Youssef *et al.* (2016) also observed that commercially available oats in different parts of the world are well known for their nutritional benefits due to their high composition of lipids, soluble fiber, unsaturated fatty acids, essential amino acids, minerals, vitamins, and avenathramide, an antioxidant found only in oats. The increased local oats as food in the study area were the opposite of that registered first by MOA as animal feed (MOARD, 2011). However, the status of local oats straw as feed resources was increasing as compared to other cereal straws in the study area (Table 20).

Table 18 . Status of local oats straw use as animal feed in the study areas

Discription	Freq.	%
Increased annual production of oats straw	82	37.2
Increased awareness on nutritional advantages of oats straw	23	10.5
Due to feed shortage and lack of other options	37	17.0
Excessively available straw	34	15.6
Less cost than others straw	27	12.3
No idea	16	7.4

Freq = Frequency

Table 19. Reason for silage was not preparing in study kebeles

Discription	Freq.	%
Lack of knowledge	89	40.5
Lack of expert extension service on silage preparation	32	14.6
Oats crops/grain needed than silage	98	44.9

Freq = Frequency

Table 20. Status of local oats as feed and food

Local oats	N	As	Discription	Freq.	%
Grain	219	Feed	Decreasing	153	69.9
			No idea	66	30.1
	219	Food	Increasing	167	76.3
			No idea	52	23.7
Straw comparing to others straw	219	Feed	Increasing	152	69.4
			No idea	67	30.6

Freq = Frequency, N = number of interviewed

4.6.4. Purpose of local oats other than feed and food

In the study areas, local oats were mostly used as feed and food sources. In line with the current result, Dawit and Teklu (2011) also reported fodder oat (*Avena sativa*) is one of the most important annual fodder crops for the cool highlands of Ethiopia. The competition between feed and food was affected livestock production. The local oats straw was also used for roofing of house (Figure 5), which was agreed with Gezahagn *et al*. (2016) findings. It was also used for fire wood and also used for house wall constructions.

Straw collected for roofing *Animals house cover* *Fire wood cover*

Figure 5. Local oats straw for other purpose.

4.7. Constraints of oats production in the study areas

The extension agents (development agents) in the study *kebeles* and the *wereda* experts were prevented the farmers to sow local oats on the crop land, which agreed with the report of Gezahagn *et al*. (2016). The respondents sowed local oats as food crops due to lower requirement of production cost as compared to other cereal crops. The constraints to use local oats as feed and food were the competition of farm land between local oats for animals and human food. The other constraint related to oats production was no management practices were applied for the production of local oats for both feed and food (Table 21). Similarly, Amanuel *et al.*, (2019) also reported that constraints related to oats production were limited agronomic practices and low biomass production.

Table 21 . Constraints to use local oats as feed and food in the study areas

Measured	Discripitions	Freq.	%
Constraints as feed	Shortage of rain during sow time	44	20.1
	Competition of oats straw for other purpose	53	24.2
	Lack of different variety of oats seed	68	31.1
	Competition as food	54	24.6
Constraints as food	Government police registered only as feed not allow as food	63	28.8
	Less productive than wheat and barely	78	35.6
	Lack of different variety of seed as food	78	35.6

Freq = Frequency

4.8. Feed resources, shortage and coping mechanism in the study areas

4.8.1. Feed resources

The main feed resources in the study areas were local oats straw, other cereal crops straw, grazing pasture and grass hay. Similar observation was given by Getnet (2012) who indicated that natural pasture, after math grazing and crop residues are the major sources of roughage in most parts of Ethiopia. In the study *kebele's* local oats straw was the main feed resource followed by other crops straw. Amanuel *et al*. (2019) also reported that oat straw is soft and its grains are also valuable feeds for dairy cows, horses, young breeding animals, and poultry. Similarly, CSA (2015) indicted that green fodder (grazing) is the major type of feed (56.23 %) followed by crop residues (30.06 %). Moreover, hay, industrial by-products, improved feed, and other feed types were also used as animal feeds that comprise about 7.44, 1.21, 0.3, and 4.76 % of the total feeds, respectively (Table 22). The respondents explained that local oats were utilized as a source of feed for their animals. As showed in Table 22, in the three study *kebeles*, the main feed resources were straw which was similar to the study of Ramana *et al*. (2015).

Table 22. Feed resource in the study area.

Discripitions	Freq.	%
Grazing pasture	59	26.9
Mixture of crops straw without oats straw	59	26.9
Oats straw	61	27.9
Grass hay	37	16.9
Oats hay	3	1.4

Freq = Frequency

4.8.2. Feed shortage and coping mechanisms

Feed shortage was one of the main obstacles for livestock production in the study *kebeles* which was similar to Getnet (2012) reports. . Of the total respondents, about 79.9 % were faced with feed shortages. The feed shortage encountered in all three *kebeles* was faced in July and August. The respondents were used different coping mechanisms such as collection and storage of crop residues mainly straw of oats and barley (Table 23 and Figure 6). According to the respondents, feed storage during the high production season was one of the coping mechanisms for feed shortage. In the study area, 36.6% of the respondent's stored oats straw during the production season, whereas 12.5% was stored hay (Table 23). Amanuel *et al*. (2019) and Gebremedhin *et al*. (2015) also observed that storage of natural grass hay and purchasing of feed (both concentrate and roughages) were used as coping mechanismAmong the given alternatives, the purchase of feed from markets was scored the least mechanism (4.8%) (Table 23). Tewodros and Amare, (2016) reported that among the forage grasses, oat (*Avena sativa*) is the best adapted and productive forage with minimum input usage and best for feed shortage coping mechanisms. Similarly, Belay and Geert (2016) also reported that farmers' adopted coping strategies by increasing the use of agro-industrial byproducts and concentrate mix, use of conserved hay, use of non-conventional feeds, purchasing green feeds when available, and reducing herd size.

Figure 6. Storage methods of feed in the study area

Table 23. Feed storage methods in study area

Discriptions	**Freq.**	**%**
Store during oats straw available	80	36.5
Store others crops straw during available (without oats straw)	74	33.8
Store oats hay during available	3	1.4
Store grass hay during available	27	12.3
Purchase from market	11	5.0
No idea	24	11.0

Freq = Frequency

4.9. Evaluation of local oats at 50% flowering as fodder and silage

4.9.1. Chemical composition of local oats at 50% flowering stage fodder and silage without additives

The DM content of oats fodders at 50% flowering stage was 27.4%. The value was higher than Ranjhnan (2001) who reported 17% DM at fresh blooming and 19% at the late blooming stage. Similarly, Khan *et al*. (2006) reported that at a different level of maturity of oats, the DM contents are not the same, which at medium maturity the DM content was 28.2% which was comparable with the current study values, and at early maturity, the value of DM was 21.4% which is lower than the current study. The same author also observed higher values of DM (34.5%) from the late maturity stage. In addition, the DM content of corn harvested at the milk stage was found to be 22.9% (Sibel *et al*., 2009) which disagreed with the current result.

The CP contents of oats fodder of the current study result was 7.12%. Comparable results were obtained by James (1987) (7-9%) and higher values were recorded by Ranjhnan (2001) (fresh early blooming (10.8%). The same author reported lower values of CP from fresh ripe oats (5.3%). Khan *et al*. (2006) also reported 7% of CP at late maturity of oats which was almost similar to the current results, but disagree with the value obtained at early maturity of oats (12.1%). Ghulam *et al*. (2014) reported a range of 8.41-9.13% CP contents of oats at different irrigated dates. In contrast, lower values were reported by Usman *et al*. (2018) who obtained 5.12% at 50% flowering stage.

The NDF value of oats fodder of the current study was 63.96%. This result was agreed with Khan *et al*. (2006) who reported 63% from early maturity oats but disagree at medium maturity (70.1%) and late maturity stage (76.1%). In addition, Usman *et al*. (2018) also recorded higher NDF values (69.95%) at 50% flowering stage. The current ADF results (48.96%) at 50% flowering stage were higher than the values obtained by Usman *et al*. (2018) (45.28%). Khan *et al*. (2006) also recorded lower values of ADF at early (30.2%), medium (38.5%), and late maturity stage (42.5%). Moreover, Ranjhnan (2001) reported 74.2% of NDF and 49.6% of ADF, and 7.51% ADL from oats straw. Khan *et al*. (2006) reported 3.2 and 4.3% of ADL at the early and medium maturity stage, respectively.

Moreover, Usman *et al*. (2018) recorded higher values of ADL (5.47%) at 50% of the flowering stage.

The ash content of oats in the current study (11.83%) was higher than the values obtained by Ranjhnan (2001), who registered 10.4% and 9.4% at the fresh blooming and late blooming stage, respectively. Khan *et al*. (2006) also observed similar ash contents at early maturity (11.2%) and medium maturity (11.3%), but higher values at late maturity (12.5%). In addition, Ghulam *et al*. (2014) reported 10.96% of ash contents from irrigated oats (*Avena sativa*) which was comparable to the current findings.

The chemical composition of local oats at 50% flowering stage of fodder and silages was presented in Table 24. The pH of silage ranged from 3.71 to 3.95 with the ensiling date of 21, 28, 42, and 56, which was considered a good quality silage. Similarly, Kang *et al*. (2018) also reported that fermented silage with pH values 4.3 or even below is considered as the most preferred silage. Rahman *et al*. (2021) also recorded pH values of 4.72 and 4.55 on the Napier grass silage at 30 and 60 ensiling days, respectively. Similarly, Saman (2004) reported pH values of 4.46, 4.32, and 4.42 for oats, barley, and triticale silages, respectively. Comparable pH values were also observed by Rafiuddin *et al*. (2016) at 21 days ensiling period (3.95).

The DM measured statistically significant at the ensiling dates of 21 and 28 but both at 42 and 56 ensiling days were ($P<0.01$) with the highest value at 56 ensiling dates. The current result of DM ranges from 32.33 to 40.73% with the ensiled dates of 21 to 56 days. This result was higher than Rahman *et al*. (2021), who observed 20.2 to 22.8% of DM on the Napier grass silage, whereas comparable values were reported by Salman (2004) who observed 38.5, 35.6, and 43.7% of DM for oat, barely and triticale silages, respectively.

The CP contents of the current study range from 9.49 to 10.61% on different ensiling dates, which was statistically different ($P<0.05$). The lowest and the highest CP was recorded on day 21 and 56, respectively. This result showed that the CP content was increased with the increasing ensiling dates. The current result was lower than the report of Saman (2004) who recorded 11.5% of CP from ensiled oats. In addition, the current report also differed from Rahmans *et al*. (2021) findings, who indicated that the CP contents of Napier grass silage fluctuate with the ensiling date where 90 days was lower than 60 days of Napier grass silage, which was opposite to the current findings. The CP content of the current oat silage was lower than the browse trees reported by Abaynesh and Getu (2018), within the range of 11.64 to 18.9%, Asmelash *et al*. (2020), ranges from 12.35 to 22.35%and Almaze *et al* (2021) which was 16.4 to 20.8 and partially comparable with the findings of Ahmed *et al.* (2017) within the rage of 3.24-16.9%, and Emana *et al*. (2017) which is ranged from 8.05% to 19.91%. The oats silage had a CP content of greater than the critical level of 8% CP to provide the minimum ammonia level for optimum rumen microbial function (Norton, 2003).

The NDF(P<0.01) and ADF(P<0.05) content of oats silage at 50% flowering stage, after 21 ensiled dates were 65.43 and 39.34 %, respectively. Volter et al. (2019) scored higher values of NDF (68.6%) and ADF (41.46%) and comparable ADF (39.1%) content were documented by Saman (2004) in the triticale silage. In addition, Rafiuddin *et al*. (2016) also studied on silage at 30 days ensiled and reported 63.31% of NDF, 33.41% of ADF at mid-bloom stage of Oats, 56.5% of NDF, and 29.39% of ADF from Sorghum, and 66.83% of NDF and 33.25% of ADF from Maize. In general, according to the current results, the NDF and ADF values were decreased as the ensiling time increased because Luiz (2016) indicted that the starch-protein matrix was degraded by proteolytic activity over an extended ensiling period. The values of ADL slowly decreased with the increment of ensiling dates (Figure 7 and 8). On the other hand, the DM of silage increased with increased ensiling date from 21 to 56 days (Figure7 and 8).

Table 24. Effect of ensiling duration on nutrient content of oat silage

Ensiling duration (days)	**Nutrient content**						
	PH	**% at DM**	**CP**	**NDF**	**ADF**	**ADL**	**Ash**
21	3.95	32.33[c]	9.49[c]	65.43[a]	39.34[a]	6.52[a]	9.53[a]
28	3.78	33.02[c]	9.79[bc]	58.86[b]	39.30[a]	5.69[ab]	9.86[b]
42	3.71	36.36[b]	10.47[ab]	56.84[b]	38.84[a]	5.14[b]	10.45[b]
56	3.82	40.73[a]	10.61[a]	52.89[c]	36.68[b]	4.65[b]	11.67[a]
CV%	3.74	3.85	3.48	2.89	2.53	9.65	5.83
PV	P > 0.05	P < 0.01	P < 0.05	P < 0.01	P < 0.05	P < 0.05	P < 0.05

ADF = acid detergent fiber, ADL= acid detergent lignin, CP = crude protein; CV=coefciant of Variance, NDF = neutral detergent fiber, PV=Probabilty Value and Means with different letters within column are significantly different at P≤0.05

4.9.2. Effects of Urea and Molasses additives on local oats at 50% flowering stage silage

The change in pH and chemical composition of local oats silage as affected by additives is presented in table 25. In both U and M treated and control silage the pH ranges from 3.84 to 3.89, which was comparable to the findings of Sibel *et al*. (2009) (3.5 to 4.2). The pH values were not significantly ($P > 0.05$) different among oat silages treated with the respective level of U and M additives, which was agreed with the results of Sibel *et al*. (2009), who indicated that the effects of U, M, and UxM mix on the pH was not significant. The pH results in this study were also similar to the findings of Khan *et al.* (2006) who reported the pH values of 3.96, 3.66, and 3.64 on M (0%), M (2%), and M (4%) respectively, on oats grass silage ensiled for 30 days. In contrast, higher values of pH was registered by Kang *et at*. (2018) who reported the pH of 4.5 and 3.99 on M (0%) and M (2%) respectively, on the cassava top silage ensiled for 30 days. The pH of the current result decreased with the level of M increased which agreed with the study of Khan *et al.* (2006) on oats grass silage and Kang *et at*. (2018) on cassava top silage ensiled for 30 days. This indicated that M facilitates better growth of lactic acid-producing bacteria.

A significant DM increment ($P < 0.01$) was observed in local oats silage treated with different levels of M as compared to the control (Table 25). Molasses has also been added to the silages to increase DM concentration, avoid DM loss, stimulate fermentation rate and production of lactic acid (McDonald *et al*., 1991). In the current study, as the level of M level increased the DM contents was also increased, which was agreed with Khan *et al.* (2006) studies on oats grass and Kang *et at*. (2018) on cassava top silage ensiled for 30 days. In addition, M has been used to supply energy sources that can fastly be fermented into lactic acid by lactic acid bacteria and to increase the DM content of forage (Thomas *et al*., 2003). The U-treated oats in the current result were less effects to increase the DM contents. These results agreed with the study of Kang *et al*. (2018) who reported that as the level of U treatment increased less effects to increase DM contents of silage.

The CP values were significant ($P<0.05$) difference among oat silages treated with the respective level of M additives. The effects of M to increase CP contents of silage was less effective in the current result, but McDonald *et al*. (1991) reported that additive-containing carbohydrates result in to decrease ammonia-N by stimulating fermentation via these effects improve the amount and quality of protein. In the current result the CP (P<0.01) content of 50% oats silage treated with U was increased with the increments of the level of U additives. Similar results were reported by Bilal and Brahim (2005) who indicated that the addition of U increased the CP contents of sorghum silage (P<0.01). Kang *et at*. (2018) also observed higher values of CP as U level increased on cassava silage ensiled for 30 days.

As indicated in Table 25 and Table 26 the NDF, ADF, and ADL concentration in different levels of U treated local oats silage was slightly decreased which was similar to previously studied on cassava top silage (Kang *et at*., 2018). The NDF concentration of the silage treated by 1% U its mean was differed from 0.5% treated. The silage treated at 0.5 and 1 % level of U, their mean level of ADL were similar. The NDF level of M treated local oats silage was highly decreased as the proportion of M increased (Table 25), this was because M as a silage additive provides a source of readily fermentable sugar promote the ensiling process, and improve the silage quality. McDonald *et al*. (2002) indicted that M reduced the pH and ammonia levels in treated silages, which Ammonia cause pungent smell in silage. Similarly, McDonald *et al*. (1991); Kung *et al*. (2003) and Dehghani *et al*. (2012) reported that lactic acid bacteria with more fermentable substrate degraded cell-wall components to simpler molecules in the silage. In addition, Arbabi and Ghoorchi (2008) studied that NDF and ADF values of silage was decreased with an increased percentage of M. McDonald *et al*. (1991) and Baytok (2005) indicted that reducing ADF due to the effect of M raising fermentation silage. This additive is also utilized by microorganisms and increase fermentation activity which helps hemi-cellulose degradation in silage (McDonald *et al*., 1991; Arbabi and Ghoorchi, 2008).In current studies, the silage treated with both U and M its NDF, ADF, and ADL values were significant (P<0.05) which was similar to the study of Bilal and Brahim (2005) on sorghum silage.

In all different levels of U ($P < 0.01$) and M ($P < 0.05$) treated silage the ash contents were slightly increased (Table 25). The ash contents at 0.5 and 1% U treated silage their means were similar, also had similar mean for the control and 2 % level of M and 2 and 4 % level of M treated silage.

In general, U and M treatment increased the quality of oats silage which was agreed with the study of Wanapat *et al*. (2013) who reported that supplementation of U and M improved the quality of whole crop rice silage by increasing CP and reducing NDF and ADF contents.

Table 25. Nutrient compostion of Urea and Molasses treated oat ensiled for 21 days

Measured parameters	**Level of Urea (%)**				**Level of Molasses (%)**			
	0	**0.5**	**1**	**PV**	**0**	**2**	**4**	**PV**
PH	3.88	3.86	3.86	P>0.05	3.89	3.86	3.84	P>0.05
DM	35.53[b]	36.57[a]	36.71[a]	P<0.05	34.31[c]	36.38[b]	38.11[a]	P<0.01
CP	9.77[c]	15.38[b]	17.07[a]	P<0.01	13.58[b]	14.36[a]	14.28[a]	P<0.05
NDF	50.49[a]	50.23[a]	48.47[b]	P<0.05	62.38[a]	45.94[b]	40.87[c]	P<0.01
ADF	34.95[a]	33.73[ab]	33.13[b]	P<0.05	36.54[a]	33.60[b]	31.68[c]	P<0.01
ADL	5.28[a]	4.93[ab]	4.81[b]	P<0.05	5.76[a]	4.92[b]	4.34[c]	P<0.01
Ash	10.00[b]	10.84[a]	11.16[a]	P<0.01	10.25[b]	10.64[ab]	11.11[a]	P<0.05

Means with different letters within column are significantly different at P≤0.05

ADF=Acid Detergent Fiber, ADL=Acid Detergent Liginin, CP=Crud Protein, DM= Dry Matter, NDF=Nuteral Detergent Fiber

Table 26. Effects of Urea and Molasses on prepared silage at 21 day of ensiling

Main effects	**Nutrient content**						
	PH	**DM**	**CP**	**NDF**	**ADF**	**ADL**	**Ash**
Urea level (%)							
0	3.88	35.53[b]	9.77[c]	50.49[a]	34.95[a]	5.28[a]	10.00[b]
0.5	3.86	36.57[a]	15.38[b]	50.23[a]	33.73[ab]	4.93[ab]	10.84[a]
1	3.86	36.71[a]	17.07[a]	48.47[b]	33.13[b]	4.81[b]	11.16[a]
Molasses level (%)							
0	3.89	34.31[c]	13.58[b]	62.38[a]	36.54[a]	5.76[a]	10.25[b]
2	3.86	36.38[b]	14.36[a]	45.94[b]	33.60[b]	4.92[b]	10.64[ab]
4	3.84	38.11[a]	14.28[a]	40.87[c]	31.68[c]	4.34[c]	11.11[a]
P-value							
U	P>0.05	P<0.05	P<0.01	P<0.05	P<0.05	P<0.05	P<0.01
M	P>0.05	P<0.01	P<0.05	P<0.01	P<0.01	P<0.01	P<0.05
U*M	P>0.05	P<0.05	P<0.05	P<0.05	P<0.05	P<0.05	P<0.05

ADF=Acid Detergent Fiber, ADL= Acid Detergent Liginin, CP=crud protein, DM=Dry Matter, M=Molasses, NDF=Nuteral Detergent Fiber and U=Urea

4.9.3. Effects of interaction of Urea and Molasses treatment on local oats at 50% flowering stage silage

The current study indicated that the pH level of the silage was decreased as the proportion of M increased (Table 27), which is proportionally similar to the report of Mehtap *et al*. (2007) observed on sorghum silage. The DM was increased with the increment of treatment levels of U and M on oats silage ($P < 0.01$). The control sample DM was lowest as compared to the other treated oats silage. The DM was increased with the increment level of M treatment which agreed with the report of Getahun *et al*. (2018) studied on sugarcane top ensiled. On the other hand, U treatment has less effects on the DM percentage.

The CP percentage of the interactions was significant ($P < 0.01$). The increased level of U treatment radically changed the CP level of silage. The control sample CP was 9.49% whereas the oats silage treated with U 1% and M 4% CP contents was 16.88 %, but less effects for M alone which agreed with the study of Getahun *et al*. (2018). The contents of NDF, ADF, and ADL were minimized significantly with the increased level of M treatment, but no significant effect on the level of U treatment. The interaction treatment of U and M decreased the NDF percentage but less effects on the ADF and ADL.

Table 27. Effects of Urea and Molasses interaction at 21 day of ensiling

Treatment (%)		**Nutrient content**						
U	M	pH	DM	CP	NDF	ADF	ADL	Ash
0	0	3.95	32.33^{e}	9.49^{d}	65.43^{a}	39.34^{a}	6.52^{a}	9.53^{d}
0	2	3.89	35.76^{cd}	9.43^{d}	45.38^{c}	33.78^{bcd}	5.07^{bc}	10.15
0	4	3.8	38.49^{a}	10.4^{d}	40.66^{d}	31.73^{cd}	4.26^{d}	10.33^{bcd}
0.5	0	3.9	35.12^{d}	14.29^{c}	61.23^{b}	35.92b	5.34^{bc}	10.46^{bcd}
0.5	2	3.84	36.77^{bc}	16.31^{ab}	47.39^{c}	33.38^{bcd}	4.84^{bcd}	11.42^{ab}
0.5	4	3.84	37.83^{ab}	15.56^{b}	42.03^{d}	31.91^{cd}	4.62^{cd}	10.63^{bcd}
1	0	3.84	35.5^{cd}	16.97^{a}	60.48^{b}	34.36^{bc}	5.43^{b}	10.77^{bc}
1	2	3.85	36.62^{bcd}	17.36^{a}	45.06^{c}	33.64^{bcd}	4.83^{bcd}	10.35^{bcd}
1	4	3.88	38.0^{ab}	16.88^{a}	39.87^{d}	31.41^{d}	4.16d	12.37^{a}
PV		P>0.05	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
CV		1.37	2.38	4.31	3.42	4.03	7.60	5.49
Mean		3.87	36.27	14.08	49.73	33.94	5.01	10.67

CV = Coefficient of variance NS = Not significant PV = Probability value CP = crude protein; NDF = neutral detergent fiber; ADF = acid detergent fiber; ADL= acid detergent lignin; Means with different letters within column are significantly different at P≤0.05

4.9.4. Comparisons of fodder, treated and ensiling date difference of local oats at 50% flowering stage

The DM of U treated 50% flowering of local oats silage was slightly increased from 0 to 1 % U treatment, which agreed with the study of Kang *et al*. (2018) who reported that U had less effect in increasing the DM values of silage. In the silage treated with M, the DM contents were slightly increased as the level of M increased. Molasses has also been added to the silage to increase DM concentration (McDonald *et al*., 1991; Thomas *et al*., 2003). The DM of silage ensiled from day 21 to 56 were increased which was agreed with Rahman *et al*. (2021) who reported that the fermentation period had a significant effect on the DM content of Napier grass silage. The local oats silage treated with U and M had less DM as compared to that of ensiled date without any additives. The fodder DM at 50% flowering stage was less than that of both U, M treated and ensiled without the two additives because the fodder had high moisture contents at the harvested time.

As indicated in table 28, the CP contents at 50% flowering stage silage was radically changed in U-treated silage. The CP contents in U zero percent was 9.77% but in 1% U level increased to 17.07%. The advantage of using ammonia positively resulted in an enhanced CP source and decreased protein degradation in the silo (Yibarek and Tamir, 2014). Molasses treated and different ensiled date silage had less effect to increase the CP contents, but as Kang *et al*. (2018) reported that the addition of different combinations of U and M may improve both the protein content and fermentation quality of the silage. The CP values of oats fodder at 50% flowering stage was less than that of all treated ensiled oats silage at the same stage.

The measured NDF, ADF, and ADL of 50% flowering stage of local oats fodder, treated with different levels of U and M and ensiled date difference showed in table 28. In current results both M and ensiled date decreased the NDF percentage this is because the addition of M to silage increases the number of lactic acid bacterium; therefore, the NDF and ADF degradation of silage increases (Bilal and Brahim, 2005).

The U treated local oats silage had less effect to decrease the NDF contents on prepared silage. The ADF content of silage decreased both treated with U, M, and ensiled date difference. Increased levels of U and M and ensiled date minimize the ADF values in local oats silage. On the other hand, the ADF and ADL concentration at 50% flowering stage fodder was higher than that of all treated and different ensiled dates.

The ash contents of 50% flowering local oats fodder, U treated, M treated, and date ensiled silage are almost similar as shown in table 28. The ensiled date not equally affected the ash contents. The increased ensiled date proportionally affected the ash content at 50% flowering stage of local oats silage.

Table 28. Nutreint content comparison for Fodder, Urea or Molasses treated and different ensiling durations of oat

Nutreints	Fodder	Ensiling durations 21 days				Ensiling durations without additives			
		Level of Urea treatment (%)		Level of Molasses treatment (%)		21	28	42	56
		0.5	1	2	4				
DM	27.14	36.57	36.71	36.38	38.11	32.33	33.02	36.36	40.73
CP	7.12	15.38	17.07	14.36	14.28	9.49	9.79	10.47	10.61
NDF	63.96	50.23	48.47	45.94	40.87	65.43	58.86	56.84	52.89
ADF	48.94	33.73	33.13	33.6	31.68	39.34	39.3	38.84	36.68
ADL	7.51	4.93	4.81	4.92	4.34	6.52	5.69	5.14	4.65
Ash	11.83	10.84	11.16	10.64	11.11	9.53	9.86	10.45	11.67

ADF=Acid Detergent Fiber, ADL=Acid Detergent Liginin, CP=Crud protein, DM=Dry Matter, NDF=Nuteral Detergent Fiber

5. SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1. Summary and Conclusion

The survey study was aimed at assessing the utilization practices of local oats as feed and food in three selected *kebeles* of *KimbibitWwereda* of North *Shewa* Zone to generate baseline information and design intervention strategies. A total of 219 randomly selected household respondents were involved in the study. Additional information was collected from the respective *district* agricultural offices, extension agents, and key informants. Data from the household-based survey was collected using a pre-tested semi-structured checklist. The result showed that almost all interviewed farmers were utilized local oats as human food in the study areas.

The main feed resources in the study areas were local oats straw, other cereal crops straw, grazing pasture, grass hay, and local oats hay. Feed shortage was one of the main obstacles for livestock production in the study *kebeles*. Farmers utilized oats in the form of straw, after math, hull, grazing, cut and carry system, and grain feeding.

According to the view of the respondents, feed shortages mostly occurred from January to May and straw and hay are the major feed resources. Local oats straw take the higher percentage as feed source than other feed resources. Most of the respondents fed straw and hay grass to their animals soon after collection. None of the respondents conserve local oats in the form of silage for later use mainly due to lack of knowledge (76.3%) and poor extension service (25.1%) on silage preparation.

Moreover, storage of oats straw and other crops straw, conservation of hay, and purchasing of feed from markets are used as coping mechanisms with feed shortage. In addition, increasing the biomass of grass, decreasing the use of local oats straw for other purposes and good storage of feed during available are also other coping mechanisms practiced to reduce feed shortage in the study areas.

The survey result revealed that of the total respondents, 76.3% confirmed the status of local oats as food was increasing. The trend of farmland use for local oats was increasing due to its capacity to grow on frost and waterlogging areas, its ability to grow in low soil fertility and higher production costs of other cereal crops, which affects the production of other cereal crops. Even though, the respondents utilized oats as food in the study area, there was less management practices (no weed control and fertilizers used) to increase its productivity and need professional interference in the study *Wereda*.. The main challenges of local oats production in the study area was also the computation of oats for feed and food, wastage for roofing of house and firewood.

Local oats silage which was treated with U at the level of 0.5 and 1% exhibited relatively the best quality silage characteristics. The local oats silage treated with U at the level of 0.5 and 1 % helps to increase the CP content. The M treated at the level of 2 and 4 % decrease the NDF and ADF values. The NDF and ADF values decreased as ensiled date increased. These showed that local oats silage treated with different levels of M and increasing ensiled date, the acceptance and palatability to the animals would be increased. In addition, the interaction of U (1%) and M (4%) increased the CP contents of the oats silage. The DM contents also increased with the level of increased treatment of U and M interaction.

In general, it is possible to conclude from the current study that quality silage could be successfully made from local oats fodder at 50% flowering stage. In addition, it is possible to satisfy the CP requirements of ruminants from silage treated with U than feeding local oats fodder at 50% flowering stage without treatment. Moreover, it is also possible to satisfy the DM requirement of the animals from oats silage without any additives by increasing the ensiled date. To feed animals with low NDF and ADF content, treating the local oats at 50% flowering stage with M is very important. Inaddition it is possible to concluded that the CP, DM, NDF and ADF contents of oat silage good quality at the ineraction level of U(1%) and M(4%). In general, U and M treatment increased the quality of oat silage.

5.2. Recommendations

From the present study, it could be recommended that

- Appropriate feed conservation and utilization practices should be applied to ensure a year-round feed supply to livestock. Oat silage treated only at 1% level of urea to get high level of CP content and treated with M at the level of 4% to harvest low level of NDF and ADF is recommended.

- In the study area, farmers should be provided all-rounded extension support related to common Oats as feed and food by stakeholders/concerned bodies
- To tackle the feed scarcity encountered during the dry season, promoting new technologies such as silage making and wise use of locally available feed resources should be practiced in the study areas.
- Awareness should be created on the use of additives especially Urea and Molasses for silage preparation from local oats.
- Generally, the survey of this study investigated that the variety of local oats was not well known in the study *kebeles*. So further research should be done to supply appropriate variety of local oats to ensure alternative feed sources for livestock.

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7. APPENDICES

Appendix I. Questionnaire format

Date ______________________

Questionnaire for local oats assessments as feed and food in Oromia North shewa Zone *kimbibit wereda.*

I. Background

I am happy to contact you. Welcome to the questionnaire. This questionnaire is prepared for assessment of local oats crops as feed and food. This questionnaire need candor and true answers. Before answering this question, I want to say thank you, because, I hope you will have been answered candor and true answers.

1. General information

- Region _____________________________________
- Zone _______________________________________
- Wereda _____________________________________
- Kebele ______________________________________
- Specific Goti /area/ in kebele's ______________________
- Name of farmer's (if possible) __________________________________

1.1. Position of household (respondent of the questionnaire)

1. Household head ☐
2. Son ☐
3. Daughter ☐
4. Others ☐

a. Status of the respondent of the questionnaire

Age (years)	Sex	Educational status							
		grade 1-3	grade 4-6	grade 7-9	grade 10-12	Certificate	Diploma	Degree	Religious

b. Status of family members

Age (years)	Total		Educational status							
	M	F	grade 1-3	grade 4-6	grade 7-9	grade 10-12	Certificate	Diploma	Degree	Religious
< 5										
6-15										
16-28										
29-45										
46-65										
>65										

2. Livestock holding:

Livestock categories	Number
Oxen	
Cows	
Bulls	
Heifers	
Calves	
Sheep	
Goats	
Horses	
Mules	
Donkeys	
Poultry	

3. Land holding in hectare and use pattern

3.1. Total land holding ____________________________hectare

3.2. Total land cultivated for crops without oats farm land ______________ hectare

3.3. Land allocated for oats crops _____________________ hectare

3.4. Land allocated for grazing from the total land holding _____________ hectare

3.5. Others (housed area, different plants) __________________ hectare

4. What is your household's major means of income generation? (Mark √)

1. Crop production only ☐
2. Livestock production only ☐
3. Crop and livestock production ☐
4. Crop production and trading ☐
5. Livestock production and trading ☐
6. Crop production, livestock production and trading ☐

II. Questions for assessment of Local Oats as animals feed and human food

1. Why do you engage in local oat production? (Mark √)

1.1. High demand Yes [ ] No [ ] No idea [ ]

1.2. Disease resistance Yes [ ] No [ ] No idea [ ]

1.3. High price Yes [ ] No [ ] No idea [ ]

1.4. Being in contract farming Yes [ ] No [ ] No idea [ ]

1.5. Frost resistant Yes [ ] No [ ] No idea [ ]

1.6. Less cost for production Yes [ ] No [ ] No idea [ ]

1.7. Do not engaged Yes [ ] No [ ] No idea [ ]

2. How long have you been in oat production? ___________________________ years
3. Do you know the time when local oats introduced to this kebele? (Mark √)

Yes [ ] No [ ]

4. If question number 3 is "yes" When? ____________________________________
5. For what purpose did oat introduced to this kebele?
   1. As animals feed only [ ]
   2. As human food only [ ]
   3. Both as animals feed and human food [ ]
   4. I don't know [ ]
6. How many variety were introduced to this area?
   1. One variety [ ]
   2. Two variety [ ]
   3. Three variety [ ]
   4. Four variety [ ]
   5. I don't know [ ]
7. If question number 6 is more than one i.e. other than local oats, explain it (Write the name of variety)?
   1. ____
   2. ____
   3. ____

7.1. If any comment and idea on the variety of oats in this kebele, pleas comment and give your idea. ____

8. How many times did you plough to sow local oats? (mark √)

1. Once, during sowing
2. Two times including sowing time
3. Three times including sowing time
4. Four times including sowing time
5. I don't practice

9. How many times did you plough to sow barely? (mark √)

1. Once, during sowing
2. Two times including sowing time
3. Three times including sowing time
4. Four times including sowing time
5. Five times including sowing time
6. I don't practice

10. How many times did you plough to sow wheat? (mark √)

1. Once, during sowing
2. Two times including sowing time
3. Three times including sowing time
4. Four times including sowing time
5. Five times including sowing time
6. I don't practice

11. When do you sow local oats? (mark √)

11.1.February	Yes	No	No idea
11.2. March	Yes	No	No idea
11.3. April	Yes	No	No idea
11.4. May	Yes	No	No idea
11.5. June	Yes	No	No idea
11.6. July	Yes	No	No idea
11.7. I don't know	Yes	No	No idea

12. If any comment on the time of sowing of oats, please comment on it specially in relation to raining time? ____

13. Is there any difference between sowing times of local oats to animals feed and as human food? (mark √)

Yes ☐ No ☐ No idea ☐

14. If question 13 is 'yes' explain the difference. ____________________________

15. Did you apply artificial fertilizers to increase the productivity of local oats as animals feed? (mark √)

Yes ☐ No ☐ No idea ☐

16. If question 15 is 'yes' which type of fertilizer did you apply?

    1. ____________________ fertilizer __________ kilogram per hectare
    2. ____________________ fertilizer __________ kilogram per hectare

17. If question 15 is 'No' why didn't you apply artificial fertilizers? ________________

18. Did you apply artificial fertilizers to increase the productivity of local oats as human food? (mark √)

Yes ☐ No ☐ No idea ☐

19. If question 18 is 'yes' which type of fertilizer did you apply?

    1. ____________________ fertilizer __________ kilogram per hectare
    2. ____________________ fertilizer __________ kilogram per hectare

20. If question 18 is 'No' why didn't you apply artificial fertilizers? ________________

21. Did you apply natural fertilizers to increases the productivity of local oats as animals feed? (mark √)

Yes ☐ No ☐ No idea ☐

22. If question 21 is 'yes' what form of natural fertilizers did you apply? (Possible to mark more than one answers) (mark √)

    1. Compost form ☐
    2. Bovines manure ☐
    3. Equine manure ☐
    4. Others (Specify) ________________________________

23. If question 21 is 'No' why didn't you apply natural fertilizers to increase productivity?

____

24. Did you apply natural fertilizers to increases the productivity of local oats as human food? (mark √)

Yes ☐ No ☐ No idea ☐

25. If question 24 is 'yes' what form of natural fertilizers did you apply? (Possible to mark more than one answers) (mark √)

1. Compost form ☐
2. Bovines manure ☐
3. Equine manure ☐
4. Others (Specify) ______________________________

26. If question 24 is 'No' why didn't you apply natural fertilizers to increase productivity?

____

27. Did you apply artificial fertilizers to increases the productivity of wheat? (mark √)

Yes ☐ No ☐ No idea ☐

28. Did you apply natural fertilizers to increases the productivity of wheat? (mark √)

Yes ☐ No ☐ No idea ☐

29. Did you apply artificial fertilizers to increases the productivity of barely? (mark √)

Yes ☐ No ☐ No idea ☐

30. Did you apply natural fertilizers to increases the productivity of barely? (mark √)

Yes ☐ No ☐ No idea ☐

31. How long will it take for the growth of local oats? (mark √)

31.1. Emerging of seed

1. 7 to 10 days ☐
2. 11 to 15 days ☐
3. 16 to 20 days ☐
4. I don't know ☐

31.2. To reach flowering stage

1. Up to 90 days ☐
2. 91 to 105 days ☐
3. 106 to 115 days ☐
4. I don't know ☐

31.3. To harvest as animals feed

1. Up to 90 days ☐
2. 91 to 105 days ☐
3. 106 to 115 days ☐
4. 116 to 150 days ☐
5. I don't know ☐

31.4. To harvest as human food

1. 120 to 150 days ☐
2. 151 to 180 days ☐
3. 181 to 210 days ☐
4. I don't know ☐

32. If any comment on growing period, please comment on it specially as animal's feed and human food? ____

33. Where is the source of local oats seeds? (mark √)

33.1. Previously engaged farmers Yes ☐ No ☐ No idea ☐

33.2. Government distributed as feed Yes ☐ No ☐ No idea ☐

33.3. Government distributed as food Yes ☐ No ☐ No idea ☐

33.4. NGO distributed as feed Yes ☐ No ☐ No idea ☐

33.5. NGO distributed as food Yes ☐ No ☐ No idea ☐

33.6. I don't know the source, but seen when my parents use as feed Yes ☐ No ☐ No idea ☐

33.7. I don't know the source, but seen when my parents use as food Yes ☐ No ☐ No idea ☐

33.8. I don't know the source Yes ☐ No ☐ No idea ☐

34. Local oats seeding rates, production and straw biomass (mark √)

34.1. Seeding rates per hectare in this kebele

1. 90 to 100 kilogram ☐
2. 101 to 110 kilogram ☐
3. 111 to 120 kilogram ☐

4. 121 to 130 kilogram ☐
5. I don’t know ☐

34.2. Local oats grain production per hectare in this kebele

1. Less than 1000 kilogram ☐
2. Between 1000 to 2000 kilogram ☐
3. Between 2001 to 3000 kilogram ☐
4. Between 3001 to 4000 kilogram ☐
5. Between 4001 to 5000 kilogram ☐
6. Greater than 5000 kilogram ☐
7. I don’t know

34.3. Biomass of oats straw in this kebele

1. Less than 500 kilogram ☐
2. Between 501 to 1000 kilogram ☐
3. Between 1001 to 1500 kilogram ☐
4. Between 15001 to 2000 kilogram ☐
5. Between 2001 to 2500 kilogram ☐
6. Greater than 2500 kilogram ☐
7. I don’t know ☐

35. What is the special features of local oats? (Mark √)

35.1. Drought resistant Yes ☐ No ☐ No idea ☐

35.2. Frost resistant Yes ☐ No ☐ No idea ☐

35.3. Resist water logging Yes ☐ No ☐ No idea ☐

35.4. Disease resistant Yes ☐ No ☐ No idea ☐

35.5. I don’t know Yes ☐ No ☐ No idea ☐

36. What types of management did you apply to increase the productivity of local oats? (Mark √)

36.1. Controlling and removing of weed by hand Yes ☐ No ☐

36.2. Controlling and removing of weed by chemicals Yes ☐ No ☐

36.3. Appling natural fertilizers like compost Yes ☐ No ☐

36.4. Appling animals manure as fertilizers Yes ☐ No ☐

36.5. Appling artificial fertilizers Urea Yes ☐ No ☐

36.6. Appling other artificial fertilizers Yes ☐ No ☐

36.7. No management except plough the farm and sow it. Yes ☐ No ☐

36.8. No idea Yes ☐ No ☐

37. Do you utilize oats crops only for animals feeding? (Mark √)

Yes ☐ No ☐

38. Do you know the species you have used as animals feed? (Mark √)

Yes ☐ No ☐

39. If question number 38 is "Yes" what was the name of species did you use as animals feed?

39.1.________________________________

39.2.________________________________

39.3.____________________________

40. Do you utilize oats crops only as food (human conception)? (Mark √)

Yes ☐ No ☐

41. If question number 40 is "yes" in what form do you consume?

41.1.____

41.2.____

41.3.____

42. Do you utilize local oats crops both as animal's feed and human food? (Mark √)

Yes ☐ No ☐

43. If question number 42 is 'yes' in what form did you utilize for your animals? (Mark √)

43.1. Grazing Yes ☐ No ☐

43.2. Oat straw form Yes ☐ No ☐

43.3. Oats hay form Yes ☐ No ☐

43.4. Oats hull form Yes ☐ No ☐

43.5. Oats Cut and carry system Yes ☐ No ☐

43.6. Oats silage form Yes ☐ No ☐

43.7. Oats grain feeding Yes ☐ No ☐

43.8. Feeding aftermath Yes ☐ No ☐

44. Why do you utilized oats as human food? (Mark √)

44.1. Because it is high quality food than other grain Yes ☐ No ☐ No idea ☐

44.2. Because of low production cost than other grain production Yes ☐ No ☐ No idea ☐

44.3. Shortage of other grain production due to environmental challenges but oats production can resist environmental challenges (Mark √)

Yes ☐ No ☐ No idea ☐

45. Explain how you use as human food. ____

46. Is there a deference between species of oats crops as animal's feed and human food?

Yes ☐ No ☐

47. If question 46 is "Yes"

47.1.Name of species used as animal's feed

1. ________________________________
2. ________________________________
3. ________________________________

47.2. Name of species used for human food

1. ________________________________
2. ________________________________
3. ________________________________

48. What is the main source of feed for your livestock? (Mark √)

48.1. Grazing pasture Yes ☐ No ☐

48.2. Mixture of crops straw without oats straw Yes ☐ No ☐

48.3. Oats straw Yes ☐ No ☐

48.4. Grass hay Yes ☐ No ☐

48.5. Oats hay Yes ☐ No ☐

48.6. No idea Yes ☐ No ☐

49. Do you face feed shortages? (Mark with √)

Yes ☐ No ☐ No idea ☐

50. If question 49 is 'yes' at what time of the year? ______________________

51. How do you cope with the feed shortage? (Mark with √)

51.1. Store during oats straw available Yes ☐ No ☐ No idea ☐

51.2. Store other crops straw during available (without oats straw) Yes ☐ No ☐ No idea ☐

51.3. Store oats hay during available Yes ☐ No ☐ No idea ☐

51.4. Store grass hay during available Yes ☐ No ☐ No idea ☐

51.5. Purchase the feed Yes ☐ No ☐ No idea ☐

52. What is the trend of oat straw use as feed in your case? Mark with (√)

1. Increasing ☐
2. Decreasing ☐
3. No change ☐
4. No idea ☐

53. If your answer is increasing for question number 52, what are the reasons for that?

53.1. Increased annual production of oats straw Yes ☐ No ☐

53.2. Increased awareness on nutritional advantages of straw Yes ☐ No ☐

53.3. There is feed shortage and lack of other options Yes ☐ No ☐

53.4. Excessively available straw Yes ☐ No ☐

53.5. Less cost than others straw Yes ☐ No ☐

53.6. No idea Yes ☐ No ☐

54. In which form did you feed oats straw to your animals? (Mark √)

54.1. Whole straw Yes ☐ No ☐

54.2. After treatments Yes ☐ No ☐

54.3. By chopping Yes ☐ No ☐

54.4. Mix with barely straw Yes ☐ No ☐

54.5. Mix with wheat straw Yes ☐ No ☐

54.6. Mix with bean Yes ☐ No ☐

54.7. Mix with pea Yes ☐ No ☐

54.8. Oil crops byproducts(Like linseed byproduct) Yes ☐ No ☐

54.9.Wheat brain Yes ☐ No ☐

55. If question 54 mark "after treatments" which treatments methods used? (Mark √)

55.1. Urea treatment Yes ☐ No ☐

55.2. Treatment with molasses Yes ☐ No ☐

55.3. Treatment with salt treatment Yes ☐ No ☐

55.4. Oil byproducts (example Linseed byproducts) Yes ☐ No ☐

55.5. Wheat brain (ፉሩሽካ) Yes ☐ No ☐

56. Which is the storage method you used for oat straw for later use? (Mark √)

56.1. Stacked outside Yes ☐ No ☐

56.2. Stacked under shade Yes ☐ No ☐

56.3. Baled outside Yes ☐ No ☐

56.4. No storage methods Yes ☐ No ☐

57. When do you start feeding Oats straw to your animals? (Mark √)

1. Soon after collection ☐
2. During the months of shortage of feed resources ☐
3. Two months after collection ☐
4. Three months after collection ☐
5. Trough out the year ☐
6. Available time ☐

58. Which straw more selected by animals? (Mark √)

58.1. Oats straw Yes ☐ No ☐

58.2. Barely straw Yes ☐ No ☐

58.3. Wheat straw Yes ☐ No ☐

58.4. Bean straw Yes ☐ No ☐

58.5. Pea straw Yes ☐ No ☐

58.6. I don't know Yes ☐ No ☐

59. Which animal more prefers to eat oats straw? (Mark √)

59.1. Cow Yes ☐ No ☐

59.2. Oxen Yes ☐ No ☐

59.3. Heifers Yes ☐ No ☐

59.4. Bull Yes ☐ No ☐

59.5. Calves Yes ☐ No ☐

59.6. Equine Yes ☐ No ☐

59.7. Sheep Yes ☐ No ☐

59.8. Goat Yes ☐ No ☐

59.9. I don't know Yes ☐ No ☐

60. Which animal prefers to eat local oats hulls? (Mark √)

60.1. Cow Yes ☐ No ☐

60.2. Oxen Yes ☐ No ☐

60.3. Heifers Yes ☐ No ☐

60.4. Bull Yes ☐ No ☐

60.5. Calves Yes ☐ No ☐

60.6. Equine Yes ☐ No ☐

60.7. Sheep Yes ☐ No ☐

60.8. Goat Yes ☐ No ☐

60.9. I don't know Yes ☐ No ☐

61. Did you feed local oats grain your animals? (Mark √) Yes ☐ No ☐

62. If question 61 is 'yes' which animal prefers local oats grain as feed? (Mark √)

62.1. Cow Yes ☐ No ☐

62.2. Oxen Yes ☐ No ☐

62.3. Heifers Yes ☐ No ☐

62.4. Bull Yes ☐ No ☐

62.5. Calves Yes ☐ No ☐

62.6. Equine Yes ☐ No ☐

62.7. Sheep Yes ☐ No ☐

62.8. Goat Yes ☐ No ☐

62.9. I don't know Yes ☐ No ☐

63. Did you prepare local oat silage to your animals? Yes ☐ No ☐ No idea ☐

64. If question 63 is 'yes' in what stage did you prepared silage? (Mark √)

64.1. Young stage Yes ☐ No ☐

64.2. Flowering stage Yes ☐ No ☐

64.3. Matured stage Yes ☐ No ☐

65. If question 63 is 'No' why did you prepare local silage? (Mark √)

65.1. Lack of knowledge Yes ☐ No ☐

65.2. Lack of expert extension service on silage preparation Yes ☐ No ☐

65.3. Oats crops/grain/ needed for food than silage preparation Yes ☐ No ☐

65.4. Because of oats straw selected by animals than silage Yes ☐ No ☐

65.5. Lack of additives like molasses and urea Yes ☐ No ☐

66. Is local oats used for other purpose other than animal's feed and human's conception? (Mark √) Yes ☐ No ☐

67. If Question number 67 is "yes" for what purpose do you use? _______________

68. What are the constraints to use oats as animals feed? (Mark √)

68.1. Shortage of rain during sow time Yes ☐ No ☐

68.2. Computation of oats straw for other purpose Yes ☐ No ☐

68.3. Lack of different variety of oats seed Yes ☐ No ☐

68.4. Computation oats as food (utilized by human) Yes ☐ No ☐

68.5. I don't know Yes ☐ No ☐

69. What are the constraints to use oats as human food? (Mark √)

69.1. Government police that is oats register as animals feed only, which not allow utilized as food Yes ☐ No ☐

69.2. High cost of oats grain on the market Yes ☐ No ☐

69.3. Less productive than other grain crops like barley and wheat Yes ☐ No ☐

69.4. Lack of different variety of oats used as food Yes ☐ No ☐

69.5. I don't know Yes ☐ No ☐

70. Currently what is the status of oats straw as animals feed comparing to others straw in this area? (mark√) Increasing ☐ Decreasing ☐

71. If question 71 is 'increasing', why is it increasing than other straws? ______________

72. If question 71 is 'decreasing', why is it decreasing? _____________________________

73. Currently what is the status of oats grain used as animals feed? (mark√)

Increasing ☐ Decreasing ☐

74. If question 74 is 'increasing' how and why? ________________________________

75. If question 74 is 'decreasing' why? ____

76. Currently what is the status of oats grain used as human food? (mark√)

Increasing ☐ Decreasing ☐

77. If question 77 is 'increasing' how and why? ___________________________

78. If question 77 is 'decreasing' why? ____

79. Do you know local oats are registered as animals feed (Grass) by ministry of agriculture of Ethiopia? (mark√) Yes ☐ No ☐

80. If question 80 is 'yes' why you use as human food? (mark√)

80.1. Because other grain crops decreased productive due to decreased fertility of farm land Yes ☐ No ☐

80.2. Less management and no cost for fertilizers, weed chemicals, and disease prevention/controlling Yes ☐ No ☐

80.3. High quality nutrient of oats crops than other grain crops Yes ☐ No ☐

80.4. High production cost to other grain crops for fertilizers, chemical to control and prevent weed and plant diseases Yes ☐ No ☐

80.5. No idea Yes ☐ No ☐

Thank you

Appendix II. Focus group discussion format

Checklist – FGD Community Level

Introduction:

The aim of the current study will be to assess the current oat production performance, what is going on in the ground oat production as feed and food, collect some information regarding the farmer's experience in oat production, what are the constraints, opportunities of oat Production, and purpose of oats production, knowledge of oats varieties.

1. Kebele ______________________________
2. No. of Participants: Adult Males: _____________ Adult Females: _____________

Discussion points

1. Discussion on the trends of oats production in the given kebele
    - As animals feed
    - As humans food (Why used as human food?)
    - Other purpose of oats
2. Discussion on the knowledge, attitude and Practices about oats silage making process in the study areas.
    - Opportunity and Constraints for silage making
3. Discussion on the utilization of oats comparing to others crops (Barely, wheat, others)
    - As income generating
    - As animals feed
    - As human food
    - Others
4. Discussion on the constraints for oats production as animals feed and human food
5. Do you think that there is computation using oat as animal's feed and human food? If so, how do you sole the computation?
6. Discussion on the productivity of oats in given kebles
    - Resistance to crops diseases
    - Frost resistance
    - Water logging
    - Others
7. Discussion on the management oats crops (Application of both natural and artificial fertilizers, farm preparation, weed removing, and others managements)
    - As animals feed
    - As human food
8. Future prospects of oats production?
9. General comments from the group participant

Thank you

Appendix III. Different tables

Appendix table 1. Land Holding

Land in hectare	**Kebele**						**Cumulative Mean (N=219)**	
	***Dalota* (n=75)**		***Adai matto* (n=71)**		***Mogoro* (n=73)**			
For Oats								
0	7	9.33	3	4.23	7	9.59	17	7.76
0.4 – 1.5	53	70.67	55	77.46	48	65.75	156	71.23
>1.5 – 3	15	20	13	18.31	18	24.66	46	21.00
For others crops out of oats								
0.75 – 2	34	45.33	56	78.87	35	47.94	125	57.08
>2 – 3.5	40	53.33	13	18.31	28	38.36	81	36.98
>3.5 – 5.3	1	1.33	2	2.82	10	13.7	13	5.94
For grazing								
0.13 – 1	51	68	65	91.55	57	78.08	173	79.00
>1 – 2	24	32	6	8.45	16	21.92	46	21.00
For others								
0.01 – 0.1	68	90.67	63	88.73	67	91.78	198	90.41
>0.1 – 0.3	7	9.33	8	11.27	6	8.22	21	9.59

Appendix table 2. Livestock holding

Livestock type	Kebele						Cumulative mean (N=219)	
	Dalota (n=75)		*Adaadi matto* (n= 71)		*Mogoro* (n=73)			
	Frequency	**Percentage**	**Frequency**	**Percentage**	**Frequency**	**Percentage**	**Frequency**	**Percentage**
Cattle number								
1 – 5	30	40	24	33.8	23	31.51	77	35.16
6 – 10	36	48	38	53.52	43	58.9	117	53.42
11 – 14	9	12	9	12.68	7	9.59	25	11.42
Sheep and goat number								
0	19	25.33	10	14.08	14	19.18	43	19.63
1 – 5	27	36	26	36.62	24	32.88	77	35.16
6 – 10	26	34.67	27	38.03	22	30.13	75	34.25
>10 – 24	3	4	8	11.27	13	17.81	24	10.96
Equines								
0	32	42.67	33	46.48	30	41.10	95	43.38
1 – 5	39	52	33	46.48	40	54.79	112	51.14
6 – 7	4	5.33	5	7.04	3	4.11	12	5.48
Poultry								
0	37	49.33	36	50.70	38	52.05	111	50.68
2 – 5	18	24	28	39.44	25	34.25	71	32.42
6 – 10	20	26.67	7	9.86	10	13.7	37	16.89

Appendix table 3. Local oats seeding rate, grain production and biomass

Descriptions	Kebele						Cumulative mean	
	Dalota		***Adadi Mattoo***		***Mogoro***			
	Frequency	**%**	**Frequency**	**%**	**Frequency**	**%**	**Frequency**	**%**
Local oats seeding rats $^{-hec}$								
90 to 100 kg	59	78.7	63	88.7	58	79.5	180	82.2
101 to 110 kg	8	10.7	4	5.6	8	11	20	9.1
I don't know	8	10.7	4	5.6	7	9.6	19	8.7
Local oats grain production $^{-hec}$								
1000 to 2000 kg	55	73.3	59	83.1	48	65.8	162	74
2001 to 3000 kg	9	12	7	9.9	16	21.9	32	14.6
I don't know	11	14.4	5	7	9	12.3	25	11.4
Local oats straw biomass $^{-hec}$								
500 to 1000 kg	43	57.3	54	76.1	38	52.1	135	61.6
1001 to 1500 kg	17	22.7	12	16.9	24	32.9	53	24.2
I don't know	15	20	5	7	11	15.1	31	14.2

Appendix table 4. Growth stage of local oats

Growth stage	**N**	**Days**	**Kebele**						**Cumulative results**	
			Dalota		***Adadi Matto***		***Mogoro***			
			Frequency	**%**	**Frequency**	**%**	**Frequency**	**%**	**Frequency**	**%**
Emerging of seed										
	219	7 to 10	18	24	14	19.7	21	28.8	53	24.2
		11to 15	48	65.3	53	74.6	45	61.6	147	67.1
		Don't know	8	10.7	4	5.6	7	9.6	19	8.7
Reached flowering stage										
		Up to 90	26	34.7	29	40.8	22	30.1	77	35.2
	219	91 to 105	38	50.7	38	53.5	28	38.4	104	47.5
		106 to 115	3	4	0	0	16	21.9	19	8.7
		Don't know	8	10.7	4	5.6	7	9.6	19	8.7
Harvested as fodder										
		Up to 90	8	10.7	14	19.7	1	1.4	23	10.5
	219	91 to 105	51	68	53	74.6	47	64.4	151	68.9
		106 to 115	3	4	0	0	11	15.1	14	6.4
		116 to 150	0	0	0	0	5	6.8	5	2.3
		Don't know	13	17.3	4	5.6	9	12.3	26	11.9
Harvested as food and straw										
		151 to 180	41	54.7	47	66.2	36	49.3	124	56.6
	219	181 to 210	30	40	23	32.4	34	46.3	87	39.7
		Don't know	4	5.3	1	1.4	3	4.1	8	3.7

Appendix table 5. Fertilizer applications for local oats, wheat and barley.

Crops	N	Fertilizers	Results		Percentage
			Discriptions	**Freq.**	
Local oats as feed	219	Natural	No	209	95.4
			No idea	10	4.6
		Artificial	No	201	91.8
			No idea	18	8.2
Local oats as food	219	Natural	No	209	95.4
			No idea	10	4.6
		Artificial	No	200	91.3
			No idea	19	8.7
Wheat	219	Natural	Yes	160	73.1
			No	41	18.7
			No idea	18	8.2
		Artificial	Yes	201	91.78
			No	1	0.45
			No idea	17	7.76
Barley	219	Natural	Yes	52	23.74
			No	149	68.03
			No idea	18	8.2
		Artificial	Yes	159	72.6
			No	42	19.2
			No idea	18	8.2

Freq.= Frequency

Appendix table 6. Local oats feeding system in study area.

Discriptions	Freq.	%
Grazing	20	9.1
Oats straw	65	29.6
Oats hay	8	3.6
Oats hull	54	24.6
Oats cut and carry system	7	3.2
Oats grain feeding	6	3.0
Feeding aftermath	59	26.9

Freq.= Frequency

Appendix table 7. Local oats straw feeding

Discriptions	Freq.	%
Whole straw	75	34.2
After treatment	35	16.0
By chopping	10	4.6
Mix with barely straw	24	11.0
Mix with wheat straw	18	8.2
Mix with bean straw	5	2.3
Mix with pea straw	4	1.8
Oil crops byproducts(Like linseed byproduct)	16	7.3
Wheat brain (ፊኖሽክ)	32	14.6

Freq.= Frequency

Appendix table 8. Local oats straw treatment

Discriptions	**Freq.**	**%**
Urea treatment	8	3.6
Treatment with molasses	37	17.0
Treatment with salt	82	37.4
Oil by product treatment	45	20.5
Wheat bran (Mixing)	47	21.5

Freq.= Frequency

Appendix table 9: -Experimental arranged silage samples

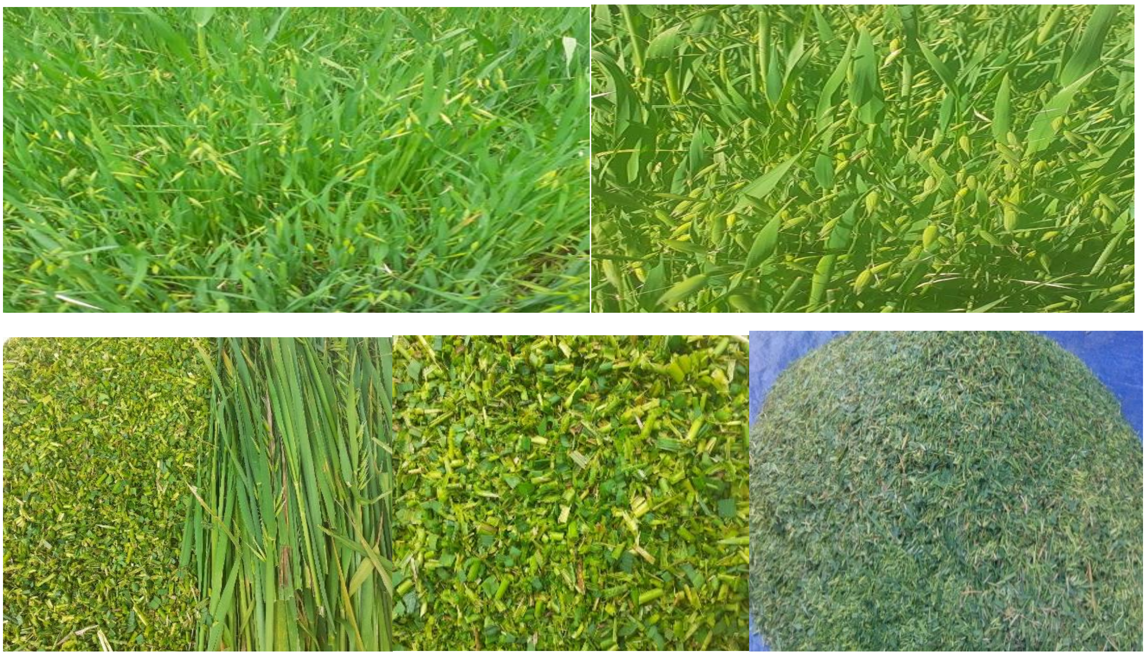
Replications of U and M treated silage			Replications of date difference prepared silage		
Rep. 1	Rep. 2	Rep. 3	Rep.1	Rep. 2	Rep. 3
T8	T6	T9	T11	T1	T10
T6	T9	T5	T1	T11	T12
T3	T4	T1	T12	T10	T1
T4	T7	T2	T10	T12	T11
T2	T5	T8			
T7	T3	T4			
T5	T8	T6			
T9	T1	T3			
T1	T2	T7			

M= Molasses, Rep. = Replications, T= Treatments and U = Urea

Appendices IV. Different figures

Appendix figure 1. Collected oats straw for feed and other purpose

Appendix figure 2. Group of sheep/“Welbo” Grazing of local oats



Appendix figure 3. Harvested local oats and chopped for silage

Appendix figure 4. Urea used for silage treatment

Appendix figure 5. Molasses used for silage treatment

Appendix figure 6. Silage samples collected for chemical analysis