



**EFFECT OF DIFFERENT LEVELS OF MOLASSES ON ELEPHANT  
GRASS (*PENNISETUM PURPEREUM*) AND DESHO GRASS  
(*PENNISETUM PEDICELLATUM*) SILAGE QUALITY**

**M. Sc. THESIS**

**BY**

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**WOLKITE, ETHIOPIA**

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**A M.Sc. THESIS SUBMITTED TO  
THE DEPARTMENT OF ANIMAL SCIENCES, COLLGE OF  
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**INPARTIAL FULFILLMENT OF THE DEGREE OF  
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(SPECIALIZATION: ANIMAL PRODUCTION)**

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## **DEDICATION**

I dedicated this thesis manuscript to my beloved families and best friends who wished me all the best and success in my expedition.

## DECLARATION

By my signature below, I declare and affirm that this thesis is my authentic work. I have followed all ethical principles of scholarship in preparation, data collection, data analysis and completion of the thesis. All sources of materials used for this thesis have been duly acknowledged.

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## **BIOGRAPHICAL SKETCH**

The author, Siraj Mehdi was born on September 15, 1982 in Kebena Special District, West Gurage Zone and Central Ethiopia Regional State. He attended his primary education in Wutign Elementary & Primary Schools. He completed his high school studies at Goro/ Yaberus / Senior Secondary School, Wolkite. After passing Ethiopian High School Certificate Examination successfully, he joined Arba Minch University College of Agriculture in 2002 E.C and graduated with B.Sc. degree in Animal Science in June, 2004 E.C. Soon after his graduation, the author was employed by the West Gurage Zone, Kebena Special District, Bureau of Agriculture and Natural Resources. Siraj was assigned as Animal Production expert at the Directorate of Income Generation and Internal Revenue at Wolkite University in 2007 E.C. In 2013 E.C, the author was joined the School of Graduate Studies of Wolkite University to pursue M.Sc. in Animal Production.

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## LIST OF ABBREVIATIONS AND ACRONYMS

ADF	Acid Detergent Fibre
ADL	Acid Detergent Lignin
AOAC	Association of Official Analytical Chemists
CF	Crude Fibre
CF	Crude Fat
CP	Crude Protein
CRD	Complete Randomised Design
CSA	Central Statistical Authority
DA	Development Agent
DG	Desho Grass
DM	Dry Matter
DMI	Dry Matter Intake
DMR	Dry Matter Recovery
DW <sub>ss</sub>	Dry Weight sub sample
ED	Enzymatic Digestion
EE	Ether Extract
EG	Elephant Grass
EM	Effective Microorganism
FAO	Food and Agriculture Organization
FJLAB	Fruit Juice Lactic Acid Bacteria
GDP	Growth Domestic Product
GLM	General Linear Model
Ha	Hectare
Hr	Hour
ILRI	International Livestock Research Institute
IOMD	In Organic Matter Digestibility
IVDMD	In Vitro Dry Matter Digestibility
IVOMD	In Vitro Organic Matter Digestibility

LA	Lactic Acid
Lb	Pound
LAB	Lactic Acid Bacteria
LSD	Least Significance Differences
ME	Metabolisable Energy
MS	Square Meters
NDF	Neutral Detergent Fibre
NFE	Nitrogen Free Extract
OM	Organic Matter
PH	Power of Hydrogen
RH	Relative Humidity
SAS	Statistical Analysis of science
SPSS	Statistical Programme for Social Science
SOC	Soil Organic Carbon
TFW	Total Fresh Weight
VFA	Volatile Fatty Acids
WS	Weight of ground Sample
WSC	Water Soluble Carbohydrates

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## ABSTRACT

*In tropical region inadequate quality and quantity of feeds are the major constraints to livestock production sector. Most of feed resources are low in nutrient content to meet nutrient requirements of maintenance, production and reproduction. The experiment was conducted to investigate the effect of different levels of molasses on elephant grass (*Pennisetum purpureum*) and desho grass (*Pennisetum pedicellatum*) silage quality in Wolkite University. The aim of this study was to identify the effect of different levels of molasses on silages quality of elephant grass (*Pennisetum purpureum*) and desho grass (*Pennisetum pedicellatum*). Elephant grasses were harvested from Wolkite University dairy farm and desho grasses were harvested from around Wolkite town from farmer's backyard when they were at the ages of medium stages of growth. The harvested grasses was chopped up to 2cm particle size each weighing 2kg each silage materials treated with different levels of molasses (0%, 3% and 5%), packed in 2kg holding plastic bags silo, doubled it and stored in thatched barn. Treatments were assigned to a completely randomized design in factorial arrangement (2x3) with three replications. The silage was opened after 30 days, analyzed for sensory qualities; chemical composition and in vitro DM digestibility. Treated silages had better appearance qualities than the control silages. All of the silages had good and very good degrees in organoleptic test method based on DM, PH. The treated silages had lower PH compared with the control ( $p < 0.05$ ). The control group had lower DM content than treated silages ( $p < 0.05$ ). Elephant grass silages had higher CP, CF and temperature than desho grass silages. Desho grass silage produced higher quality and preserved better than Elephant grass as indicated by higher sensory qualities, ether extract, invitro dry matter digestibility and stability. But lower PH, DM, Crude Protein and Crude Fiber. Desho grass with 5% molasses showed that its silage contains higher Moisture, IVDMD and EE (C. fat) than elephant grasses. Silages with 5% molasses had higher quality than silages mixed with 0% and 3% molasses levels as indicated by higher DM, EE and IVDMD, but lower PH and NDF. Therefore, it was concluded that Elephant and Desho grasses ensiled with 5% molasses level was the most optimal techniques to achieve high quality silage fermentation under smallholder farmers.*

**Key words:** *Desho grass, Elephant grass, Molasses, Silage*

# 1. INTRODUCTION

## 1.1 Background

Ethiopia has the largest livestock population in Africa with 65 million cattle, 40 million sheep, 51 million goats, 8 million camels and 49 million chickens (CSA, 2020a). The productivity of livestock is low with the major hindrances being shortage of feed resources in terms of quantity and quality (ILRI, 2009; Tegegne and Assefa, 2010; Demeke *et al.*, 2017). Feed cost accounts for 60 to 70% of the total cost of livestock production (Abebe *et al.*, 2008). As a result, shortage of feed and escalating price of feeds is adversely affecting the productivity and profitability of commercial livestock operations (Shapiro *et al.*, 2015).

Sustainable livestock production is highly dependent on the availability of quality feed and forage resources. Elephant grass is one of the most important tropical forage crops. It is widely used in cut and carries feeding systems (Lukuyu *et al.*, 2012; Kabirizi *et al.*, 2015). However, when it is cut in young stage of growth, it has a good nutritive value, the low percentage of dry matter, the high buffer power and low sugar concentration can result in low quality silage. Some additives can be used to increase dry matter concentration of elephant grass silage and they should also present a known water retention capacity, good palatability and supplement of carbohydrates for fermentation (Wilkinson, 1983).

Conserving high quality forages reduces the need to purchase concentrates for use in ruminant rations (Sanh *et al.*, 2002). Surplus and cultivated quality forages should be conserved during the wet season for use during the dry season (Mtengeti *et al.*, 2013). The conservation of Elephant grass (*Pennisetum perpureum*) among the plentiful tropical forages is preferable due to its high forage yield and favorable concentration of soluble carbohydrates in providing good fermentation condition (Yeruham, *et al.*, 2003). The merits of Desho grass (*pennisetum pedicellatum*) to provide multi-cut forages suggests that it is a potential feed source in the dry season when feed availability in the tropics is critical (Brias and Tesfaye, 2009).

Indigenous forages are familiar with the smallholder farmers grow with low inputs and are adaptable to different agro-ecological conditions (Anele *et al.*, 2009). One of the options in combating the existing livestock nutritional constraints is the use of indigenous cultivated multi-purpose forages as livestock feed (Abebe *et al.*, 2008; Anele *et al.*, 2009). The use of

indigenous forages as a feed resource is appealing under the present Ethiopian conditions to increase production and productivity of livestock (Shapiro *et al.*, 2015). Desho grass (*Pennisetum pedicellatum*) is one of the indigenous forage species which need comprehensive research in Ethiopia. Desho grass (*Pennisetum pedicellatum*) is indigenous grass to Ethiopia and belonging to the family of Poaceae (Leta *et al.*, 2013) and it is a perennial grass which has an extensive root system that anchors well with the soil and has high biomass production potential. Different Desho grass varieties have register at country level for their biomass production potential (Tekalegn *et al.*, 2017). They are utilized as a means of soil conservation practices, rehabilitates degraded land and provides a small business opportunity and animal feed in the highlands of Ethiopia (Leta *et al.*, 2013; Bimrew, 2016). Moreover, it has high drought resistant nature (FAO, 2010; EPPO, 2014).

Among the improved grasses, Elephant grass (*Pennisetum purpureum*) and Desho grass (*Pennisetum pedicellatum*) feedstuff values have been given a major emphasis now days. These grasses contain high level of dry matter production (DM), high amount of moisture content and appreciable amount of metabolisable energy (ME). The use of tropical forages, such as elephant grass (*Pennisetum purpureum Schum.*) and desho grass (*Pennisetum pedicellatum*) may be a viable alternative for silage production because it has a high productivity and animal acceptance (Rodrigues *et al.*, 2005). Among the non-grain grasses used in silage production, Elephant grasses (*Pennisetum purpureum*) are an excellent potential for dry matter production (DM) (54 tons /MS/ hectare) and with a high amount of soluble carbohydrates (4.1-13.8 % in DM) (Santos *et al.*, 2013).

Silage making is a strategy to store the excessive production of forage grass in the rainy season for supplementation during the forage scarcity and weight losses in ruminant livestock at the dry season (Olivo *et al.*, 2014). It is a fermentation process aimed at preserving forage in its wet state under anaerobic condition (away from air). The aim is to minimize loss of dry matter and nutritive value and to avoid creating products toxic to the animals. The quality of silages are influenced by the crop-inherent factors, it is important to ensure that the silage is properly sealed, avoiding soluble compound losses and development of fungi responsible for production of mycotoxins (Jobim, Nussio, 2014). Good silages have been observed when molasses was applied at different additive levels i.e., 3-5% (Manyawu *et al.*, 2003).

Adding silage additives can improve the fermentation characteristics and nutritional value of silage, especially for grass silage (Li *et al.*, 2022). The lactic acid bacteria can promote the fermentation process by consuming WSC to produce lactic acid and inhibit the growth of harmful bacteria and then improve silage quality (Li *et al.*, 2018a). Although anaerobic conditions can be obtained by proper ensiling for silage crops having high level of WSC content, there can still be considerable activity of aerobic microorganisms during the very early stages of ensiling and when there is an improper silage management practice (Melkamu and Birhan, 2014). Due to this fact, the application of additive during silage making has a paramount importance to produce quality silage. Various types of additives have been used to control undesirable microorganisms (e.g., aerobic bacteria and fungi) and improve aerobic stability in silages (Pedroso *et al.*, 2008). Molasses, effective micro-organisms (EM) and fermentative juice of lactic acid bacteria (FJLB) are the cheapest and available additives found in Ethiopia.

## **1.2. Statement of the problem**

In Ethiopia, forage quality and quantity have been limited at optimal production level both for elephant and desho grasses due to inhibiting factors like shortage of land, shortage of planting materials, poor soil fertility and shortage of improved forage seeds and lack of awareness (Yenesew *et al.*, 2014). In order to overcome the existing feed shortage considerable research works have been in progress in Ethiopia elsewhere and a number of improved forage feedstuffs have been analysed and evaluated for their nutritive and supplementary values as dairy cow feeds (Abebe *et al.*, 2008).

In the other direction, desho grass has high structural cell wall carbohydrates that can help to improve the silage quality made from these grass species (VanSoest, 1994). This implies that the need for strategies to tackle the identified problem by using additives. Like Molasses, because it has high water-soluble carbohydrates (WSC) content (79 %), made of 45 to 50 % of sucrose containing soluble carbohydrates (Oladuso *et al.*, 2016). It provides a relatively cheap source of fermentable carbohydrate for lactic acid.

Molasses is widely used as an additive to enhance the process of ensiling (Van Niekerk *et al.*, 2007). Molasses in numerous silage experiments has been proven to be an effective silage additive in terms of promoting Lactic Fermentation (Kung *et al.*, 2003; Filya *et al.*, 2007), reducing silage PH (Mtengeti *et al.*, 2013), discouraging a clostridial fermentation (Kung *et*

*al.*, 2003) and proteolysis and generally decreasing organic matter losses (Borreani, 2018) both under the small holder farmers and intensive livestock production system with appropriate management practices (Mengistu *et al.*, 2012). However, the effect of different levels of molasses on silage quality of elephant (*Pennisetum perpureum*) and desho (*Pennisetum pedicellatum*) grass species are not documented especially Desho grass.

There is a comparative study under effect of different levels of molasses on elephant grass (*Pennisetum perpureum*) and desho grass (*Pennisetum pedicellatum*) silage quality in the study area. There is also limited information on silage quality of different species of grasses using different molasses levels in Ethiopia (Gizaw, 2017). In addition to the above, there is also less documentation in evaluation of chemical composition of improved forages particularly desho grass in the study area. There is also lack of information on fermentative quality of fodder grasses ensiled using varying levels of molasses. Therefore, this study is designed to fill the following research objectives:

### **1.3. General objective**

- To investigate the effect of different levels of molasses on silages quality of elephant grass (*Pennisetum purpureum*) and desho grass (*Pennisetum pedicellatum*).

### **1.4. Specific objectives: -**

- To evaluate the chemical composition of elephant grass (*Pennisetum perpureum*) and desho grass (*Pennisetum pedicellatum*) silages in the study area.
- To evaluate invitro dry matter digestibility of elephant grass (*Pennisetum purpureum*) and desho grass (*Pennisetum pedicellatum*) silages treated with varying levels of molasses.
- To evaluate the effect of ensiling elephant (*Pennisetum purpureum*) and desho (*Pennisetum pedicellatum*) grasses with varying levels of molasses on its fermentative quality.

### **1.5. Significance of the Study**

The study enables livestock producers to balance rations for their animals such as fattening bulls, dairy cows and small ruminants as well. Animals which are fed balanced rations will be productive and the farmers will be self-sufficient and better standards of living. The evaluation will enable livestock farmers to have proper knowledge of conservation methods for dry period of the year. It gives baseline information for the researchers, for higher teaching institutions, totally for those working in the fields of animal sciences.

### **1.6. Research Hypothesis**

To study the effect of different levels of molasses on elephant grass (*Pennisetum perpureum*) and desho grass (*Pennisetum pedicellatum*) silage qualities the following research hypothesis are designed.

1. Null hypothesis ( $H_0$ ): adding different levels of molasses had no effect on elephant grass (*Pennisetum perpureum*) and desho grass (*Pennisetum pedicellatum*) silage qualities.
2. Alternate hypothesis ( $H_A$ ): adding different levels of molasses affects elephant grass (*Pennisetum perpureum*) and desho grass (*Pennisetum pedicellatum*) silage qualities.

## 2. LITERATURE REVIEW

### 2.1 Major Cattle Feed Resources in Ethiopia

Poor grazing management (e.g., continuous over-grazing) has resulted in very low carrying capacities brought by replacement of productive and nutritious flora. Natural pasture is characterized by seasonal fluctuation in total dry matter (DM) production and nutritional quality. In the mixed cereal cattle farming system of the Ethiopia, crop residues provide on average about 50% of the total feed resources for ruminant cattle. The contributions of crop residues reach up to 80% during the dry seasons of the year (Tolera, 2010).

Green pasture (55.2%) and crop residues (30.8%) are the main feed types available in the country (CSA, 2020a). The available feed resources in the mixed crop-livestock production areas are natural pastures, crop residues, and to a lesser extent, improved forage, concentrates, and non-conventional feeds. Natural pasture is the primary feed source for livestock and is abundant during the rainy season. In some areas, it is harvested during wet seasons and conserved as hay for dry seasons (Duressa *et al.*, 2014; Feyissa *et al.*, 2014; Geleti *et al.*, 2014b ;). Crop residues are the second most abundant feed source and include straw or stover of teff (*Eragrostis teff*), barley, wheat, sorghum, and maize (Duressa *et al.*, 2014; Tegegne *et al.*, 2013; Duguma *et al.*, 2012), and legume residues such as fava bean and field pea (Abate, 2012).

Animals are fed on crop stubble during harvesting seasons. In some places, improved forage is cultivated and fed to dairy cows to increase milk production, but this practice is not widespread (Abate, 2012). Non-conventional feeds, such as weeds and brewers grains, a by-product of local tella (beer) production, are also fed to livestock (Feyissa *et al.*, 2014). Agro-industrial by-products such wheat bran, oil cake and molasses are available only to farmers close to urban areas and they are unaffordable to most of them for frequent purchase (Geleti *et al.*, 2014b).

Livestock feed resources in Ethiopia are mainly natural pasture, crop residues, improved pastures, forage crops and agro-industrial by-products (Mengistu, 2004). The contribution of these feed resources, however, depends up on the agro-ecology, the types of crop produced, and accessibility and production system. According to CSA, (2017) report, the major feed resources in the country are green fodder (54.59%), crop residue (31.6%), hay (6.81%) and agricultural by product (1.53%), which have poor quality.

Feed problem is one of the major factors that hinders the development and expansion of cattle production. The main feed resources to cattle in the different part of the country are natural pasture, crop residues, and stubbles grazing from fallow lands, forest and shrub areas. Among the feed resources, natural pasture and crop residues contribute the largest source of feed cattle in the study area which is the case in most developing countries (Sere *et al.*, 2008).

### **2.1.1. Improved Forages and Pasture Crops**

In Ethiopia, most improved tropical species can be grown in the lowlands (1,500-2000 meters) except temperate species, which can grow in areas between 2,100 to 3,000 meters above sea level (Mengistu, 2002). Heavy emphasis is put in Ethiopia on the use of forage legumes in cropping system, through under-sowing, improvement of fallows and establishment of tree legumes as hedges to partly address the major problems of long-term sustainability of crop production (Mengistu, 2002). Improved forages have been grown and used in government ranches, state farms, farmer's demonstration plots and dairy and fattening areas.

Over the past three decades several introduced forages were tested on station in different ecological zones, and considerable efforts were made to test the adaptability of different species of pasture and forage crops under varying agro-ecological conditions (Mengistu, 2013). As a result, quite a number of useful forages have been selected for different zones, although the adoption rate is extremely low. Forage crops are commonly grown for feeding dairy cattle with oats and vetch mixtures, fodder beet, elephant grass mixed with siratro and Desmodium species, Rhodes/Lucerne mixture, phalaris/trifolium mixture, hedgerows of sesbania, leucaena and tree-Lucerne being common ones (Mengistu, 2013). Due to unprecedented population increase, land scarcity and crop- dominated farming, there has been limited introduction of improved pasture and forages to smallholder farming communities and the adoption of this technology by smallholder mixed farmers has been generally slow (Mekoya *et al.*, 2008).

### **2.1.2 Natural Pastures**

The natural pasture region of Ethiopia accounts for 30.5% of the area of the country and is most extensive in the western, southern and southwestern semi-arid lowlands. It is changing due to increasing population and cropping, the total grazing and browsing land in the country is estimated to be 61-65 million hectares (Alemayehu, 2003). Recently the share of natural

grazing pasture at the national level as livestock feed resource has become reduced to about 57% (CSA, 2013) from an earlier level of 90% (Mengistu, 1985).

Natural pastures include annual and perennial species of grasses, forbs and trees (Masiwa, 2009). They comprise the largest feed resource, but estimates of the contribution of this feed resource vary greatly. According to Alemayehu, (2010) estimated that 80-85 % of the cattle feed in Ethiopia comes from natural pasture. Other works estimated that the natural pasture provides 88-90 % of the feed. This is because the quantity and quality of native pasture varies with altitude, rainfall, soil and cropping intensity. There are two types of grazing lands i.e., private and communal. Over 50% of the feed to animals came from natural pasture, which conforms to the general indication that natural pasture is one of the major sources of animal feed (Mengistu, 2010).

## **2.2 Feed Related Challenges in Ethiopia**

### **2.2.1 Seasonal distribution of cattle feed**

Most of the feed in the Ethiopia is obtained from natural pasture and crop residues. Feed shortage is critical during the dry season. Feeds are abundant from December to February, and rationing starts afterwards. Quality feed is usually allotted to draught oxen, mainly in the peak farming months, when land preparation and planting operations are commonly practiced. In the months of May and June, when there is almost no green feed, but a very high demand for draught power, crop residues become the major feed source. Improved grass forages provide a good source of energy almost throughout the year (MoA, 2012). Where seasonality of forage production is a problem, there are methods that can be used by the farmer to ensure adequate year-round feed supplies e.g., stock adjustments, seasonal breeding programs, growing a range of pasture species, grass-legume mixtures, tree legumes and special fodder areas and employing fodder conservation techniques.

### **2.2.2 High price of feed ingredients and compound feeds**

Seasonality, shortage and very high prices of feed ingredients are key challenges for sustainable and affordable delivery of compound feeds. During the last five years, prices of feed ingredients and compound feeds have increased by an average of 52 and 82 percent respectively, leading to low demand of compound feeds. This situation has even led to

closing of some commercial farms (dairy and beef), essentially due to low return on the investment (Seyuom *et al.*, 2018).

### **2.2.3 Feed safety, quality and quantity**

Ensuring feed safety and quality is recently one of the key challenges in the commercial feed sector. It is also of high importance for the livestock producers and consumers of animal source foods. Among feed safety issues, the recent detection of high aflatoxin levels in oilseed cakes and compound feeds has raised serious concerns in ensuring the desired quality and safety of feed along the food value chain (Seyum *et al.*, 2018).

Natural grazing is the major source of Cattle feed and in the lowlands, cattle production is almost totally dependent on it. However, grazing lands do not fulfill the nutritional requirements of human population and high demand for food; pastures are steadily being converted to farmlands.

## **2.3 Grass Species known for Silage Preparation**

### **2.3.1 Elephant Grass**

Elephant grass (*Pennisetum purpureum*) is a native grass grown widely in Southern Africa that is commonly used as a silage crop in tropical climates due to its high quality and yield (Bureenok *et al.*, 2012). Elephant grass is known for producing good-quality silage either alone or mixed with other crops (Budiman *et al.*, 2012). It is also mixed with molasses at level 5% was the most optimal technique to achieve high quality silage under smallholder farmers (Lyimo *et al.*, 2016).

### **2.3.2. Desho Grass**

Desho grass (*Pennisetum pedicellatum*) is used as fodder and considered to be a very palatable species to cattle (FAO, 2010). From animal feed resource point of view, desho grasses is used in temporary pastures or in cut and carry systems since, it provides ample quantities of good quality green forage and stands several cuts a year. The grass is also useful for hay and silage preparation (Ecocrop, 2010). The grass has the ability to recover after water stress even under severe drought conditions (Noitsakis *et al.*, 2014). In short rotation with maize or groundnuts, the grass yields better than traditional forage grasses, especially when fertilized, while the roots and stubbles also increase soil fertility (Leta *et al.*, 2013).

### **2.3.3 Guatemala Grass**

Smallholder dairy producers of the highland areas of East Africa (Kenya and Tanzania) have been encouraged since the 1970s to grow Guatemala grass as a high-yielding fodder. When Guatemala grass is intended for silage, it is recommended that the re-growth (after first cut for direct feeding) reaches 0.8-1 m high and still in the vegetative state (about 8-week-old). Ensiling Guatemala grass results in 12% DM loss during the process (FAO, 2012). Guatemala grass has relatively high moisture content (69%) and a relatively low content of water-soluble carbohydrates (3 to 9% DM), which can result as in most tropical grasses in ineffective PH reduction during ensiling and low storage stability. It is thus recommended to wilt the Guatemala grass before ensiling in order to increase dry matter (%) and the content of water-soluble carbohydrates and to reduce nutrient losses through effluent production (Nussio, 2005).

### **2.4 Experience of Major Grass Species used for Silage Making**

During the moon-soon season, cultivated as well as forest grass grow luxuriantly, and there is abundant availability of green fodder. These grasses can be harvested at their pre-flowering or flowering stage when growth has leveled off while their feeding value is still high. If the weather is too humid for hay making, these grasses might be conserved in the form of silage for feeding during scarcity periods (Tripathi *et al.*, 2010).

Bana grass is also known as elephant grass, it is known for producing good-quality silage either alone or mixed with other crops. However, ensiling of Bana grass is complicated by the low concentration of water-soluble carbohydrates and its high cell wall content (Mendieta *et al.*, 2009; Budiman *et al.*, 2012). Studies done in Zimbabwe concluded that for good quality silage production, the optimal time for harvesting Bana grass should be when the concentration of water-soluble carbohydrates is at their pick point (6–7 weeks), to increase DM content and optimize herbage production without affecting nutritive value.

Due to its rapid growth rate, Desho grass provides regular harvests, even reaching monthly cuts during the rainy season. Once a year, just before the dry season, sufficient grass is harvested and stored as hay and can be prepared as silage to feed the livestock until the rains return (Danano, 2007). From an animal feed resource point of view, desho grass is used in temporary pastures or in cut and carry systems since it provides ample quantities of good

quality green forage and stand several cuts a year. The grass is also useful for hay and silage preparation (Ecocrop, 2010).

#### **2.4.1 Elephant grasses (*Pennisetum purpureum*)**

##### **2.4.1.1 Characteristics of Elephant grasses (*Pennisetum purpureum*)**

Elephant grass is one of the most important fodder crops, particularly in Eastern and Central African smallholder farming communities (Lukuyu *et al.*, 2012; Kabirizi *et al.*, 2015). Elephant grass is a perennial C4 grass species (Harris *et al.*, 2010; Kandel *et al.*, 2016). Native to Sub-Saharan Africa from where it is believed to have been distributed to other tropical and subtropical regions around the world. It has been reported to be adapted to grow across a wide range of soil conditions and agro-ecologies. From sea level to 2100 m and it can withstand minor dry spells, although it grows best in areas where the annual rainfall is between 750 and 2500 mm (Singh *et al.*, 2013). As a result, today it is widely grown in tropical and sub-tropical regions of the world, for use predominantly as animal fodder.

It is mainly used to feed livestock in cut and carry feeding systems (Ishii *et al.*, 2013; Heuze, *et al.*, 2016). It is a multi-purpose forage crop that can be grazed directly, or made into silage or hay (Orodho, 2011). In crop land management systems, it is used as a mulch to control weed infestation and soil erosion (Kabirizi *et al.*, 2015). And also as a trap plant in the push–pull strategy, a pest management practice which uses repellent intercrop ‘push’ plants and attractant trap ‘pull’ plants for insect pest control in Africa, particularly for the maize stem borer (Khan *et al.*, 2006; Khan *et al.*, 2007).

The yield of elephant grass mainly depends on the type of cultivar used which in turn is influenced by both the environment and management practices employed. Nevertheless, there are two major categories of elephant grass cultivars based on their morphology, the normal or tall (4–7 m) varieties (for example ‘Australiano’, ‘Bana’ and ‘French Cameroon’) and the dwarf or semi-dwarf (< 2 m) varieties (for example ‘Mott’) (Rengsirikul, 2013). It has the ability to withstand repeated cutting and will rapidly regenerate, producing palatable leafy shoots (Lowe *et al.*, 2003).

Elephant grass is a monocotyledonous flowering plant belonging to the family Poaceae (family of grasses) and the genus *Pennisetum* (Singh *et al.*, 2013; Sandhu *et al.*, 2015). High dry matter production, ease of establishment and regeneration, persistence and enhanced

water use efficiency make elephant grass the primary forage of choice in the regions of Eastern and Central Africa, where smallholder dairy farmers and pastoralists suffer from sporadic droughts and possess limited irrigation infrastructure (Nyambati *et al.*, 2010).

Elephant grass undergoes changes in its morphology including leaf rolling, reduced stomata conductance and enhanced water use efficiency when subjected to water stress conditions (Cordiso *et al.*, 2015). However, the grass is susceptible to water-logging and frost but has some drought tolerance (Ecocrop and FAO, 2010).

Nutritional quality is strongly influenced by management practices and age at harvest. But, on average, Elephant grass is considered to contain 9% CP, 20% DM, 70% NDF, 50% ADF, 9% ash and 6% lignin in samples taken from 10–15-week-old plants (Islam *et al.*, 2003). Elephant grass possesses many desirable characteristics, including high yield per unit area, tolerance to intermittent drought and high water use efficiency (Kabirizi *et al.*, 2015) making it forage of choice. However, this grass is seasonal with high dry matter yield over the short rainy season; thus, silage making is an increasingly important method to preserve fresh forages for feeding ruminants year-round (Pholsen *et al.*, 2016).

Despite many desirable characteristics, elephant grass is generally considered to be of inferior nutritional quality depending on management (particularly in terms of metabolisable energy, digestion kinetics and percentage crude protein) and palatability when compared to other forage crops (Halim *et al.*, 2013; Heuze *et al.*, 2016; Bayble *et al.*, 2017). Elephant grass is reported to possess around 50% NDF, which is higher than the recommended NDF content for forage grasses (Halim *et al.*, 2013). Feeding experiments using Friesian cows revealed a loss of body weight and reduced milk yield when solely fed elephant grass varieties (Jung *et al.*, 2016). On the other hand, dwarf and semi-dwarf elephant grass varieties have been shown to contain a higher CP content and lower ADF and hence are considered to be more suited as forage for dairy farming applications (Halim *et al.*, 2013).

In general, in areas where supplementary feed is scarce, inter-cropping elephant grass with legumes is considered to be a better option, using an increased amount of fertilizers can enhance organic matter content of elephant grass and subsequently enhance its nutritive quality as a feed (Okwori *et al.*, 2005).

#### **2.4.1.2 Importance of Napier Grass**

Napier grass is a perennial, deep-rooted and highly productive forage species that can be easily adopted by farmers. The importance of Napier grass can be seen from the role it plays as the major livestock feed in smallholder livestock production systems. Napier grass is the most important fodder crops, particularly in Eastern and Central African smallholder farming communities (Lukuy *et al.*, 2012; Muyekhu, 2015 and Alemayehu *et al.*, 2017). It is also important perennial fodder recommended for the smallholder crop-livestock farming systems in Ethiopia (Tessema and Alemayehu, 2010 and ILRI, 2013). This is because it can withstand considerable periods of drought (Orodho, 2006 and ILRI, 2010b). Alemayehu *et al.*, (2017) concluded that the varied uses provide an indication of the diversity of roles that Napier grass could contribute to the reduction of poverty and nutritional insecurity. It is mainly used to feed livestock in cut and carry feeding systems (Ishii *et al.*, 2013 and Alemayehu *et al.*, 2017). Napier grass used to be promoted in Uganda for soil conservation and for mulching coffee (Orodho, 2006). The main uses of Napier grass include livestock feeding, soil conservation and mulching (especially in coffee plantations). Napier grass can be cut every 3 months if there is good growth under rain fed conditions (ILRI, 2010b).

#### **2.4.1.3 Current Status of Elephant grasses (*Pennisetum purpureum*)**

Due to the fact that most smallholder livestock producers predominantly own small and fragmented pieces of land, grasses such as elephant grass of forage best-fit alternative too their feed options, as these are high yielding forages which require a minimum amount of inputs and acreage. Elephant grass possesses a number of attributes including: high biomass yield (Wangchuk *et al.*, 2015), rapid re-growth potential and ease of propagation (Lee *et al.*, 2016); attributes that help with the control of soil erosion; resistance to a broad spectrum of pests and diseases (Van den Berg *et al.*, 2015) and suitability for cellulosic biofuel production (Tsai *et al.*, 2016).

The aforementioned qualities of elephant grass make it an attractive option for livestock production systems. However, the adoption and utilization of elephant as an alternative forage crop has not been totally successful due to the limited amount of research and attention given to this crop (Mwendia *et al.*, 2014). Therefore, in order to increase the utility of elephant grass and advance its breeding initiatives, genotyping by sequencing (GBS) of the elephant grass collection held at ILRI is currently underway.

#### **2.4.1.4 Future Prospects of Elephant grasses (*Pennisetum purpureum*)**

Through years of effort, a number of cultivars have been selected and are currently in production in different regions of the world (Singh *et al.*, 2013). In addition, active breeding programs have been established to generate and capture greater diversity for both animal production and biofuel applications (Faleiro *et al.*, 2016).

However, the efforts made so far, the production and use of Elephant grass remains constrained by many factors. Nutritional quality, palatability, and propagation by seed or vegetative organs are currently the main limitations and the diseases elephant grass stunt and head smut are significantly challenging its production in some regions of Africa. Moreover, enhancing the crop's water use efficiency is another key area of research which will allow for production and use in areas with annual rainfall below its optimal range (< 750 mm) and maintenance of current areas under the threat of climate change. Consequently, the potential to use Elephant grass as a 'climate-smart' forage crop, with traits such as enhanced water use efficiency, disease resistance and temperature tolerance stacked in new varieties which perform well in the face of climate change, has not been fully realised (Singh *et al.*, 2013).

#### **2.4.1.5 Nutritional Quality**

Significant variation in dry matter production (DM), crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF) and other nutritional qualities have been reported across different studies and accessions of Napier grass. CP was highest in the early stage compared with the intermediate stage and late stage. The highest nutritional quality of Napier cultivars was indicated at the early age of growth. Nevertheless, the DMY of Napier cultivars were too low (Zailan *et al.*, 2016). It was observed that the CP level decreased by 16% from early to late stage. CP content serves as an important indicator of fodder quality. The NDF and ADF contents of Napier grass decreased from early to intermediate and then increased at the late stage (Alemayehu *et al.*, 2017).

The maturity stage of pasture grass at harvesting or grazing is considered a crucial management practice because this determines the nutritional value of the grasses (Jusoh *et al.*, 2014). On average, Napier grass is considered to contain 9% CP, 20% DM, 70% NDF, 50% ADF, 9% ash and 6% lignin in samples taken from 10–15 weeks (Gwayumba *et al.*, 2002; Islam *et al.*, 2003).

#### **2.4.1.6 Palatability**

Napier grass becomes coarse and unpalatable when it matures. Napier grass is palatable and could be fed fresh, as silage or directly grazed on the field as sighted by (Deribe *et al.*, 2017). Lyimo *et al.*, (2016) showed that Napier grass silage was more stable and palatable than Guatemala and Rhodes grass silage. In a trial in Nigeria, fresh Napier grass cut during the dry season was less palatable to West African dairy goats than Guinea grass (*Megathyrsu smaximus*), *Gliricidia septum*, *Leucaenaleucocephala* or *Terminaliacatappa*. Goats were also found to refuse Napier grass in a free-grazing trial (Babayemi, 2007). For that reason, fresh Napier grass is often chopped to prevent animals from selecting the best parts (Moran, 2011).

#### **2.4.1.7. Digestibility and Intake**

As in most grasses, young grass has a better nutritional value. However, because its cell wall content does not increase with age as fast as in other tropical forages, such as Kikuyu (*Pennisetum clandestinum*) and pangola grass (*Digitaria eriantha*), Napier grass retains a given level of digestibility for a longer period (Orodho, 2006). The authors recommended using Napier grass between 30 and 35 days of regrowth (Machado *et al.*, 2008). With increasing harvest interval, neutral detergent fiber (NDF) and acid detergent fiber (ADF) increases and digestibility decreases (Van Soest, 1994). When Napier grass is very young, its high-water content might decrease voluntary intake due to a fill effect caused by water intake (Soares *et al.*, 2009). Chopping is a common method for improving the overall value of the crop. Further processing with a roller mill may increase forage intake due to the higher rate of rumen digestion of the fibrous material through a greater cell wall surface area available for digestion by rumen microbes.

#### **2.4.1.8. Chemical Composition of Napier Grass**

Napier grass is rich in fiber: depending on the stage of maturity, NDF concentrations vary from 55 to 75% 16% DM (Moran, 2011). DM, NDF and lignin contents of Napier grass hay did not differ among samples cut at 30, 50 70 and 90 days of regrowth, but ADF and non-structural carbohydrates increased linearly. The range of protein content of Napier grass varies from 4.4 to 20.4% with the mean around 12% ((Xie *et al.*, 2009; Rusdy, 2016) that crude protein of Napier grass ranged from 4 – 15%. Age at harvest is the most important factor affecting crude protein content of Napier grass (Wadi *et al.*, 2004). The high moisture supply to Napier grass is associated with high rate of growth and maturation; hence less

concentration of CP and ash due to “dilution effect” and a high cell wall content (Gezahagn *et al.*, 2016a). Cultivar had a significant effect on stem CP concentration. CP concentration of leaves declined dramatically with the increase in cutting interval from 28.2% at 40 days to 8.8% at 80 days (Wangchuk *et al.*, 2015). The average NDF, ADF, and ADL (lignin) values of Napier grass reported by some workers are around 67, 42 and 6%, respectively. Consequently, great care should be taken to determine the optimum time when planning to harvest or graze, Napier grass in order to maximize both yield and nutritional qualities (Na *et al.*, 2016).

## **2.4.2 Desho Grasses (*Pennisetum pedicellatum*)**

### **2.4.2.1 Characteristics of Desho grasses (*Pennisetum pedicellatum*)**

Desho is an indigenous grass of Ethiopia belonging to the family of Poaceae (Smith, 2010). In Ethiopia desho grass is known as a perennial plant originated in Southern Nations, Nationalities Peoples Regional State in a place called Chenchu in 1991 (Welle *et al.*, 2006). Now widely used in other regions of the country (Welle *et al.*, 2006, Yakob *et al.*, 2015). Its home environment is the Wolayta zone of South Ethiopia Regional State, where it is valued by the natives as a highly palatable forage plant and as gully stabilizing agent in soil conservation plantings.

Desho grass is a very palatable species to cattle and sheep (Ecocrop, 2010). It is used for livestock fodder, soil conservation practices, and sold for income generation as small business opportunity mostly for high land Ethiopian farmers (Shiferaw *et al.*, 2011; Leta *et al.*, 2013). Ethiopian Minister of Agriculture and Rural Development was documented planting of Desho grass technology as an example of a locally tried and tested land management technique as a success to mitigate land degradation (Bimrew *et al.*, 2017). In short rotation with maize or groundnuts, the grass yields better than traditional forage grasses, especially when fertilized, while the roots and stubbles also increase soil fertility (Gerba *et al.*, 2013).

Desho grass fodder yield of 30–109 ton green herbage/ha/year; as a year-round fodder for livestock (Leta, 2013; Heuze and Hassoun, 2015). Morphologically, it is closer to the genus *Brachiaria* with which it shares the acidic wetter areas of Ethiopia. Desho grass is a many-branched leafy grass growing up to 1 m high or more (FAO, 2010; Gerba *et al.*, 2013). The

culms are erect and branching, and the leaves are 15-25 cm long and 4-10 mm wide, flat and glabrous. The spikelet's are 4 mm long, usually solitary (Ecocrop, FAO, 2010).

Desho grass has a potential to control water loss effectively and recovers rapidly after watering even under severe drought conditions (Welle *et al.*, 2006). DM production has been shown to increase significantly over consecutive cuttings from the first to the third (Amin *et al.*, 2016). Although cultivar and environment specific, recommended a 60 day cutting interval in the optimum growing season to maintain a high yield without compromising nutrient composition too much (Wangchuk *et al.*, 2015).

Desho grass has a crude protein content of 9.6% on DM basis at early stage and 1.6% at straw stage, respectively. The digestibility and voluntary intake decrease with increase in stage of maturity which indicates that the grass should be fed at early stage of maturity (Danano, 2007).

#### **2.4.2.2 Current Status of Desho grasses (*Pennisetum pedicellatum*)**

Currently, desho grass is utilized as a means of soil conservation practices and animal feed in the highlands of Ethiopia (Ecocrop, 2010). The grass is popular, drought resistant plant, used as feed for ruminants (FAO, 2010; EPPO, 2014). It has the potential of meeting the challenges of feed scarcity since it provides more forage per unit area and ensures regular forage supply due to its multi-cut nature (Ecocrop, 2010). Desho grass is suitable for intensive management and performs well at an altitude ranging from 1500 to 2800 m.a.s.l (Gerba, 2013).

#### **2.4.2.3 Future Prospects of Desho grasses (*Pennisetum pedicellatum*)**

More extension work should be done on the production and utilization of desho grass to integrate it in the farming systems of mid and highland areas of Ethiopia. As desho grass has relatively low CP, the grass should be combined with local protein sources such as indigenous and improved leguminous fodders, agro-industrial and breweries byproducts as supplements and tested on different types of animals. To improve availability of livestock feed in terms of quantity and quality, it is better to cultivate Desho grass forage that have better biomass yield and nutritional quality (Ecocrop, 2010).

## **2.5 Major feed conservation techniques**

Forage conservation is a valuable pasture management strategy. In a bad season or during seasonal shortages, the conserved feed can be fed to maintain milk production or as a longer-term emergency feed. Forage conservation can be the link between growing and managing pastures and providing realistic rations for dairy cows. Hay and silage are the main forms of conserved forage.

### **2.5.1 Hay**

Hay is preserved by drying and will generally keep while it is kept dry. Hay is defined as forage conserved under aerobic dry or limited moisture conditions. Fresh forage typically has between about 75% and 85% moisture concentration (Collins and Coblenz, 2013). Thus, the goal in hay production is to remove moisture as quickly as possible to achieve a target moisture concentration equal to or less than 20% (or a target dry matter concentration greater than 80%). The process of reducing moisture is called curing and is normally accomplished with energy provided by the sun (field curing) or by artificial barn drying using heated or unheated air. Moisture concentration less than 20% prevents plant respiration and allows for an almost complete conservation of plant nutrients for extended periods.

Hay is dried forage, containing less than 15% water. Fresh forage is harvested and dried as quickly as possible. Drying can be done naturally (exposure to the sun on the ground aerating the forage regularly by turning it over) or artificially by active circulation of air. Hay can be made from improved grasses and/or legumes (Castro-Montoya *et al.*, 2019; Pousga *et al.*, 2019). The quantity and quality of hay also depend on the resting period before harvesting the pasture and occasionally excessive feed/nutritional losses in quality and quantity are made during processing.

### **2.5.2 Silage**

The primary goal of making silage is to maximize the preservation of original nutrients in the forage crop for feeding of livestock at a later date in livestock feeding programs (Stewart, 2011). Silage is high-moisture fodder preserved through fermentation in the absence of air in order to preserve forage nutrients for feeding at a later date. According to Mtengeti *et al.*, (2013), silage making provides opportunities to store surplus forages even during the wet

season and allow pasture regrowth. Stability prevents silage from spoiling when exposed to air and by doing so; it can improve the efficiency of a farm by preserving forage as high-quality silage (Lyimo *et al.*, 2016).

Adding silage additives can improve the fermentation characteristics and nutritional value of silage, especially for grass silage (Li *et al.*, 2022). The lactic acid bacteria can promote the fermentation process by consuming WSC to produce lactic acid and inhibit the growth of harmful bacteria, and then improve the alfalfa silage quality (Li *et al.*, 2018a).

Silage involves natural fermentation, which produces lactic and other acids, which 'pickle' or preserve the forage. This fermentation takes place only under anaerobic (oxygen-free) conditions, so the forage must be packed to remove air and sealed to keep air out. Silage will generally keep while it remains sealed and anaerobic. Silage is the final product when forage of sufficient moisture (>50%) is conserved and stored anaerobically (oxygen-free), under conditions that encourage fermentation of sugars to organic acids. The acidity generated by the organic acids (mainly lactic acid, but also acetic and propionic acids) and the lack of oxygen prevent the development of spoilage microorganisms.

Lactic acid fermentation must predominate in the anaerobic conditions. Successful silage fermentation depends on achieving both anaerobic conditions and a low PH. The low PH is usually accomplished through the fermentation of sugars in the crop to lactic acid by lactic acid bacteria, which decreases plant enzyme activity and prevents the proliferation of detrimental anaerobic microorganisms, especially clostridia and enterobacteria (Yang *et al.*, 2004). However, several factors may interfere with the quality of fermentation, including microorganisms that lead to secondary fermentation, soluble carbohydrates and DM contents and compacting density (Ferreira *et al.*, 2013).

## **2.6. Molasses as Additives**

Sugarcane molasses, a waste product of sugar production has been widely used as a silage additive (Kwak *et al.*, 2009; Nkosi *et al.*, 2009). The addition (supplementation) is widely utilized for making silage as a source of water-soluble carbohydrates. Therefore, supplementation of water-soluble carbohydrates is needed to ensure success in making silage. Water-soluble carbohydrate supplementation can also be used for preservation in silage.

Molasses is made of 45 to 50 % of sucrose containing 79 % soluble carbohydrates (Oladuso *et al.*, 2016).

Regardless of its origin, molasses is considered an energetic feedstuff due to its high content of easily fermentable sugars. Low cost allows it to be a very popular feedstuff as a partial substitute for cereals (it has approximately 2/3 of the energy value of corn) in feed formulations and in rations for many species of zoo technical interest. The binding and appetizing properties of molasses have recently been recognized, its use in the preparation of supplements for lactating cows (Mordenti, 2017; Consorzio , 2018).

According to Kung (2014), molasses provides a relatively cheap source of fermentable carbohydrate for lactic acid bacteria and has been applied at a rate of 40-80 lb. per ton of fresh forage. The amount of molasses used varies on the type of silage crop used. Studies indicated that up to 13 to 10% molasses can be added to forage to provide fast fermentable carbohydrate to ensile tropical herbage.

The most important organoleptic characteristic of molasses is represented by its sweetening property and its taste, which results in being particularly appreciated by the animal (appetizing role) and which increases the ingestion of feedstuffs that do not always have good palatability (Mordenti, 2017; Consorzio *et al.*, 2018).

Molasses is better used by diluting in water at a ratio of 1:2 to 1:4-6 (molasses: water) and given together with dry forages or concentrates (Senthilkumar *et al.*, 2016). Molasses in numerous silage experiments has been proven to be an effective silage additive in terms of promoting lactic acid fermentation, reducing silage pH, discouraging an undesirable micro-organism and /or decreasing organic matter losses (Kung, 2014).

According to Bolsen *et al.*, (1996) categorized silage additives into fermentation inhibitors, fermentation stimulants and substrate or nutrient sources. It is widely accepted that silage additives can increase animal intake and animal performance through their effect on silage quality (R.J. Merry *et al.*, 2000). Other research also found that the applying of molasses improved fermentative quality (Yohanes *et al.*, 2015). Animal Production quality, feed intake and digestibility of Napier grass (Bureenok *et al.*, 2012). There is an opinion that Napier grass ensiled without the additive was low in lactic acid and high in pH value, ammonia, nitrogen and VFA (Yokota *et al.*, 1996). In summer session, fermentation quality of Napier

grass was improved by the input of additives with the highest quality in lactic acid bacteria and Acremonium cellulose (LAB + AC) resulting in low PH.

### **2.7. Different Molasses levels in Silage Making**

According to a previous study, Molasses additive improved the fermentation quality of alfalfa-mixed silage and 2.5% Molasses was enough and more suitable than 5% Molasses for practical application (Jian, *et al.*, 2017). On the contrary, other studies have found that Molasses additive increases aerobic stability, with no effects on the fermentation quality of alfalfa silage (Su, *et al.*, 2019).

Several authors have evaluated the effects of adding molasses at different percentages of inclusion (0 controls, 3% and 5%) during ensiling (Lyimo, 2016). Good silages have been observed when molasses was applied at different additive levels i.e., 3-5% (Manyawu, *et al.*, 2003), 4% (Aminah *et al.*, 2000), 5% (Lyimo, 2010; Mtengeti, *et al.*, 2013).

### **2.8 Silages Quality**

Quality encompassing all the attributes that influence the silages nutritive value-determines the potential animal production per ton of silage and so is an important indicator of whether producing the silage has been profitable. High quality silage is likely to be achieved when lactic acid is the predominant acid produced, as it is the most efficient fermentation acid and reduces silage PH more efficiently than other fermentation products (McDonald *et al.*, 2002). Technologies for grass silage quality improvement include: wilting, chopping, additives (maize bran and molasses), ensiled amount and storage positions (thatched barn and trench).

### **2.9 Factors Affecting Silage Quality**

The fermentation processes reach to the greatest stage a few hours after the material being ensiled, but may continue for a week or more depending on the acidity, compaction, available carbohydrates, moisture level, available oxygen and other factors (Kamstra *et al.*, 1979). These factors (stage of maturity, moisture content, crop type, chopping length and compaction and air exposure) during storage influence the fermentation process and meter glass electrode was inserted to determine the PH. Important factor affecting forage quality; plants continually change in quality as maturity stage increased (Jones *et al.*, 2004).

The moisture concentration of the crop at ensiling affects the rate and extent of fermentation. Moisture concentration profoundly affects fermentation and subsequent nutritive value of silage because of its effects on microbial growth. The type of crop, crop maturity, and environmental factors affect the buffering capacity and amount of sugar at harvest (Wiley, 2020).

Environmental factors also affect crop ensilability. High soil fertility and shade reduce WSC concentrations, whereas drought has the opposite effect (Buxton and Fales, 1994). Concentrations of WSC vary diurnally, being highest in late afternoon and lowest in early morning. Higher temperatures in tropical climates negatively affect silage production by impacting growth of silage bacteria (Gulfam *et al.*, 2017) and because WSC concentrations are generally lower in herbaceous forages grown at higher temperatures. The temperature of the crop at ensiling will affect the dominant microbial species, the speed of fermentation and the products of fermentation. Laboratory silage research studies have typically been run at room temperature (20-25°C).

Several factors contribute to the quality of silage made from tropical grasses. These include age of forage at harvest, moisture and sugar content in grass, forage length, filling time, efficiency of compaction, sealing, pressure with weights and use of additives (Chiba *et al.*, 2005).

### **2.10 Chemical Composition change due to Silage making**

The silage plant named (*Chromolaena odorata*) treated with molasses showed increased dry matter, crude protein, in vitro dry matter digestibility and reduced NDF, ADF contents as compared to other additives (cassava tuber flour, corn meal, rice bran) used (Rusdy, 2015). According to Yunus, *et al.*, (2001), molasses addition at the rate of 3% increased DM of Napier grass silage from 19.57% to 20.86% and the PH value decreased significantly from 5.13 to 3.97.

Other studies also indicated that molasses addition to Napier grass before ensiling enhanced the fermentation process and consequently, avoided the DM loss (Bolsen *et al.* 1996) by early stabilization of the medium. However, total DM loss, up to 5% during fermentation process is tolerable and considered normal, presumably due to the loss of soluble nutrients (McDonald *et al.*, 2010).

More DM recovery with molasses at 5% level compared to level 0% and 3% may be due to the addition of WSC that improves the fermentation characteristics. Observed high CP may be due to increased level of molasses (Lyimo *et al.*, 2016). Found higher CP in treated silages than in untreated silages. Observed high WSC could be attributed by increased energy for lactic bacteria due to increased substrate resulted to more lactic acid production, leads to rapid PH reduction and when the process stops WSC remains as recovery substrate (Lyimo *et al.*, 2016). Increased IVDMD could be attributed to the provision of useful energy substrate for ruminal microbes and thus improve their effectiveness in digesting feed particles. Low NDF and ADF value of 5% than 3% and 0% (control) could be attributed to increased acidity which stimulated further hydrolysis of linked sugar molecules in the cell wall causing further breakdown of hemicelluloses (Lyimo *et al.*, 2016).

The CP content of Common Napier increased significantly ( $P \leq 0.05$ ) from 8.13 to 9.26% after ensiling process. Increase of CP content ( $P > 0.05$ ) in Napier cultivars after ensiled could be accompanied by the populated anaerobic microorganism during ensiling process (Zakaria, 2011). The NDF content of ensiled Napier grass was clearly affected ( $P \leq 0.05$ ) by the process of fermentation. The reduction of NDF content from 72 to 67% can be explained by the hydrolysis of NDF content during fermentation process (Huisden *et al.*, 2009).

The crude protein content increased significantly ( $p < 0.05$ ) with increase molasses levels. The high value 7.88 was shown in 15% molasses and the low value 6.54 recorded in the 0% (control molasses). The Ash generally increased due to increase in the level of molasses, the high Ash content 9.3% was found in 15% molasses and low value 8.23% in control 0% molasses. Acid detergent fiber (ADF) and Neutral detergent fiber (NDF) were significantly ( $p < 0.05$ ) decreased with increased levels of molasses (Ahmed and Idris, 2007).

### **2.11 PH of Silage**

PH is a measure of acidity and highly influenced by fermentation process. High moisture silages are unstable with respect to PH and good quality silages being associated with low PH. According to Yang *et al.*, (2004) attainment of low PH is one of the important determinants for final silage fermentation quality. Well fermented silage should have a PH of  $< 4.2$  (Mceteka, 2008). High PH at high water content is associated with proteolysis (aberrant clostridial fermentation) and low PH is associated with lactic acid production. In high dry

matter silages, PH is a less useful criterion of quality since deficiency of water restricts fermentation (Lyimo *et al.*, 2016a) and acid production.

During PH reading, the electrode was immersed in the solution and the beaker or bag was gently turned to make good contact between the solution and the electrode. Because the solution was unfiltered, we avoided contact between the electrode and silage particles. Afterward, the electrode was rinsed well with distilled water and then dabbed lightly with tissues to remove any film formed on the electrode. All procedures were performed in a room at  $25 \pm 1^\circ\text{C}$ . To record the ambient temperature, 3 data loggers were distributed across the room. Although the PH meter has an integrated sensor for temperature compensation, this room temperature was chosen to optimize readings, because the device has greatest accuracy at  $25^\circ\text{C}$ . Because the operator may represent a source of variation when performing an analytical method, a single person performed all PH measurements. For statistical analyses, duplicates were averaged and the 3 means were considered as 3 observations for each replicate ( $n = 18$ ). Lactic acid is a fermentation end-product known to be efficient in reducing the PH of the silages (Kung *et al.*, 2018).

## **2.12 Dry Matter**

The DM of the fresh ensiling material and silages were determined by drying in an oven at  $65^\circ\text{C}$  for 48-h (AOAC, 1984). The silages were freeze-dried in a Lyphilizer maintained at  $-40^\circ\text{C}$  for 24-hrs according to Snowman (1988) so as to get a dry sample for ash, crude protein, neutral detergent fiber (NDF), WSC analysis and in-vitro dry matter digestibility (IVDMD) determination.

## **2.13 Types of Silage Test to ensure Quality**

Feed testing is an integral part of a well-managed forage conservation programme, it establishes the quality of the silage and the success of ensiling process, and can be a useful way to determine if quality and wilting targets have been met. Techniques for evaluating the quality of silage involve sensory evaluation or organoleptic test, chemical composition and physical characteristics (Saun and Heinrichs, 2008).

### **2.13.1 Visual Appraisal**

Measuring quality of silage with visual appraisal, such as by sight, smell and feel, has distinct limitations, but they are important tools for evaluating forages of silages. Color; leaf content; stem texture; maturity; contamination from weeds, molds or soil; and observations on palatability are examples of useful visual determinations (NDSU, 2018).

### **2.13.2 Organoleptic Test**

The organoleptic test of the silage was type of test used to identify the quality of silage to Undergraduate and Postgraduate Students. Each assessor assessed the silage from each treatment and scored its physical characteristics in terms of appearance, texture and smell (Lyimo, 2010). According to Otieno *et al.*, (1990) three distinct types of silage involved in sensory evaluation namely: - well fermented silage, badly fermented and overheated silage have been identified on the basis of smell, taste, colour and texture.

### **2.13.3 Chemical Composition Analysis Test**

While laboratory testing provides an objective assessment of silage quality such as PH value, dry matter content, crude protein content, crude fat content, content of ether extract and others, a preliminary appraisal made in the field using sample was subjective criteria such as colour and aroma.

## **2.14 Ensiled Grasses with Different levels of Molasses and its Impact on the Quality of Silage**

Several authors have evaluated the effects of adding molasses at different percentages of inclusion (0% (control), 3% and 5%) during ensiling (Lyimo, 2016), 40 days after silage closing, the silage mass was stabilized with considerably higher levels of lactic acid as compared to the control and with lower levels of organic acids (acetic, propionic and butyric) and ammonia. The rapid PH lowering inhibits the development of coliform bacteria; this inhibition of proteolytic activity is additionally confirmed by the lower ammonia content at silage opening.

In previous studies, the silage crop ensiled with molasses showed better results in terms of physical characteristics like colour, odor, flavor (Getahun *et al.* 2018). The texture of elephant grass silage was also improved due the application of molasses (Mtengeti *et al.*,

2014). The PH values of silage crops treated with additives decreased more quickly than silage without additives (Nhan *et al.*, 2009; McDonald *et al.*, 2010).

### **2.15 Effect of Ensiling Elephant (*Pennisetum perpureum*) and Desho (*Pennisetum pedicellatum*) Grasses Silage Quality**

According to (Evangelista *et al.*, 2004), tropical grasses; elephant and desho present low dry matter, high buffering capacity and low soluble carbohydrates endangering the conservation through ensilage, once secondary fermentations are possible to occur. In order to improve herbage preservation and its feeding value various additives such as molasses have been applied (Keady *et al.*, 2000). The additives enhance efficient fermentation of sugar to lactic acid. Efficient fermentation of sugar and minimal proteolysis are crucial for silage preservation (Nadeau *et al.*, 2000). It was well documented that the fermentation quality of silage can be improved through lactic acid bacteria-based additives (Kung *et al.*, 2003; Filya *et al.*, 2007).

Lyimo *et al.*, (2016) revealed that, elephant grass had higher CP and ash but lower DM and digestibility than Guatemala and Rhodes grasses. Elephant grass silages had higher CP and ash but lower DM and WSC than Guatemala and Rhodes grass silages. There was no difference among Elephant, Guatemala and Rhodes grass silages on NDF. Silages with molasses at 5% level had higher DM, CP, WSC, Ash, IVDMD but lower NDF than silages with molasses at 3% and 0% levels. Increased IVDMD could be attributed to the provision of useful energy substrate for ruminal microbes and thus improve their effectiveness in digesting feed particles.

The observed higher lactic acid and acetic acid but lower ( $p \leq 0.05$ ) PH and  $\text{NH}_3\text{N}$  in silages with molasses at 5% level than molasses at 3% and 0% levels probably, could be due to additional energy supplied by the increased molasses which created more conducive environment for the anaerobic fermentation bacteria (Mannetje, 2000). The aerobic stability of the silage with molasses was increased thereby potentially preventing the growth of spoilage organisms (Danner *et al.*, 2003).

### 3. MATERIARLS AND METHODS

#### 3.1. Description of the Experimental Site

The experiment was conducted at Wolkite University found in Gubre sub city of Wolkite town which is the capital city of West Gurage zone, Central Ethiopia Regional State, Ethiopia. The University is situated 165 km from south west of Addis Ababa (155 kilo meters through Addis Ababa –Jimma main road and then 10 km towards the East on Wolkite – Hosanna Road). Gubre sub city is located at about 12 km away from Wolkite town in South West direction. The geographical location of the town is approximately 8<sup>0</sup> 33'N latitude and 37<sup>0</sup> 59' E longitude. The average elevation of the town is about 1870 meter above sea level. The mean annual temperature of the town ranges between 13-30<sup>0</sup>c with annual average temperature of 32<sup>0</sup>c. The area is characterized by bimodal rainfall Pattern 'Kiremt', is the main rainy season and the short rainy season called 'Belg'. The town has weynadega climatic condition with the mean annual rain fall ranges 600-1600 mm (Meles and Bogale, 2018). Dominant soil type of the study site is Vertisol which covers 82.4 % of the study area.

#### 3.2 Sources and Preparation of Ensiled grasses

##### 3.2.1. Sources of grasses

The two species of grasses and different levels molasses on silages quality were used in the current experiment include: - Elephant (*Pennisetum purpureum*) and Desho (*Pennisetum pedicellatum*) grasses. Elephant grasses were brought from the existing established forage site at dairy farm in WKU and desho grasses were bought from farmer's backyard around Wolkite for silage making.

##### 3.2.2 Determination of Optimum Dry Matter Percentage (DM %) of grasses

Before the experiment was done harvesting fresh elephant and desho grasses were wilted sixth different wilting times (Table 1.) and chopped about 2-3cm particle size then get in to oven-dry machine at 65<sup>0</sup>c for 48-hours to determine optimum dry matter percentage of ensiled grasses. After sixth trial the researcher assigned the elephant grass was wilted for half of a day and the desho grass was wilted for one day to get optimum dry matter percentage of silages.

Table 1 .Determination of dry matter with different wilting time

s.no	Wilting time	DM (%)		Moisture (%)	
		EG	DG	EG	DG
1	Fresh (0)	50	40.4	50	59.6
2	One day	65.68	32.8	34.32	67.2
3	Two days	74.71	69	25.29	31
4	Three days	90.9	65.5	9.1	34.5
5	Eight hours	70	28	30	72
6	12 hours	30	40	70	60

EG= elephant grass DG =desho grass %= percent

### 3.2.3 Procedures for Silage making

Grasses on the farm were cut close to the ground level (5 cm above the ground) using manual sickle. Samples of experimental grasses were harvested and wilted for 8-hours, 12-hours and 1 day made ready for dry matter analysis. Then samples of each experimental grass were placed in dry-oven at WKU department of Animal Science in Animal nutrition Laboratory repeated times and analyzed for their DM.

The Molasses was bought from Wanji Sugar Factory. After the adjustment of DM, the elephant grasses (*Pennisetum perperum*) were harvested at 1.5m of height, in late afternoon, overnight wilted for 12-hours and desho grasses (*Pennisetum pedicellatum*) were cut/ harvested at the height of 0.5m, in early morning wilted for 24-hours. In the wilting process, Elephant (*Pennisetum perpereum*) and Desho (*Pennisetum pedicellatum*) grasses were harvested and scattered in the bare house in Agriculture and Natural resources research site in WKU and after 12-hours and 24-hours of sun exposure in the shade respectively. To identify effect of different levels of molasses on elephant (*Pennisetum perpereum*) and desho (*Pennisetum pedicellatum*) grasses silage qualities.

Forage materials were chopped into about 2 cm length using a manual forage chopper (Fig.6). Then ensiled grasses were weighed for six treatments of grasses with three replications. Each of the grasses was treated with different levels of molasses (0%, 3% and 5%). After the weighed of individual treatment, measured of water in measuring cylinder, the grasses were scattered in 3m\*3m flattened plastic. Grasses were pumped with highland plastic with small hole at head and equally distributed the mixture of molasses with grasses (Fig 7.).

For treatment one (T1) (E.G +0% molasses) weighing 2kg of elephant grass silage with three replications was taken without molasses as control (0%) (Fig.8). Then for treatment two (T2) (E.G+3% molasses) weighing 1.95 kg of elephant grass, 60ml of molasses was mixed and added to 0.15 liter of water at 3% level and for treatment three (T3) (E.G+5% molasses) weighing 1.90 kg of elephant grass was required and mixed with 100ml of molasses added 0.25 liter of water at 5% level. And also, these procedures were repeated for each desho grass treatments i.e., (T4 (D.G+0% molasses) weighing 2kg of desho grass silage with three replications was taken without molasses as control (0%), T5 (D.G+3% molasses) weighing 1.95 kg of desho grass, 60ml of molasses was mixed and added to 0.15 liter of water at 3% level and T6 (D.G+5% molasses) weighing 1.90 kg of desho grass was required and mixed with 100ml of molasses added 0.25 liter of water at 5% level (Table 2.)).

After the grasses were mixed with molasses then packed in small plastic bag, doubled it. All plastic silos were properly packed with the forage materials; the grass material was compacted thoroughly with wooden compacter to removed oxygen from silages. The neck of the bags was twisted, turned over and tied with a rubber band and closed as airtight as possible. Then after, each of the treatment of plastic bags was labeled for identity (Fig 9.).

One treatment with three replication was inserted into 50 kgs of fertilizer sack with plastic sheet, which protects the entrance of air from outside from replication one to three and each variety of ensiled grasses with treatment 1-3 was inserted into 200 Liter plastic container and treatment 4-6 with 200-liter plastic container loaded with cement for more compaction and closed it to control the silage from rodents & rats and labeled it. Ensiled grasses were stored for 30 days at Agriculture and Natural Resources research site in WKU.

The stored material was opened after 30 days in plastic silo for further analysis of chemical composition and in-vitro studies of silages at WKU department of Animal Science in Animal nutrition laboratory (Fig 9.).

### **3.3 Treatments and Experimental design**

The experimental design was performed in a complete randomized design (CRD) as described by (Steel and Torrie, 1980). The experiment was had a 2 x 3 factorial arrangement for two grass species (elephant and desho), with three levels of molasses (0 (control), 3% and

5%). The experiment was done in 6 treatment combinations designated as three replications each as shown below.

- T<sub>1</sub> Elephant grass + 0% Molasses
- T<sub>2</sub> Elephant grass + 3% Molasses
- T<sub>3</sub> Elephant grass + 5% Molasses
- T<sub>4</sub> Desho grass + 0% Molasses
- T<sub>5</sub> Desho grass + 3% Molasses
- T<sub>6</sub> Desho grass + 5% Molasses

Table 2. Amount of grasses ensiled with different levels of molasses

Types of Grass species	Treatment Number	Levels of molasses (%)	Amount of grasses ensiled (kg)	Amount of molasses ensiled (ml)
EG	1	0	2	0
EG	2	3	1.95	60
EG	3	5	1.90	100
DG	4	0	2	0
DG	5	3	1.95	60
DG	6	5	1.90	100

EG = Elephant grass, DG=Desho grass, Kg=Kilogram, %=Percent, Ml=milliliter

### 3.4. Data Collection

Both primary and secondary data sources were used for this study. The primary data was obtained by observation of the experiment and laboratory analysis and Secondary data were collected from published and unpublished sources to support the primary data.

#### 3.4.1. Organoleptic Test

Following 30 days fermentation period, the resultant silage was evaluated for colour by giving scores and for aroma evaluation also done by giving a scale of 1-4 by 10 independent scorers. The organoleptic test was carried out at the Department of Animal Science in Animal nutrition laboratory by Advisors, Animal Science Laboratory assistants and 4<sup>th</sup> year Animal

Science Students of Wolkite University. Each laboratory assessor was assessing the silage from each treatment and was score its physical/sensory characteristics in terms of appearance, texture and smell (Lyimo, 2010). In this study each of the factors including like structure (texture and appearance), smell, color and texture on fliegs score has given a number.

Appearance score No.1 (poor) was indicate spoiled silage which would be dark brown in color with mold growth, score No. 2 (moderate) greenish in colour with some mold growth, score No. 3 (good) yellowish green to brown colour and score No.4 (very good) indicate well pickled yellowish green to light brown colour silage. Smell score No.1 (poor) indicate foul smell associated with putrefaction, score No. 2 (moderate) pungent smell of ammonia, score No. 3 (good) pleasant aroma and score No.4 (very good) pleasant estery aroma typically silage smell. Texture score, No.1 (poor) slimy and watery, score No.2 (moderate) less slimy and wet No.3 (good) non-slippery and wet No.4 (very good) non-slippery and slightly wet. When ensiling bags (silos) are opened and spoiled silage separated from well preserved silages (Lyimo, 2010).

#### **3.4.2 PH Analysis**

About 30 minutes before starting the procedures, samples were taken to the room where the procedures were performed. For all methods, the PH was monitored at 0, 5, 10, 15, 30, 60, and 120 min after mixing by using an electrode. Before PH reading, the electrode bulb was rinsed in distilled water to remove any salt crystals. After rinsing, a 3-point calibration (4.01, 7.01, and 10.01 buffers) was performed. Afterward, the electrode's calibration was ascertained by checking the slope and offset of the meter. During PH reading, the electrode was immersed in the solution and the beaker or bag was gently turned to make good contact between the solution and the electrode. Because the solution was unfiltered, we avoided contact between the electrode and silage particles. Afterward, the electrode was rinsed well with distilled water and then dabbed lightly with tissues to remove any film formed on the electrode. All procedures were performed in a room at  $25 \pm 1^\circ\text{C}$ .

Silages that has been properly fermented will have a much lower PH (be more acidic) than the original forage. The PH value of the silages which ranges of 3.5-5.5 classified to be PH for good silages (Menesses *et al.*, 2007). According to Lyimo, (2010) silages with PH below 5 were considered as stable silage.

### 3.4.3 Temperature and humidity of silage storage data

To record the ambient temperature, 3 data loggers were distributed across the room. Although the PH meter has an integrated sensor for temperature compensation, this room temperature was chosen to optimize readings, because the device has greatest accuracy at 25°C. Because the operator may represent a source of variation when performing an analytical method, a single person performed all PH measurements.

The production of heat is a normal occurrence during silage fermentation. If silage is well packed and sealed immediately, the average temperature of the forage mass should not increase to more than about 5 to 8°C above the ambient temperature at filling. However, temperatures in the uppermost layers (top 5–10 cm) of forage mass may reach as high as 45 to 60°C, especially if left overnight in warm weather for several days due to equipment breakdowns or packing delays because of bad weather. These high temperatures are a result of excessive amounts of air trapped in the forage mass leading to oxidation from aerobic microorganisms. The key is that these temperatures should decrease quickly as further packing removes air from the mass and fermentation takes place. Penetration of air into the silage mass results in growth of lactate-assimilating yeasts and an increase in silage temperature and is followed by an increase in silage PH. The latter ultimately results in the growth of opportunistic bacteria and molds that thrive in oxygen and causes more heating and spoilage (Gerlach *et al.*, 2013). The temperature (20°C) obtained in this study indicate well-made silage (O.O Falola, *et al.*, 2013). Signs that silage is aerobically spoiling include measuring temperatures in excess of 40°C 10 to 20 cm in the upper.

Thus, forages will be chopped adequately, packed quickly, and sealed tightly as soon as possible to remove and keep the air out of the forage mass. When the active phase of fermentation is complete, temperatures in the core of the silo often decrease slowly to 25 to 30°C. Small silos (bag silos) will cool more quickly than larger silos. In some instances, silages may be relatively hot (>30–35°C) even after 4 to 6 week (or more) in the silo (Gerlach *et al.*, 2013). Silages that have been harvested dry (>40–45% DM) and poorly packed causes prolonged heat may be the result of a slow fermentation or aerobic oxidation.

Temperature and humidity are the two variables that affect the activity of grains, silage and organisms living in bulk. At higher temperature and humidity, the silage had the greater

microbial activity (Chulze *et al.*, 2010). A drying system should allow eliminate excessive grain moisture, silage moisture short term and ensure their conservation. Moreover, the power to have a conservation method that achieves secure and maintain grain quality, silage quality is of great importance, since it guarantees satisfy food supplies to the population and animals for prolonged periods.

#### **3.4.4 Chemical Composition of Silages**

The Laboratory analysis was done at Wolkite University College of Engineering Department of Food Science, Wolkite, Ethiopia. Representative samples were taken from six treatments of silages used for analysis of the effects of different levels of molasses on elephant (*Pennisetum purpureum*) and desho (*Pennisetum pedicellatum*) grasses silage quality. Samples were dried in an oven set at a temperature of 65°C for 48-hours, ground to pass through a 1 mm sieve screen. Ash, Dry matter (DM) and Crude Protein (CP) were determined according to the procedures described by AOAC (1990). The samples were milled to pass through a one (1) mm sieve in a Wiley mill. They were allowed to equilibrate with room temperature for 24- hours. Each sample was stored in air tight plastic bags until required for analysis. The Parameters analyzed were: Dry matter (DM), Power of Hydrogen (PH), Relative Humidity (RH), water soluble carbohydrates (WSC)/nitrogen free extract (NFE), inorganic matter (ash), crude protein (CP), Crude fat (Ether Extract) (EE), Crude Fiber (CF), Acid detergent fiber (ADF), Neutral Detergent Fiber (NDF) and in vitro organic matter digestibility (IVDMD) (Van Soest *et al.*, 1991).

##### **3.4.4.1 Dry Matter Determination**

The DM of the fresh ensiling material and samples of silages were determined by drying in an oven at 65°C for 48-h (AOAC, 1990). Dry matter of the forages is all its constituents excluding water. All nutritional analyses are based on dry matter content. Dry matter and moisture content in the sample were measured by considering loss in weight during drying.

The weight of the fresh samples of elephant (*Pennisetum purpureum*) and desho (*Pennisetum pedicellatum*) grasses were measured in the WKU Agriculture and Natural Resource research site and 500g of samples of each grass was taken from research site and brought to the Wolkite University Animal Nutrition Laboratory and placed in the oven dried at 105°C for 24-hours for dry matter determination.

Samples of the pre-ensilage material (approximately 500 g) were collected, pre-dried in a forced air oven (Fig.11) at 65°C for 72-hours to get constant weight and ground in a Wiley mill (Fig.10) to pass through a 1 mm sieve screen later determined the concentrations of dry matter, Invitro dry matter digestibility and chemical composition such as; crude protein, water soluble carbohydrates, neutral detergent fibre, acid detergent fibre, and invitro dry matter digestibility following methodologies described by (Silva and Quiroz, 2002). Dried and ground samples were stored in airtight containers away from heat and light. Caution has to be taken to avoid insect damage. The predicted values were corrected by DM and the percentage values were used for statistical analysis.

Methods of drying of silages lead to some loss of dry matter depending upon the sample, length of drying period, drying temperature, with in two days observation of the oven and changed the position of samples in the oven.

The dry matter percent was determined by using the formula: -

$$\text{DM}\% = \text{ODW} / \text{FW} * 100$$

Where, DM% is dry matter percent, ODW is oven dry weight, FW is fresh weight

#### **3.4.4.2 Determination of Ash**

Ash was determined according to the procedures described by AOAC (1990). Ash is inorganic ignition of biological material at 550°C in a muffle furnace. During this process Organic matter is oxidized & inorganic matter (ash) remains. The ash component was determined by igniting the dried sample in a muffle furnace at 550°C for 6-hours (AOAC, 1990). The residue after burning in the furnace was the ash.

#### **3.4.4.3 Determination of CP**

Crude Protein was determined according to the procedures described by AOAC (1990). In a feed sample organic nitrogen when digested with concentrates sulphuric acid in the presence of a catalyst ( $\text{K}_2\text{SO}_4$  &  $\text{CuSO}_4$  in 9.5:0.5 ratios).  $\text{NH}_3$  liberated by making the solution alkaline in form of  $(\text{NH}_4)_2\text{SO}_4$ . This solution when distilled into a known volume of standard acid through chemical trapping reactions (ammonium borate) which is than back titrated crude protein content is obtained by multiplying % nitrogen value with factor 6.25.

Digestion mixture /catalyst made up of  $K_2SO_4$  and  $CuSO_4$  in 9.5:0.5 ratios: The  $K_2SO_4$  is added to raise the boiling point of effective oxidation of material and is added as a catalyst to speed up the reaction.

#### **3.4.4.4 Estimation of Crude Fat (Ether Extract) (EE %)**

Ether extract content of the silages was carried out in triplicates as described by AOAC (1990). Ether Extract content was determined by treatment of the sample with petroleum ether in reflux system, at 60°C for 4-hours (Soxhlet) (Fig 13.). Crude fat or ether is estimated by extracting the feed sample using continues evaporation and condensation of fat solvent used petroleum ether. In special made extraction apparatus that is soxhlation apparatus. Petroleum ether extract include all fraction of which is soluble in ether is simple fat. The dried feed sample is dissolved with petrol ether and then the ether is evaporated in the Soxhlet apparatus. The residues are crude fat.

#### **3.4.4.5 Determination of Nitrogen Free Extract**

Water Soluble Carbohydrate was determined according to the methodologies described by (Silva and Quiroz, 2002) in Weende's system of analysis. Nitrogen Free Extract (NFE) represents the soluble carbohydrate fraction of the feed. In the Weende's system of analysis, NFE is not estimated but calculated.

- $NFE \text{ on dry matter basis} = 100 - (\text{Crude protein} + \text{Ether extract} + \text{Crude fibre} + \text{Total ash})$

#### **3.4.4.6 Acid Detergent Fiber Analysis**

- ✓ The method of Van Soest and Robertson (1985) was used to determine Acid Detergent Fiber (ADF).

#### **3.4.4.7. Determination of Neutral Detergent Fiber**

Neutral Detergent Fiber was determined according to the procedures described by Van Soest *et al.*, 1991. Important fractions of feed are fibers that affect the digestibility. Insoluble fiber in feed is determined as neutral detergent fiber (NDF). Neutral detergent solution recovers its main components cellulose, hemicelluloses and lignin. Detergent fiber is the residue of plant

cells after fractionation using detergent solutions for the volatilization of protein and starch. NDF expressed as organic matter: Ash insoluble in neutral detergent.

#### **3.4.4.8 Estimation of Crude fiber content of silage**

Crude fiber was determined according to the procedures described by Van Soest *et al.*, 1991. Crude fiber includes cellulose, hemicelluloses and highly variable proportion of lignin along with minerals, which are undigested by monogastric animal. e.g. pig, poultry etc.

#### **3.4.5 Determination of In Vitro Dry Matter Digestibility of silage**

The invitro dry matter digestibility (IVDMD) of the silages was determined according to the two stage technique developed by Tilley and Terry (1963). All samples used for chemical analysis was used for invitro dry matter digestibility (IVDMD). This was analyzed at Wolkite University College of Engineering and Technology, Food Science laboratory. The two-stage rumen 25 inoculums pepsin method of Tilley and Terry (1963) was used to determine IVDMD. A duplicate sample (0.5 g each) was incubated with 30 ml of rumen liquor in 100 ml test tube in a water bath at 39°C for a period of 48- hours for microbial digestion followed by another 48-hour for enzyme digestion with acid pepsin solution. Blank samples containing buffered rumen fluid was incubated in 18 duplicates for adjustment. Drying of samples residues was done at 105°C for 24-hours. IVDMD was calculated (Jeans and Yolande, 2007) as:

### **3.5 Statistical Analysis**

Laboratory analyzed data were entered in coded excel sheets then transferred to SAS for General Linear Model (GLM) procedure of SAS version 9.1.3 (SAS, 2012). Organoleptic test was analyzed by SPSS (version 23.0). The significant differences among the means were declared at  $P \leq 0.05$  and means of factors were separated using Duncan's least significant difference (LSD) test, Factors tested were levels of molasses, Elephant grass (*Pennisetum purpureum*) and Desho grass (*Pennisetum pedicellatum*) species and interaction factors. The following model was used to study the effect of different levels of molasses on elephant grass (*Pennisetum purpureum*) and desho grass (*Pennisetum pedicellatum*) silage quality.

With model of  $Y_{ijk} = \mu + M_j + G_k + MG_{jk} + E_{ijk}$

Where,  $Y_{ij}$  = Response variable (experimental unit)

$\mu$  = Grand (overall) mean

$M_j$  = factor effect (level of molasses)

$G_k$  = factor effect (grass species)

$MG_{jk}$  = interaction effect (between molasses \* grass species)

$E_{ijk}$  = random error

## 4. RESULTS AND DISCUSSION

### 4.1 RESULTS

#### 4.1.1. Effect of Different levels of molasses on grass silage stability during Organoleptic Test

Treated elephant and desho grass silages with additives had better appearance than control group. All levels of molasses in this study produced good silage. In this study the maximum value of PH (Power of Hydrogen) scored was very good degree silage with 24 % DM for elephant grass and 21.8% DM for desho grass was 3.42 - 5.2 and 3.85-4.97 respectively. In the present study average DM was 25.3% for elephant grass and 20.9% for desho grass, PH ranges from 3.42-5.2, therefore, all of silages were stated in good and very good class (Table 3.). The untreated silage showed higher value of PH (5.2) for elephant grass and 4.97 for desho grass in this study, but it should rapidly fall in PH to 3.77- 3.42 for elephant grass silage and for desho grass silage, 3.91-3.85 due to 3% and 5% molasses respectively.

The results showed that, elephant grass silage was more stable than desho grass silage as indicated by PH (Table 3.). PH is one of the simplest and quickest ways of evaluating silage quality. However, PH may be influenced by the moisture and the buffering capacity of the original materials. Silage that has been properly fermented will have a much lower PH (be more acidic) than the original forage (control). The PH value of the silages which ranges of 3.5-5.5 classified to be PH for good silage (Menesses *et al.*, 2007). According to Lyimo, (2010) silage with PH below 5 was considered as stable silage. In this present study, Elephant grass silage was stable than desho grass silages. Elephant grass Silages with molasses at 5% level was more stable (in terms of maintaining low PH (< 5%) than desho grass during opening. The results were comparable to that reported by (Lyimo *et al*, 2016).

Table 3. Mean of DM, PH and fermentative quality of elephant and desho grass silages

Grass type	Additive type	DM (%) (Overall mean)	PH (Overall mean)	Judgement
Elephant grass	0%	27.3	5.2	Good
	3%	24.3	3.77	Very good
	5%	24	3.42	Very good
Desho grass	0%	19.5	4.97	Good

3%	21.5	3.91	Very good
5%	21.8	3.85	Very good

DM=Dry Matter, PH=Power of Hydrogen, %=percent

#### 4.1.2 Effects of species and different levels of molasses on fermentative quality of grass silages

Elephant grass silage had higher PH but slightly lower fermentative quality than desho grass silages (Table 4.). Treated Silages with molasses at 5% and 3% level had lower PH than molasses at 0% levels. The PH was significantly decreased with increasing molasses levels in this study ( $p < 0.05$ ). The addition of molasses 5% significantly ( $p < 0.05$ ) ensiling with molasses lowered the PH composition of silage as a result, increased the quality of the silages. The effect of grass species of silages on fermentative quality of silages was non – significantly different at ( $p < 0.05$ ).

Table 4. Mean effect of species and additive levels on fermentative quality of grass silages

Parameter (%)	Factors			SEM	p-value
	Effect of species				
	Elephant grass silage	desho grass silage			
PH	4.24 <sup>a</sup>	4.13 <sup>a</sup>		0.326	0.0001
	Effect of additive levels				
	MOL 0%	MOL 3%	MOL 5%		
PH	5.088 <sup>a</sup>	3.843 <sup>b</sup>	3.64 <sup>b</sup>	0.215	0.0001

MOL – molasses, SEM - Standard error of means. a, b = least significant means and means within row with different superscript letters are significantly different ( $P < 0.05$ ).

#### 4.1.3 Effects of species and different levels of molasses on organoleptic of grass silages

The effect of grass species of silages on organoleptic test in appearance, smell and texture was non-significant at ( $p < 0.05$ ). But, treated silages had higher on organoleptic test in appearance, smell and texture than untreated (control) silages in additive levels (Table 5.). That is, molasses levels of 5% and 3% on organoleptic test result of grass species of silages was significantly higher in appearance and smell than untreated silages (control) 0% levels of molasses ( $p < 0.05$ ). Appearance is significantly increased with molasses levels ( $p > 0.05$ ). Texture was slightly significant in molasses levels ( $p > 0.05$ ). Desho grass silage had higher

appearance and texture than elephant grass silages in organoleptic test quality in these studies. But elephant grass silages had higher smell than desho grass silages in organoleptic test quality.

Table 5. Mean effect of grass species and different levels of molasses on organoleptic of silage quality

Parameters	Factors			SEM	P-VALUE
Effect of species					
	Elephant	Grass	Desho Grass		
Appearance	3.089 <sup>a</sup>		3.167 <sup>a</sup>	.0161	0.2945
Smell	3.5 <sup>a</sup>		3.356 <sup>a</sup>	.111	0.1841
Texture	3.378 <sup>a</sup>		3.444 <sup>a</sup>	.1358	0.3085
Effect of additive levels					
	MOL 0%	MOL 3%	MOL 5%		
Appearance	3.08 <sup>c</sup>	3.5 <sup>a</sup>	3.38 <sup>b</sup>	.1529	0.1141
Smell	2.95 <sup>b</sup>	3.4 <sup>a</sup>	3.38 <sup>a</sup>	.0667	0.2088
Texture	3.3 <sup>a</sup>	3.41 <sup>a</sup>	3.46 <sup>a</sup>	.0167	0.0636

MOL-molasses, Score 1 = Poor Score 2=Moderate Score 3= good, 4= very good, SEM - Standard error of means. a,b,c - Means within row with different superscript letters are significantly different ( $P > 0.05$ ).

#### 4.1.4 Effect of grass species and different levels of molasses on chemical composition and in vitro dry matter digestibility

The findings of this study showed that CFI value of silages of all molasses levels (0%, 3% and 5%) were significantly ( $p < 0.05$ ) decreased. The increment of molasses levels on grass species decreased the amount of crude fiber content.

The PH values of the silages of grass species with levels of molasses are non-significant ( $p < 0.05$ ). At 0% levels which had higher than 3% and 5% levels, but the quality of the silages were increased with increased molasses levels. The Elephant grass silages presented a higher PH value ( $P < 0.05$ ) when compared with the other treatments (Table 6.). The highest value of PH observed may be related to low soluble carbohydrates content of grass, low content of DM and age of the plant, thus hampering the fermentation and quality of silage compared to other treatments.

In this study, the NDF values of silages of grass species with molasses levels were 0% ,3% and 5% significantly different ( $p<0.05$ ), but 0% level had higher than 3% and 5% levels. But, the addition of molasses on grass species reduces the NDF contents. And also, the ADF values of the silages of grass species with molasses levels 0%, 3% and 5% were significantly ( $p<0.05$ ) decreased. But, the increment of molasses levels 0%, 3% and 5% with this grass species of silages were decreased the amount of ADF values.

Table 6: Mean effect of different levels of molasses on chemical composition of silages

Parameter (%)	Molasses level (%)			LSD (5%)	P value	CV (%)
	0 %	3%	5%			
PH	5.088 <sup>a</sup>	3.843 <sup>b</sup>	3.64 <sup>b</sup>	0.43	0.0001	8.15
Temperature	22.98 <sup>b</sup>	24.53 <sup>a</sup>	25.35 <sup>a</sup>	1.21	0.0036	3.97
NDF	59.775 <sup>a</sup>	52.355 <sup>b</sup>	51.023 <sup>b</sup>	6.591	0.0284	9.63
ADF	41.093 <sup>a</sup>	39.528 <sup>a</sup>	34.778 <sup>b</sup>	4.47	0.0243	9.23
CFI	35.28 <sup>a</sup>	31.01 <sup>b</sup>	28.19 <sup>c</sup>	2.2	0.0001	5.54

Means within row and column with different superscript letters are significantly different ( $P < 0.05$ ); CV = Coefficient of variation; LSD = Least significance difference.

Chemical composition of silages CP, CFI and Temperatures were significantly different ( $p<0.05$ ) with the grass species. Elephant grass silages had higher CP, CFI and temperature than desho grass silages (Table 7.). There was no difference among elephant and desho grass silages on composition of NDF. Elephant grass Silages had higher CP, CFI and temperature than desho grass silages.

Table 7: Mean effect of different types of grass species on chemical composition

Parameter (%)	Grass Species		LSD (5%)	P value	CV (%)
	Elephant grass silage (EGR)	Desho grass silage (DGR)			
CP	10.30 <sup>a</sup>	9.32 <sup>b</sup>	0.49	0.0009	4.83
Temperature	23.333 <sup>a</sup>	25.244 <sup>b</sup>	0.99	0.0012	3.97
CFI	32.83 <sup>a</sup>	30.17 <sup>b</sup>	1.97	0.0072	5.54

Means within row and column with different superscript letters are significantly different ( $P < 0.05$ ); CV = Coefficient of variation; LSD = Least significant difference.

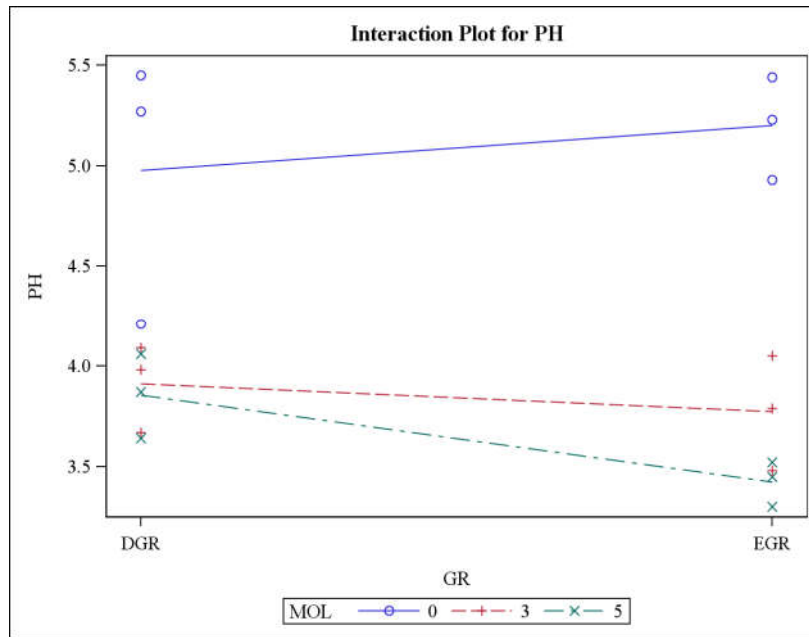
#### 4.1.5 Interaction effect of grass species and different levels of molasses on composition of silage quality

The interaction of desho grass and 5% level of molasses showed that desho grass produced silage with higher Moisture, IVDMD and EE (crude fat) than elephant grasses (Table 8.). The interaction of desho grass with these chemical composition DM, Moisture, INVDMD and Ether Extract (EE) with all levels of molasses were significantly difference ( $p < 0.05$ ). But the interaction of elephant grass silages IVDMD with all molasses levels showed that non-significant differences ( $p < 0.05$ ). DM of elephant grass and desho grass with 3% and 5% levels of molasses were not significant different ( $p < 0.05$ ). The interaction of desho grass silages with molasses levels showed higher values of EE than elephant grass silages. The interaction of desho grass silages with molasses levels (3% and 5%) showed the higher significant difference than control. EE values of elephant grass had not significantly different with in molasses levels.

Table 8: Mean effect of interaction of grass species and different levels of molasses on chemical composition and Invitro dry matter digestibility.

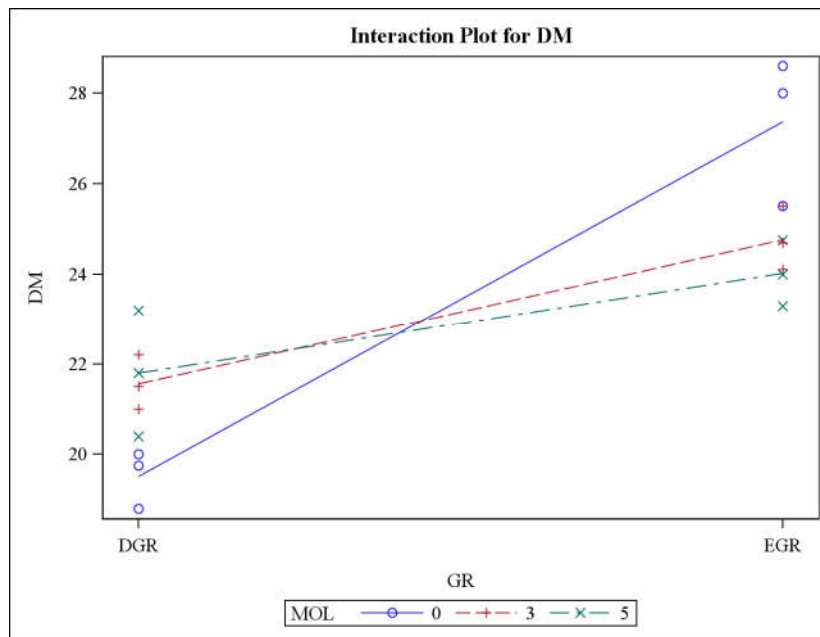
Parameter (%)	MOL (%)	E. Grass	D. Grass	LSD (%)	P value	CV (%)
<b>DM</b>	0%	27.40 <sup>a</sup>	19.52 <sup>d</sup>	1.84	0.0011	4.47
	3%	24.8 <sup>b</sup>	21.60 <sup>c</sup>	1.84	0.0011	4.47
	5%	24.02 <sup>b</sup>	21.80 <sup>c</sup>	1.84	0.0011	4.47
<b>IVDMD</b>	0%	55.65 <sup>c</sup>	60.13 <sup>c</sup>	1.16	0.0007	1.10
	3%	56.60 <sup>dc</sup>	62.15 <sup>b</sup>	1.16	0.0007	1.10
	5%	56.89 <sup>d</sup>	65.25 <sup>a</sup>	1.16	0.0007	1.10
<b>EE (C.fat)</b>	0%	3.88 <sup>b</sup>	3.39 <sup>b</sup>	1.179	0.0001	11.47
	3%	3.40 <sup>b</sup>	10.76 <sup>a</sup>	1.179	0.0001	11.47
	5%	3.53 <sup>b</sup>	9.71 <sup>a</sup>	1.179	0.0001	11.47

a,b,c,d,e- Means within row and column with different superscript letters are significantly different ( $P < 0.05$ ). MOL = Molasses; E. Grass = Elephant grass; D. Grass = Desho grass; CV = Coefficient of variation; LSD = Least significant difference.



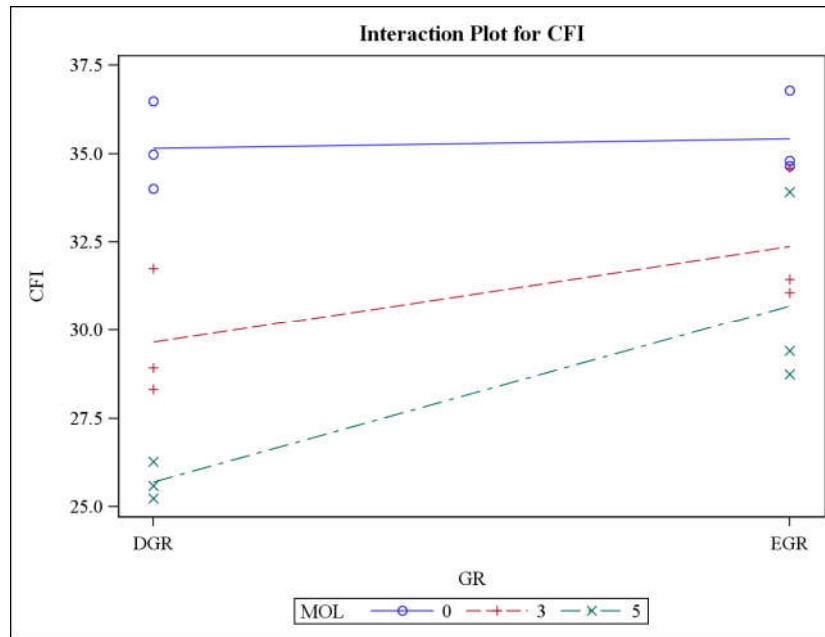
Dependent variable PH

Figure 1. Interaction plot for PH of ensiled grasses with levels of molasses



Dependent variable DM (measurement) linear

Figure 2. Interaction plot for Dry matter of ensiled grasses with levels of Molasses



Dependent variable CF=Crude Fiber, DGR=Desho grass silage, EGR=Elephant grass silage, GR= grasses

Figure 3. Interaction plot for CFI of ensiled grasses with levels of Molasses

## 4.2 DISCUSSION

### 4.2.1 Effect of grass species and different levels of molasses on organoleptic of silage quality

Higher sensory scores from desho grass than elephant grass silage might have been caused by improved fermentation condition in desho grass silages than in elephant grass silages (Table 5.). But this was in agreement with Lyimo *et al.*, 2016 who found that elephant grass silages had higher sensory quality than desho, Guatemala and Rhodes grass silages. Good silage usually preserves the original colour of the pasture or any forage. The olive-green color obtained from desho and elephant grass in the present study was in order. It was close to the original colour of the grass which was an indication of good quality silage that was well preserved (Oduguwa *et al.*, 2007) reported that pleasant smell is accepted for good or well-made silage. The pleasant smell could be attributed by good aroma from molasses of well fermented silages. The texture of the elephant grass silages was firm which was expected to the best texture of good silage (Kung and Shaver, 2002).

Higher sensory scores observed in silages with molasses at 5% level and 3% than silages with molasses at 0% levels. These were due to increased substrate for lactic bacteria which enhanced more lactic acid production resulted to good fermentation process (Table 3.). This implied that, molasses at 5% is optimal level which secured good fermentation compared to other levels. This was in agreement with observation reported (Lyimo *et al.*, 2016, Mtengeti and Urio, (2006) and Lyimo (2010) who found well fermented silages after molasses was applied at 5% level.

#### **4.2.2 Effects of species and different levels of molasses on fermentative quality of grass silages**

Some parameters can be used as indicative of good fermentation and good silage quality, including DM levels and PH (Pires *et al.*, 2009). In this study, the addition of molasses linearly increased the levels of DM and reduced the PH of the silages ( $P < 0.05$ ). this study also agreement with the study of Danillo G. *et al.*, (2016) who observed that addition of dried cashew bagasse (DCB) linearly increased the levels of DM and reduced the PH of the silages ( $P < 0.05$ ).

The PH value of silage was significantly decreased when molasses level increased. Ensiling elephant and desho grass with molasses decreased the PH of the resultant silage. This finding was in line with the findings of (Muluken, 2017), who observed that PH value of silage was significantly decreased when poultry litter amount increased. Ensiling desho grass with broiler litter increased the PH of the resultant silage. The highest PH was recorded in control T1 (5.2) and in control T4 (4.7) with the least in T3 (3.42) and T6 (3.85). This agrees with the findings of Rasool, (1998) who reported an increase in PH of Sudan grass ensiled with 30% Broiler litter and 6% molasses however, the PH values obtained were lower than the ones recorded in this study. Hadjipanayiotou *et al.*, (1994) observed a similar trend with tomato pulp and broiler litter silage. The increase in silage PH observed might be due to buffering capacity as a result of ash and ammonia from uric acid hydrolysis. In this study, the PH levels of, T2 (3.77), T3 (3.42), T5 (3.91) and T6 (3.85) were at the desired level which was similar with (Menesses *et al.*, 2007) for good quality silage (5.0) and the remained treatments were also below the desired level. This may indicate there are organic acids being generated by fermentation.

On the basis of decreased PH value of buffering capacity and increase lactic acid production it may be concluded that addition of molasses as additive may improves quality and palatability of silage and also helpful as energy source.

#### **4.2.3 Effect of grass species and different levels of molasses on chemical composition and in vitro dry matter digestibility**

More DM recovery with molasses at 5% level (Table 8.) compared to level 0 and 3% may be due to the addition of WSC that improves the fermentation characteristics. Once the silage gains the stability then there is no more fermentation and at very low PH the microbes become the part of medium and reduction in DM is prohibited. The results were inconsistency with Lyimo *et al.*, (2016). From this study observed that high CP, DM, WSC, ASH and IVDMD. High CP may be due to increased level of molasses.

The addition of molasses leads to increase in CP content. The results were in agreement with those found by Lyimo *et al.*, (2016) who found higher CP in treated silages than in untreated silages. Observed high WSC could be attributed by increased energy for lactic bacteria due to increased substrate resulted to more lactic acid production, leads to rapid pH reduction and when the process stops WSC remains as recovery substrate. This was in agreement with McDonald *et al.* (2002) who observed good fermentation after adding more WSC to the herbage with high water and low WSC. Observed high ash could be attributed by high minerals found in molasses that can increase ash. This result was similar with (Gofoon and Khalifa, 2007, Aksu *et al.*, 2006, Donmez *et al.*, 2003) who found higher levels of ash after addition of molasses to the grasses.

Increased IVDMD could be attributed to the provision of useful energy substrate for ruminal microbes and thus improve their effectiveness in digesting feed particles. The importance of molasses as useful energy substrate for ruminal microbes have been documented by McDonald *et al.* (1973). Low NDF could be attributed to increased acidity which stimulated further hydrolysis of linked sugar molecules in the cell wall causing further breakdown of hemicelluloses. Breakdown of up to 50% of hemicelluloses during silage fermentation has been documented by McDonald *et al.* (1991)

#### **4.2.4 Interaction effect of grass species and different levels of molasses on organoleptic of silage quality**

Lowest PH produced from the interaction of desho grass and 5% level of molasses (Table 4.) possibly was due to improved fermentation condition in desho grass mixed with molasses at 5% level which leads to efficient fermentation than in the other interactions. The effect of interaction of grass species of organoleptic test quality of appearance and smell had significance difference with all levels of molasses, but texture was the only organoleptic test quality had no significant difference by the interaction of grass species with levels of molasses.

#### **4.2.5 Interaction effect of grass species and different levels of molasses on composition of silage quality**

Higher DM, IVDMD and EE from interaction of Desho grass and 5% level of molasses than other interactions (Table 8.) is related to the original DM, IVDMD and EE of Desho grass compared to those of elephant grass ( $p < 0.05$ ). But, the interaction of elephant grass and 5% molasses had higher moisture, slightly significantly increased and there was no effect on ether extract on this grass species ( $p < 0.005$ ). Higher WSC/NFE possibly was due to increased molasses level at 5% than molasses at 3% and 0% levels revealed in this study. Thus, the interaction of desho grass and molasses at 5% level resulted to efficient fermentation than other interactions in this study. The results implicated that nutrient contents of the grass silage vary depending on the species and silage additives levels. The results are related to those of Lyimo *et al.*, (2016) who found that, both nutrients and PH of the grass silage vary depending on the species and silage additives. Thus, from this study, consideration of grass species and silage additive level can be useful tools to improve silage quality.

#### **4.2.6 Correlation analysis of chemical composition and IVDMD of grass species of silages**

The simple linear bivariate correlation analyses among fermentative quality and nutrient composition parameters of elephant and desho grass silages quality are presented in (Table 8). CP content of the silage was positively correlated with DM of the silages. And also, CP content was positively correlated with ash content of the silages but non-significant. ODM nutrient of the silages was positively correlated with PH and Temperatures of the silages which had non-significantly difference. But ODM was highly negatively correlated with ash.

Therefore, ash increases the ODM decreases and vice versa. CFI was positively correlated with PH. Moisture was highly significantly negatively correlated with DM. Because as the increment of moisture of the silages leads to the reduction of DM of the silages. However, DM of the silage was significantly negatively correlated with Temperature these is the fact that, over temperature disappears the DM content of silages. NDF was positively significantly correlated with CFI and PH of the silages. ADF was significantly positively correlated with NDF and CFI, which might be due to the fact that, as plant matures it, increases the stem portion which has more DM than the leaf part. IVDMD of the silage was positively correlated with temperature and moisture of silages. However, IVDMD of the silage was highly negatively correlated with nutritional parameters DM, CFI and NDF of the silages. As a result, the maturity of the grasses increases with increasing of DM and increases fiber content of the grasses reduced the degradability of the silages. CFI had very highly significant correlation with temperature of silages. These might be the fact that, Cellulose, lignin and other cell wall constituents degraded at higher temperature. EE (C. fat) was positively correlated with temperature and IVDMD of the silages. NFE was non-significantly positively correlation with compositional parameters of Temperature, Moisture, Ash, IVDMD and EE.

## 5. CONCLUSIONS AND RECOMMENDATIONS

### 5.1. Conclusions

The current study was conducted with the objectives of evaluating the effect of different levels of molasses on silages quality of elephant grass (*Pennisetum purpureum*) and desho grass (*Pennisetum pedicellatum*) in Wolkite University. The silage preparation study was conducted under College of Agriculture and Natural Resource research site.

When evaluated their nutritional qualities, elephant grass had higher DM, CP and CF. The higher percentages of DM and CP may be the management practices of Elephant Grass was brought at WKU dairy farm. But, lower Moisture and PH than desho grass silages.

Treated elephant and desho grass silages had higher on organoleptic test in appearance, smell and texture than untreated (control) silages in additive levels. Higher sensory scores observed in silages with molasses at 5% level and 3% than silages with molasses at 0% levels. These were due to increased substrate for lactic acid bacteria from the addition of molasses, which enhanced more lactic acid production, resulted to good fermentation process. Generally higher sensory scores i.e. appearance and texture from desho grass than elephant grass silage might have been caused by improved fermentation condition in desho grass silages than in elephant grass silages.

Nutritional composition of forage is the most important criteria to determine forage quality. Species variation of silages had no significant ( $P>0.05$ ) difference on Ash, Nitrogen Free Extract (NFE %), Neutral Detergent Fiber (NDF). On the other hand, Crude Protein, Crude fiber and temperature of silages had a significance ( $P<0.05$ ) difference among species. The CP content of desho and elephant grasses of silages increased with increased levels of molasses from 0% to 5% after ensiling process.

The result of the current study showed that elephant and desho grasses had higher dry matter, crude protein, IVDMD, organic matter and other nutritional components but, low ash content, NDF and ADF contents. So in my study these grasses i.e. elephant and desho grasses were ranked at the top. Farmers also are using for multi-purpose use as soil protection and animal feed in dry season which is abundant during the main rainy season in the study area.

In this study, NDF values of silages of grass species also with molasses levels were 0% ,3% and 5% significantly different ( $p<0.05$ ), but 0% level had higher than 3% and 5% levels. So that, the addition of molasses on grass species was reduced the NDF contents of grasses. These study shows that addition of molasses on tropical grasses improves its nutritional qualities.

The PH values of the silages of grass species with levels of molasses are non-significant ( $p<0.05$ ). At 0% levels which had higher PH than 3% and 5% levels, but the quality of the silages were increased with increased molasses levels. The Elephant grass silages presented a higher PH value ( $P<0.05$ ) than desho grass silages.

Grass silages treated with molasses at 5% level had higher appearance, smell and texture score, DM, CP, WSC, ash, IVDMD, stability but lower NDF, PH and compared to silages with molasses at 3% and 0% levels. These studies suggested that addition of molasses at 5% molasses levels on elephant and desho grass increases its organoleptic quality, chemical composition as well as stability of silages.

The findings of this study showed that CF, PH, Neutral Detergent Fiber (NDF) and Acid Detergent Fiber (ADF) value of silages of all molasses levels (0%, 3% and 5%) were significantly ( $p<0.05$ ) decreased. The increment of molasses on grass species of silages decreased the amount of CF, PH and ADF value of silages with molasses levels had significantly ( $p<0.05$ ) difference. As a result, increases the invitro dry matter digestibility of the grass species of silages, dry matter intake, palatability and animal acceptance.

Elephant and desho grasses were high yielding grasses. Ensiling of desho grasses increased the digestibility (IVDMD) and degradability rates. Fermentation of available substrates contributed to the formation of organic acids during ensiling process increased the energy content of species of grasses.

The interaction between grass species (Elephant and Desho grasses) showed that, Desho grass silage produced higher quality and preserved better than Elephant grass as indicated by higher sensory qualities, ether extract, invitro dry matter digestibility and stability.

Higher DM, IVDMD and EE from interaction of Desho grass and 5% level of molasses than other interactions was related to the original DM, IVDMD and EE of Desho grass compared to those of elephant grass ( $p<0.05$ ). But the interaction of elephant grass and 5% molasses

had higher moisture, but slightly significantly increased and there was no effect on ether extract on this grass species ( $p < 0.005$ ). Higher WSC/NFE possibly was recorded due to increased molasses level at 5% than molasses at 3% and 0% levels revealed in this study.

The interaction between grass species (Elephant and Desho grasses) and different molasses levels (0%, 3% and 5%) showed that, the interaction of desho grass and molasses at 5% produced best silage as indicated by highest IVDMD and EE (C. fat), but lowest DM and PH. Therefore, it was concluded that, desho and elephant grasses mixed with molasses at 5% level was the most optimal technique to achieve high quality silage under smallholder farmers.

Silage-making provides an opportunity to preserve surplus forage during the wet season for later use by cattle during the dry season when forage is scarce. Since, silage-making is less dependent on weather conditions than hay.

The finding suggests that these grasses can be one of the most important grasses which can be productive on rainfall condition or under irrigation in areas where irrigable land is accessible. Both livestock producers and other farmers could use this information to assist in making decisions based on the relative importance of forage yield and quality in their livestock and farming operations.

It was therefore, concluded that, 2 kg of elephant grass and desho grass ensiled in shopping plastic bag silo doubled it and stored in thatched barn for research studies was the most optimal combination technology to achieve high silage quality.

## **5.2 Recommendations**

The shortage of feed both in quality and quantity is decreasing as compared to the past and an interesting thing is that forage development strategies increasing from time to time throughout the country working at different institutions in livestock activities. So, this study will contribute in the forage production related problems of the farmers. Therefore, based on findings of the study the following recommendations are given:-

- Wilted elephant and desho grass, chopped at 2 cm, treated with molasses at 5% level or with molasses at 3% level, ensiled in 2 kg shopping plastic bag doubled it, stored in thatched barn is the appropriate technology recommended for research studies to achieve high quality grass silage production.

- More extension work should be done on the production and utilization of elephant and desho grass to integrate it in the farming systems of different agro ecological areas of Ethiopia.
- To improve availability of livestock feed in terms of quality and quantity, it is better to cultivate elephant and desho grass forage that have high biomass yield and nutritional quality.
- The agronomic trial should be conducted to investigate nutritional quality of these grass silages in the future to minimize variation of nutrients on effects of species of grasses due to different management practice.
- The response of elephant and desho grasses to different levels of molasses up to 10% should be investigated for further analysis of the grasses.
- Further research on the use of technologies under this study for grass silage production from other locally available grasses, such as Rhodes and Brancharia for smallholder dairy farmers is highly recommended.
- Sustainable solution to feed shortage should be planned and practiced when technical efforts are invested to improve production and utilization of forages. Participatory effort and approaches in collaboration with government, researchers, farmers and livestock stakeholders is really required.
- Further study on economic feasibility of inclusion of elephant and desho grass silage in animal diet must be investigated. Animal evaluation should be done on feeding trial of elephant and desho grass silages under on-farm condition.
- To make the best silage always use an additive is a good recommendation if care should be taken when choosing a silage additive.
- Government, Researchers and Livestock Development Agencies are advised to incorporate silage as one of prior criteria in solving the problem of livestock feed conserved during wet season at times of surplus production deficit during dry season in the country.

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## 7. APPENDICES

**Appendix table 1: Analysis of Variance table for chemical composition parameters.**

Parameters	Source of variation	DF	SS	MS	F value	P value
PH (%)	GR	1	0.061	0.06	0.52 <sup>NS</sup>	0.4827
	MOL	2	7.378	3.69	31.60 <sup>***</sup>	0.0001
	GR*MOL	2	0.324	0.16	1.39 <sup>NS</sup>	0.2863
	Error	12	1.4	0.12		
	Total	17	9.16			
RH (%)	GR	1	19.22	19.22	0.93 <sup>NS</sup>	0.3531
	MOL	2	32.87	16.43	0.80 <sup>NS</sup>	0.4728
	GR*MOL	2	116.70	58.35	2.83 <sup>NS</sup>	0.0983
	Error	12	247.2	20.60		
	Total	17	415.997			
Temperature	GR	1	16.44	16.44	17.71 <sup>**</sup>	0.0012
	MOL	2	17.34	8.67	9.35 <sup>**</sup>	0.0036
	GR*MOL	2	2.81	1.40	1.51 <sup>NS</sup>	0.2594
	Error	12	11.13	0.93		
	Total	17	47.72			

\*\* significant at  $p \leq 0.01$ ; \*\*\* significant at  $p \leq 0.001$  by LSD; NS= non- significant at  $p > 0.05$ . DF= Degree of freedom; SS = Sum of square; MS = Mean square

**Appendix table 2: Analysis of Variance table for chemical composition parameters.**

Parameters	Source of variation	DF	SS	MS	F value	P value
DM (%)	GR	1	88.00	88.00	81.90 <sup>***</sup>	0.0001
	MOL	2	0.85	0.43	0.40 <sup>NS</sup>	0.6807
	GR*MOL	2	27.16	13.58	12.64 <sup>**</sup>	0.0011
	Error	12	12.89	1.07		
	Total	17	128.91			
Ash (%)	GR	1	1.596	1.60	4.29 <sup>NS</sup>	0.0605
	MOL	2	0.429	0.21	0.58 <sup>NS</sup>	0.5763
	GR*MOL	2	1.45	0.72	1.95 <sup>NS</sup>	0.1843
	Error	12	4.46	0.37		
	Total	17	7.939			
ODM (%)	GR	1	1.596	1.60	4.29 <sup>NS</sup>	0.0605
	MOL	2	0.429	0.21	0.58 <sup>NS</sup>	0.5763
	GR*MOL	2	1.45	0.72	1.95 <sup>NS</sup>	0.1843
	Error	12	4.46	0.37		
	Total	17	7.939			

\*\* significant at  $p \leq 0.01$ ; \*\*\* significant at  $p \leq 0.001$  by LSD; NS= non- significant at  $p > 0.05$ . DF= Degree of freedom.

**Appendix Table 3: Analysis of Variance table for chemical composition parameters.**

Parameters	Source of variation	DF	SS	MS	F value	P value
CP (%)	GR	1	4.312	4.31	19.20 <sup>***</sup>	0.0009
	MOL	2	1.147	0.57	2.55 <sup>NS</sup>	0.1191
	GR*MOL	2	0.117	0.06	0.26 <sup>NS</sup>	0.7742
	Error	12	2.695	0.22		
	Total	17	8.272			
CFI (%)	GR	1	31.760	31.76	10.42 <sup>**</sup>	0.0072
	MOL	2	152.745	76.37	25.06 <sup>***</sup>	0.0001
	GR*MOL	2	16.762	8.38	2.75 <sup>NS</sup>	0.1039
	Error	12	36.57	3.04		
	Total	17	237.83			
NDF (%)	GR	1	31.893	31.89	1.16 <sup>NS</sup>	0.3023
	MOL	2	266.842	133.42	4.86 <sup>*</sup>	0.0284
	GR*MOL	2	169.796	84.90	3.09 <sup>NS</sup>	0.0826
	Error	12	329.428	27.45		
	Total	17	797.961			

ADF (%)	GR	1	4.361	4.36	0.35 <sup>NS</sup>	0.5673
	MOL	2	129.781	64.89	5.15*	0.0243
	GR*MOL	2	21.772	10.89	0.86 <sup>NS</sup>	0.4463
	Error	12	151.276	12.60		
	Total	17	307.191			

\* Significant at  $p \leq 0.05$ \*\* significant at  $p \leq 0.01$ ; \*\*\* significant at  $p \leq 0.001$  by LSD; NS= non- significant at  $p > 0.05$ . DF= Degree of freedom.

**Appendix table 4: Analysis of Variance table for Invitro Dry Matter Digestibility and chemical composition parameters.**

Parameters	Source of variation	DF	SS	MS	F value	P value
IVDMD (%)	GR	1	169.034	169.03	395.99***	0.0001
	MOL	2	30.381	15.19	35.59***	0.0001
	GR*MOL	2	12.036	6.01	14.10**	0.0007
	Error	12	5.122	0.43		
	Total	17	216.575			
EE (%)	GR	1	85.151	85.15	193.88***	0.0001
	MOL	2	41.996	20.99	47.81***	0.0001
	GR*MOL	2	53.673	26.84	61.10***	0.0001
	Error	12	5.270	0.44		
	Total	17	186.091			
NFE (%)	GR	1	15.07	15.07 <sup>NS</sup>	1.14 <sup>NS</sup>	0.3069
	MOL	2	41.965	20.98 <sup>NS</sup>	1.59 <sup>NS</sup>	0.2449
	GR*MOL	2	10.937	5.47 <sup>NS</sup>	0.41 <sup>NS</sup>	0.6706
	Error	12	158.80	13.23		
	Total	17	226.78			

\*\* significant at  $p \leq 0.01$ ; \*\*\* significant at  $p \leq 0.001$  by LSD; NS= non- significant at  $p > 0.05$ . DF= Degree of freedom.

Appendix Table 5: Analysis of variances table for Correlation study for chemical compositional parameters

	<b>PH</b>	<b>RH</b>	<b>Temp.</b>	<b>DM</b>	<b>Ash</b>	<b>ODM</b>	<b>CP</b>	<b>CFI</b>	<b>NDF</b>	<b>ADF</b>	<b>IVDMD</b>	<b>EE</b>	<b>NFE</b>
<b>pH</b>	1												
<b>RH</b>	0.026 <sup>NS</sup>	1											
<b>Temp.</b>	-0.49*	0.15 <sup>NS</sup>	1										
<b>DM</b>	0.11 <sup>NS</sup>	-0.26 <sup>NS</sup>	-0.48*	1									
<b>Ash</b>	-0.22 <sup>NS</sup>	0.13 <sup>NS</sup>	-0.05 <sup>NS</sup>	0.38 <sup>NS</sup>	1								
<b>ODM</b>	0.22 <sup>NS</sup>	-0.13 <sup>NS</sup>	0.05 <sup>NS</sup>	-0.38 <sup>NS</sup>	-1.00 <sup>***</sup>	1							
<b>CP</b>	-0.35 <sup>NS</sup>	-0.28 <sup>NS</sup>	-0.33 <sup>NS</sup>	0.57*	0.23 <sup>NS</sup>	-0.23 <sup>NS</sup>	1						
<b>CFI</b>	0.58*	0.189 <sup>NS</sup>	-0.76 <sup>***</sup>	0.19 <sup>NS</sup>	0.03 <sup>NS</sup>	-0.03 <sup>NS</sup>	0.002 <sup>NS</sup>	1					
<b>NDF</b>	0.51*	-0.27 <sup>NS</sup>	-0.43 <sup>NS</sup>	0.17 <sup>NS</sup>	-0.36 <sup>NS</sup>	0.36 <sup>NS</sup>	0.01 <sup>NS</sup>	0.57*	1				
<b>ADF</b>	0.44 <sup>NS</sup>	-0.15 <sup>NS</sup>	-0.37 <sup>NS</sup>	-0.2 <sup>NS</sup>	-0.23 <sup>NS</sup>	0.23 <sup>NS</sup>	-0.21 <sup>NS</sup>	0.53*	0.57*	1			
<b>IVDMD</b>	-0.19 <sup>NS</sup>	0.14 <sup>NS</sup>	0.79 <sup>***</sup>	-0.67 <sup>**</sup>	-0.23 <sup>NS</sup>	0.23 <sup>NS</sup>	-0.62 <sup>**</sup>	-0.67 <sup>**</sup>	-0.43 <sup>NS</sup>	-0.17 <sup>NS</sup>	1		
<b>EE</b>	0.026 <sup>NS</sup>	0.15 <sup>NS</sup>	0.75 <sup>***</sup>	-0.32 <sup>NS</sup>	-0.19 <sup>NS</sup>	0.19 <sup>NS</sup>	-0.36 <sup>NS</sup>	-0.71 <sup>***</sup>	-0.33 <sup>NS</sup>	-0.19 <sup>NS</sup>	0.81 <sup>***</sup>	1	
<b>NFE</b>	-0.49*	-0.26 <sup>NS</sup>	0.36 <sup>NS</sup>	-0.25 <sup>NS</sup>	0.03 <sup>NS</sup>	-0.03 <sup>NS</sup>	-0.27 <sup>NS</sup>	-0.36 <sup>NS</sup>	-0.27 <sup>NS</sup>	-0.23 <sup>NS</sup>	0.33 <sup>NS</sup>	0.37 <sup>NS</sup>	1

- = Negative correlation; \* = Significant correlation, \*\* = highly significant correlation, \*\*\* = Very highly significant correlation, NS = non-significant correlation

APPENDIX FIGURES



Appendix figure 1. Elephant grasses



Appendix figure 2. Desho grasses



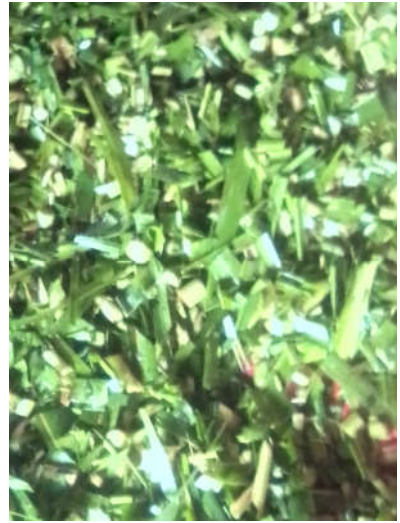
Appendix figure 3. Wilted elephant grasses



Appendix figure 4. Chopped elephant grasses



Appendix figure 5. Wilted desho grasses



Appendix figure 6. Chopped desho grasses



Appendix figure 7. Ensiled desho grasses



Appendix figure 8. Grasses weighed for packing



Appendix figure 9. Packed grass silages



Appendix figure 10. The researcher grinded  
Samples of silage in Wiley mill



Appendix figure 11. Samples of silages in  
Oven -dry Machine



Appendix figure 12. Oven dried samples  
were ground and prepared before analysis  
begun



Appendix figure 13. Soxhlet apparatus  
when extraction of crude fat



Appendix figure 14. Acid Detergent  
Fiber after dried out in oven cooled in  
Desiccator