ASSESSMENT OF MORPHOLOGICAL CHARACTERISTICS, DRY MATTER YIELD AND EFFECT OF HARVESTING STAGE AND ADDITIVES ON FERMENTATION CHARACTERISTICS AND NUTRITIONAL VALUE OF SILAGES FROM ANDROPOGON GAYANUS AND DESHO (PENNISETUM PEDICELLATUM) GRASSES

MSc THESIS

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COLLEGE OF AGRICULTURE

HAWASSA, ETHIOPIA
JANUARY, 2021

Assessment of morphological characteristics, dry matter yield and effect of harvesting stage and additives on fermentation characteristics and nutritional value of silages from *Andropogon gayanus* and Desho (*Pennisetum pedicellatum)* grasses

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A Thesis Submitted to the School of Animal and Range Sciences, Hawassa University College of Agriculture, School of Graduate Students, Hawassa University

In partial Fulfillment of the Requirements for the Degree of the Master of Animal and Range Science (Specialization: Animal Nutrition)

Hawassa University, Hawassa, Ethiopia

January, 2021

APPROVAL SHEET-I

This is to certify that the thesis entitled "**Assessment of morphological characteristics, dry matter yield and effect of harvesting stage and additives on fermentation characteristics and nutritional value of silages from *Andropogon gayanus* and Desho (*Pennisetum pedicellatum)* grasses**", submitted in partial fulfillment of the requirements for the degree of Master's with specialization in Animal Nutrition, to the Graduate Program of the School of Animal and Range Sciences, Hawassa University College of Agriculture, has been carried out by **Alayu Tarekegn**, under our supervision. Therefore, we recommend that the student has fulfilled the requirements and hence hereby can submit the thesis to the school.

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Merga Bayssa (PhD) ________________ ______________

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APPROVAL SHEET- II

We, the undersigned, members of the Board of Examiners of the final open defense by **Alayu Tarekegn** have read and evaluated her thesis entitled **"Assessment of morphological characteristics, dry matter yield and effect of harvesting stage and additives on fermentation characteristics and nutritional value of silages from *Andropogon gayanus* and Desho (*Pennisetum pedicellatum)* grasses",** and examined the candidate. This is therefore to certify that the thesis has been accepted in partial fulfillment of the requirements for the degree of Master of Science.

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CERTIFICATION OF THE FINAL THESIS

I hereby certify that all the corrections and recommendation suggested by the Board of Examiners are incorporated into the final Thesis entitled **Assessment of morphological characteristics, dry matter yield and effect of harvesting stage and additives on fermentation characteristics and nutritional value of silages from *Andropogon gayanus* and Desho (*Pennisetum pedicellatum*) grasses**

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ACKNOWLEDGEMENT

First of all, I would like to praise the Almighty **God** for keeping me healthy and strong enough to successfully undertake both the course and field research work as well as for enabling to write this manuscript. Next, it is my pleasure to express my heartfelt appreciation and special gratitude to my major advisor Prof. Ajebu Nurfeta for his continued technical guidance, encouragement and unreserved support from the beginning of thesis proposal writing up to completion of this thesis with truthfully fatherhood relationship. You provided me with an outstanding role model for what it means to be a researcher. I am profoundly thankful for all you did for me while I was under your supervision and guidance and for your continued friendship. I am also grateful to Dr. Merga Bayssa my co-advisor he gave unlimited willingness, technical support, and professional skill to this work.

My appreciation also goes to Ethiopian Institute of Agricultural Research for giving me the study opportunity and financial support. I also express my thanks to Assosa Agricultural Research Center staff members and individuals who had helped me during implementation of the experiment, laboratory works and data collection. My gratitude also goes to Debre Brihan Agricultural Research Center support me to do our laboratory work.

My gratefulness goes to my father Tarekegn Beyene and my mother Aberash Kebede who had shared their resources on my education which made me for this where I am today. Finally, my deepest grateful thanks also goes to my best friend Lijalem Abeble for his technical and moral support during my graduate studies. I am also grateful to all my brothers and sisters for their moral support and encouragement.

DEDICATION

I dedicated this thesis document to my mother Aberash Kebede for her nurturing me with care and love and for her dedicated partnership in the success of my life. My mother is a woman like no other. There are no enough words I can say to describe just how important my mother was to me.

STATEMENT OF THE AUTHOR

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

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ABBREVIATIONS (ACRONYMS)

FAO	Food and Agricultural Organization of the UN
ANOVA	Analysis of Variance
CSA	Central Statistics Agency
VFAs	Volatile Fatty Acids
TDN	Total Digestible Nutrients
WSC	Water Soluble Carbohydrate
DM	Dry matter
EIAR	Ethiopian Institute of Agricultural Research
CP	Crude Protein
ME	Metabolizable Energy
SCFA	Short Chain Fatty Acid
OM	Organic Matter
OMD	Organic Matter Digestibility
ADF	Acid Detergent Fiber
NDF	Neutral Detergent Fiber
NDL	Neutral Detergent Lignin
IVDMD	*Invitro* Dry Matter Digestibility
AOAC	Association of Official Analytical Chemists
CH_4	Methane
RPI	Relative Palatability index

Assessment of morphological characteristics, dry matter yield and effect of harvesting stage and additives on fermentation characteristics and nutritional value of silages from *Andropogon gayanus* and Desho (*Pennisetum pedicellatum)* grasses

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ABSTRACT

The objectives of the study was to assess the effect of harvesting stage/height on morphological characteristics and dry matter yield of grasses and determine the effect of harvesting stage/height and additives on silage quality, preference, feed intake and digestibility of silages made from Andropogon gayanus (A.gayanus) and P.pedicellatum (desho) grasses. Two separate experiments were carried out using A.gayanus and desho (Kulumsa ecotype). The experimental plot (402.5 m^2) was prepared for each grass and divided into six blocks (11.5 x 5 m^2) and three plots (3.5 x 5 m^2) with a total of 18 plots for each grass for morphological evaluation, laboratory silage making and chemical analysis. Six random plots from the 18 plots (one replicate in each block) were used for morphological data collection and silage preparation at each harvesting stage/height with 3 x 4 factorial arrangement for each grass (3 harvesting stage/height), 4 additive type (without, T1, 4% molasses, T2, 0.6% urea, T3 and 0.6% urea + 4% molasses, T4) and 3 replications). For *morphological data collection and laboratory silage making the grasses were harvested at vegetative, boot and full bloom for A. gayanus and a height of 70,90 and 110 cm for desho grass For preference test and digestibility experiment an additional area of 450 m^2 (12 m x 36 m) was prepared in a similar manner to harvest A.gayanus at boot stage and desho grass at 90 cm height. The grasses were ensiled in triplicates for each treatment. The number of leaves per plant, NTPP (number of tiller per plant) and leaf length per plant were the highest ($p<0.05$) at boot stage for A.gayanus and the highest ($P<0.05$) leaf to stem ratio was recorded during vegetative stage. Dry matter yield (DMY) increased ($P<0.05$) with increasing grass maturity/height for both grasses. Desho grass harvested at 70 cm resulted in the lowest ($P<0.05$) NTPP A.gayanus silages score for smell, color and moldiness decreased ($P<0.05$) with increasing ($P<0.05$) stage of harvest. Better ($P<0.05$) score for smell and texture was recorded for silage produced for T2 and T4 for desho grass. The highest ($P<0.05$) pH was observed at full bloom while the lowest ($P<0.05$) was at boot stage of A.gayanus. The neutral detergent fiber (NDF) content of A.gayanus silage for T1 was greater ($P<0.05$) than that of T3 and T4 while the highest ($P<0.05$) acid detergent fiber (ADF) content was for T1 and T4. A.gayanus silage in T1 was lower ($P<0.05$) in crude protein (CP) content compared with the other treatments. The CP content of desho grass harvested at 90 cm and for T2 and T4 was the highest ($P<0.05$). The highest ($P<0.05$) DM* *intake and relative palatability index was for T2 followed by T4 while the lowest ($P<0.05$) was for T1 and T3 during preference study for A.gayanus silage. In Desho grass silage, the highest ($P<0.05$) DM intake was for T2 while T3 resulted in the lowest DM intake. In A.gayanus silages, goats in T2 and T3 digested more ($P<0.05$) dry matter (DM), organic matter (OM) and CP compared with the other treatments while the least ($P<0.05$) was for T1.The digestibility DM and OM of desho silage for T2 was greater ($P<0.05$) than T1 and T4. The highest ($P<0.05$) digestibility of CP in desho grass silage was for T3 and T4. For desho grass silage the lowest ($P<0.05$) digestibility of NDF and ADF was for T1. In conclusion, A.gayanus and desho grass could be harvested at boot stage and 90 cm, respectively, for achieving optimum DMY. Ensiling A.gayanus with 4% molasses and desho with 4% molasses plus 0.6% urea are recommended to produce good quality silage.*

Key words: *A.gayanus*, Arab goats, Desho grass, Harvesting Height, Harvesting stage, Preference, silage,

1. INTRODUCTION

1.1. Background and Justification

Feed scarcity in terms of quantity and quality has remained to be the main limiting factor hampering productivity of the Ethiopian livestock sector. Feed shortage is more aggravated during dry season in both highlands and lowlands of Ethiopia (Alemayehu, 2006). The major feed related problems in Ethiopia that are hindering the livestock productivity include seasonal variation in availability of green feeds, poor nutritional quality of feeds, unavailability and unaffordability of concentrate feeds and less adoption of forage conservation techniques like hay and silage making (Alemayehu *et al*., 2017).

In Benishangul Gumuz regional state livestock herders depend on green fodder/ grazing (86.9%), crop residues (9.5%), improved feed (0.4%), hay (1.5%), by- products (0.5%), and others (1.3%) as feed resource (Yilma *et al.,* 2013). In Benishangul Gumuz during wet season of the year green forage are plenty, but serious feed shortage occur in dry season (Alemayehu *et al.*, 2017).

In Benishangul gumuz conservation techniques like hay and silage making is less adopted. Study shows that the contribution of natural pastures to livestock feeding as conserved hay is limited to 2.8% (CSA, 2011). In the region feed shortage is mainly caused by lack of feed conservation practices (Altaye *et al*., 2014). The native pasture deteriorate rapidly especially in the dry season. In addition to this critical feed shortage occurs from December to April when the communities practice burning of pasture lands and bushes in the region (AsARC, 2006).

In the recent time governmental and non-governmental bodies introduced different improved forage species in the region. These forage species have tremendous potential to alleviate the problem of feed shortage if properly developed and used in the farming system. Accordingly, the overall average productivity of the improved fodder crops per unit area has been found to exceed the productivities of seasonally rested and continuously grazed natural pastures by about 3 fold and 10 fold, respectively (Fekede *et al*., 2015). In addition to their productivity, most of the improved forage crops are also nutritionally superior to that of natural pasture and crop residues. They also have a long growing season and help to extend the green feed period and could provide useful nutrients mainly in the rural areas where availability and accessibility of agro industrial by products are limited.

From introduced improved grass *Andropogon gayanus (A.gayanus)* and Desho grasses ((*Pennisetum pedicellatum (P.pedicellatum))* are widely adapted and productive grass species. But due to long rainfall (May- December) in the region hay making is not practiced in the area. One management approach to avoid this problem is ensiling the surplus forage during the rainy season.

The first and most important condition to prepare quality silage is maturity of grass at harvesting stage. Buxton (1996) and Kidane (1993) reported that forage maturity stage at harvest is identified as the most important factor affecting the composition and nutritive value of pastures especially tropical grasses and legumes. Harvest of grass for silage at an early stage of maturity is expected to result in silage with a high concentration of energy and CP and may be a prerequisite for high energy intake and production (Randby *et al*., 2012).The aging of forage is frequently associated with a decrease in leafiness and an increase in stem to leaf ratio (Van Soest, 1982). The stage of maturity of the plant can also influence digestive efficiency and therefore, enteric CH_4 emissions (Ribeiro *et al.*, 2014).With advancing plant maturity, soluble carbohydrates decrease and lignification of plant cell walls increases

(Robertson and Waghorn, 2002). Therfore, assesment of the optimum stage of maturity for silage making is important.

In addition to harvesting stage to prepare quality silage low DM (dry matter) and water soluble carbohydrate (WSC) content of grasses results in poor fermentation of freshly cut material (Thiago *et al*., 2017). To increase the silage quality and nutritive value additives are important. Additive like fermentation stimulants carbohydrate sources (e.g. molasses, cereals, beet and citrus pulps) serve as an energy source for the lactic acid bacteria. Molasses is one of the most widely used additive to provide fast fermentable carbohydrate for the ensilage of tropical herbages. Chemical treatment, such as urea treatment, is also considered effective to improve the nutritive value and nutrient digestibility of feed. Urea is an interesting alternative nitrogen source to anhydrous ammonia in the treatment of lignocellulose feedstuff due to its low cost, easy handling and low danger in handling (Ahmed *et al*., 2013).

There is little information available concerning optimum harvesting stage of *A.gayanus* and *P. pedicellatum* for silage making using urea and molasses as additives to improve the silage quality and nutritive value.

1.2. Objectives

- To asses the effect of harvesting stage/height on morphological characterstics and dry matter yied of *A.gayanus* and *P. pedicellatum* grasses.
- To determine the effect of harvesting stage and additives on silage quality of *A.gayanus* and *P. pedicellatum* grasses.
- To determine preference, feed intake and digestibility of silages made from *A.gayanus* and *P. pedicellatum* grasses

2. LITRATURE REVIEW

2.1. Improved Forage

Nutritional factors are the binding constraint to sustaining livestock production in Ethiopia. During the latter part of the dry season, livestock feed is normally in short supply and is also of poor quality. Residues from cereals are the main source of forage but these are low in protein and have poor digestibility (Alemayehu *et al.*, 2016). In the rangelands poor nutrition is one of the most important factors that affect livestock production (Coppock and Reed, 1992). Moreover, according to Adugna (2008) most rangelands are degraded and thus do not fulfill the nutritional requirements of livestock. This is caused mainly by prolonged and extensive rangeland use, recurrent droughts, inefficient use of locally available feed resources, restricted livestock mobility, encroachment by invasive species, change in land use, weakening of customary institutions and lack of investment in rangeland improvement. Natural pastures would be adequate for live weight maintenance and weight gain during wet seasons, but would not support maintenance for the rest of the year (Zinash *et al*., 1995).

Improved forage species were introduced to farmers in different agro-ecologies of Ethiopia since 1970 to supplement the roughage feed resources (EARO, 2002). Various research institutions, universities, non-governmental organizations and ministry of Agriculture have been involved in introduction and popularization of these technologies. Improved forage species including Elephant grass, Oats, Rhodes grass, Pigeon pea, Sesbania and other were introduced and adapted to the region by Assosa Agricultural Research Center for the last decade. In recent time also to combat the livestock feed shortage, the use of improved indigenous forage plants as a feed source is recommended. Among those grass *A. gayanus* grass and Desho grass are the most productive and adaptive grass were introduce in the region.

However, diffusion of these technologies among smallholder farmers seems below the expectation. Producing and utilizing improved forage crops can be more easily accessible with relatively low price compared to concentrates. The cultivation of high quality forages with a high yielding ability, adaptable to biotic and abiotic environmental stresses is one of the possible options to increase livestock production under smallholder farmers conditions (Tessema, 1999).

2.2. Morphological characteristics and leaf to stem ratio of improved grasses

2.2.1. *Andropogon gayanus*

A.gayanus pasture height increased quadratically with increasing proportion of and the proportion of leaves linearly decreasing with increasing grass maturity (Ribeiro *et al*., 2014). Plant height increased as harvesting stage increases. Study on such type of grass the plant height and number of tiller growth were consistent with plant maturity until the optimum stage. Malede (2006) also found that, leaf length of grass was highly affected by the different stages of plant growth; when the growth stages of plant advanced the leaf length was raised.

As the stages of growth of *A. gayanus* grass increased, LSR become reduced, this indicated that, there was an inverse relationship between the growths of plant to leaf to stem ratio. This could be due to the reason that old leaves fall down when a plant gets older and older, thereby reducing the number of leaves.

2.2.2. *Pennisetum pedicellatum* (Desho grass)

Study by Asmare (2016) desho grass shows high number of leaves per plant at later stages of harvesting. Generally, the longer the vegetative phase and the taller the plant, the greater the number of leaves produced (Hunter 1980); a situation reflected in a study as the number of leaves from new tillers generally increased with increase in age at harvesting. Another study by (Birmaduma *et al*., 2019) also shows as the plant height increases both number of tillers per plant and number of leaves per plant also increases. Plant height must be taken into consideration when determining the optimum harvest maturity. When plant height increases the forage quality and relative feed value decreases at all maturity stages. Note that the relative feed value decrease 71 units at late vegetative, 61 units at late bud, and 53 units at late flower when forage increases from 20 to 40 inches in height. Therefore, the taller the plant the earlier in plant maturity at harvest must be taken in order to get prime quality forage. But the leaf length reduces when the plant height increases (Tilahun *et al*., 2017). Research result also further indicates both number of tillers and number of leaves per plant very high positive correlation coefficients and leaf length negatively correlated with plant height (Tilahun *et al*., 2017). Asmare *et al*. (2016) who reported that the mean value of Desho grass plant height (39.4 cm) under irrigation at Northern Ethiopia.

Since leaf length is strongly influenced by micro-environment, i.e., the status of the leaf in the plant including interactions with other organs, this micro-environment should be taken into account during the estimation of genetic values.

The behavior of desho grass were produced more leaf (prolific tiller) and lie horizontal than erect. The increasing tendency in number of leaves per plant with advanced in stage of harvesting indicated that, time of harvesting had high influence on number of leaves per grass. This might be due to the extended growth; there was increment in plant height, number of tillers, and the larger number of nodes that produce comparable number of leaves (Tilahun *et al*., 2017).

2.3. Dry matter yield, chemical composition and management

2.3.1. *Andropogon gayanus*

A.gayanus is an important tropical grass due to its high biomass production and its ability to tolerate long dry seasons and low fertility, acidic soils (Ribeiro *et al*., 2014). It is tolerant of pests, and has high adaptation to arid conditions, high palatability and great potential for producing dry matter in sandy, acidic and infertile soils (Nascimento and Renvoize, 2001). It is one of the most widely adapted grasses to the tropical savannah (CIAT, 1990). *A.gayanus* is one of the grasses native to tropics and it is drought resistant, tufted and leafy perennial grass. Study shows 1.77 ton DM yield/ha at 56 day of regrowth and 10.52 ton DM yield/ha at 112 day of regrowth (Ribeiro *et al*., 2014). It is quite palatable with 6-12% protein (Alemayehu *et al*., 2016). NDF and ADF contents of *A.gayanus* were high (716 g/kg DM and 417g/kg DM) respectively (Phengvichith & Ledin,2007).

2.3.2. Desho grass

The grass is native to tropical and sub-tropical Africa and tropical Asia (FAO, 2010). It serves for land rehabilitation and as fodder for livestock in the tropics (EPPO, 2014). It is currently utilized for soil conservation practices and livestock fodder in the highlands of Ethiopia (Leta *et al.*, 2013). Desho grass is suitable for intensive management and performs well at elevations of 1500-2800 masl (Leta *et al*., 2013). Desho grass is perennial grass collected from Chencha district in Southern Ethiopia (Welle *et al*., 2006). It grows in naturally spreading across the escarpment of the Ethiopian highlands and used for multiple purposes (Smith, 2010).

Desho grass is used as a year-round livestock fodder. It is a very palatable species to cattle and sheep (Ecocrop, 2010). To maintain the sustainability of the intervention, the plot is permanently made inaccessible to free grazing livestock; instead, a cut-and-carry system is encouraged (Danano, 2007). Due to its rapid growth rate, Desho grass provides regular harvests, even reaching monthly cuts during the rainy reason. Once a year, just before the dry season, sufficient grass is harvested and stored as hay and can prepared as silage to feed the livestock until the rains return (Danano, 2007). Desho grass is used as fodder and considered to be a very palatable species to cattle (FAO, 2010).

Desho grass can attain the first harvest between 4-5 months after planting. At 4-5 months after planting; the grass reaches height of 50-60 cm. But other report also showed that the height of desho grass ranges 90-120cm depending on the type and fertility of the soil (Leta *et al.,* 2013 and Shiferaw *et al.,* 2011). In CASCAPE Hawassa cluster, under on farm management, 7-9 t/ha DM yield was obtained at 10*50 cm plant spacing (between plant and row respectively) and 50cm harvesting height (Bereket, 2016). And also other study shows the grass provides high green herbage yield ranging between 30 - 109 t/ha (Ecocrop, 2010).

Desho grass average chemical composition and digestibility, % DM of sun dried aerial parts of an ecotype from north western Ethiopia and other study is as follows in table (1). The crude protein content of desho grass 9.6% on DM basis at early stage and 1.6% at straw stage (Asmare *et al*., 2016). The content of minerals in desho grass was affected by both location and stage of maturity and research indicated that almost all of the minerals were within the range of required levels of livestock (Asmare *et al*., 2018).

Table 1. Chemical composition (% of DM)of Desho grass

Constituents	(Asmare *et al*., 2017) Desho grass hay	Genet *et al*., (2017) Desho at 105 day of harvest	Genet *et al*., (2017). Desho at 135 days of harvest
Dry matter (%)	93.50	88.40	89.00
CP	5.40	10.20	9.30
Ash	12.10	7.89	7.00
NDF	67.30	46.20	51.70
ADF	38.10	37.60	42.60
ADL	3.60	18.30	20.70
IVOMD%	58.00	-	-

2.4. Forage Conservation

Adugna (2008) who stated that feed conservation is not common in most parts of Ethiopia. Natural pasture hay was the dominant feed conserved followed by crop residues. Oats/vetch mixture hay was also reported to be conserved by some dairy farmers. Especially in Benishangul Gumuz even though, the availability of natural pasture is good at rainy season of the year in the area, there is no (100%) tradition of conservation practices (hay and silage making). Study by Wondatir (2015) reported as the production of improved and cultivated forage crops are not a common practice in the Nile Basin. The same is true in the case of proper management of crop residue which is not under practice for its abundant availability during the crop harvesting season. This is in agreement with Yisehak *et al*. (2013) in which he indicated as there is no conservation practice in Jimma zone of his target study districts. Different reasons were suggested by the respondents for not practicing forge crop cultivation and conservation among which lack of knowledge or information on the use of improved forage, land shortage and its less importance were reported respectively. In addition to this majority of agro pastoral communities have no trends of growing improved forage species. This is due to shortages of land, lack of knowledge, lack of forage seeds, cuttings and splitting. Mekoya *et al*. (2008) reported that improved forage species are not well developed under the present Ethiopian conditions. Moreover, the contribution of improved forage crops to livestock supply in Ethiopia less than one percent which calls for further efforts from governments, research institutes and non-governmental organization in promotions of developing improved forage species through filling awareness gap and input provisions (CSA, 2015).

To avoid the loss of nutrients from green fodder at the time of abundant availability, and/or to maintain the nutrient supply during scarcity periods, fodder conservation can be useful. In humid areas, roadside/forest grasses may be preserved as silage. Fodders and grasses can be preserved as hay (dried fodder) or as silage (wet fodder), depending on the weather conditions and the available resources. Providing quality forage for animals in the dry season is one of the biggest problems in animal production in Ethiopia. The most important reason why fodder should be conserved is to provide high quality fodder to the animals during the dry season, and bridge the gap between the feed requirement of the animals and the production of the fodder (Alemayehu, 2002).

In Benishangul Gumuz, inefficient utilization of natural pastures and improved forage in the study areas should be improved by feed conservation techniques like hay and silage making practices. To make hay the recommended is the early flowering stage. Strategies to improve the quality of hay produced, is by cutting at 10% flowering stage, rapid removal of moisture from cut herbage (Irenie, 2012). Cutting when the grass is very young gives high quality but the dry matter yield is low. In hay making even under good conditions, losses are inevitable. Generally under good conditions, losses would range; 15-18% of DM, 22-25% Net energy and 30-33% of digestible products (Enoh *et al*., 2005). Poor hay making practices can worsen the situation. In general, there would be losses during drying (mechanical), due to rain and during storage.

A.gayanus and desho grass production and utilization are a relatively new experience. In the lowland area very little has been done in collection and conservation of indigenous improved forage species which have invaluable importance in the livelihood of the farmers. Hence, introduction of high yielding and nutritious indigenous forage species like desho grass is the foremost issue to minimize feed shortage both in quality and quantity especially during dry season (Worku *et al*., 2017).

2.4.1. Silage Making

Hay making is feasible for smallholder livestock keepers, while silage making and treatment with urea are most feasible in medium and large scale animal enterprises (Bayer and Wanyam, 2007). At more advanced maturity, DM yield is higher and DM content (30 to 35% DM) of the pasture can be more favorable for silage production, but the high cell wall and lignin content can limit intake and nutritional value of the forage (Van Soest, 1994). Silage can be used both as maintenance and a production ration.

The ensiling process show advantages such as conservation of large quantities of forage in short time and forage conservation is less weather dependent. However, a disadvantage of the ensiling process is the relative reduction of feeding value of the silage when compared to the original crop (Charmley 2001). In the tropical humid region, high humidity in the atmosphere and more rains in the production period limit the time of making hay and ensiling is considered to be the most promising preservation technique. The mechanism of ensiling involves the conversion of WSC by epiphytic and/or inoculated LAB into lactic acid (LA) under anaerobic conditions (Cai, 1999). The increased in LA content resulted in a reduction of pH value of the silage and a subsequent restriction in the growth pace of undesirable microbes which are deleterious to the fermentation process (Mohd 2012). It is known well, a predominant aspect of grass-based materials application is how to preserve the original nutrients and ensure sustainable supply (Li *et al*., 2015). An important objective in ensiling forage is to reduce extensive proteolysis, which increases the nutritional losses and leads to affect the quality of silage regarding protein quality and the intake (Saarisalo, 2017).

Ensiling tropical grasses has gained importance due to the high productivity of these forages, which favors the reduction of the cost of feeding ruminants. Grasses ensiling result generally in higher pH and lower values of lactic acid. Resistance to change in pH or buffer capacity is one of the main obstacles to the quality of silage. The rapid lowering of the pH is effective in reducing the activity of deleterious microorganisms to nutrient forage ensiled. Although the buffering substance content may hamper acidification of the silo environment. Rong *et al*. (2013) observed pH values of 4.1 in Napier grass (*Pennisetum purpureum Schum*) silage; still, high butyric (12.1 g/kg DM) and acetic acid concentrations (12.7 g/kg DM) and ammonia content (100 g/kg). Butyric acids can negatively influence the silage intake in ruminant animals (Charmley 2001).

2.5. Grasses silage

The grasses silages have some interesting advantages, such as a high annual productivity per area, perennially, a low risk of loss, and greater harvest flexibility (Gonçalves *et al*., 2004). However, when compared with corn or sorghum silages, the grass silages also have unfavorable aspects, such as a low content of soluble carbohydrates necessary for proper fermentation, low DM content at the time of cutting, high buffering capacity and lower energy content (Keady *et al*., 2008).

Detailed evaluations have indicated that a kilogram of total digestible nutrients (TDN) from grass silage is more expensive than TDN from corn silage (Pereira et al., 2007). Thus, tropical grasses are only an attractive option if they are highly productive. Assuming that the potential for biomass production must be achieved, the use of nitrogen can be a viable alternative for enhancing the production of DM.

2.6. Factors affecting silage quality

2.6.1. Harvesting stage

Harvest of grasses for silage production should occur in the vegetative stage when the plant is at a balance between appropriate DM yield and nutritional quality (Ribeiro *et al*., 2014). Maturity is considered to be the primary factor affecting the chemical composition and nutritional quality of most forage (Nelson and Moser, 1994). An increase in DM content with increasing maturity was expected. According to Demarquilly and Dulphy (1977) the optimal DM content for ensiling of forage is 270 to 380g/kg in order to avoid seepage losses and the growth of spoilage microorganisms. The best time to harvesting stage, there is a high DM yield and the quality of the crop is still relatively high. The sugar content is also relatively high and this encourages lactic acid formation. It is well known that vegetative pastures have higher nutritional quality than mature pastures, but they also have lower DM yield and high moisture content. These properties can make ensiling challenging as they can lead to secondary fermentation, production of silage effluents and spoilage of the silage (McDonald *et al*., 1991). Tropical grasses are characterized by low nutritive value due to the higher lignin content and less degradable materials in their cell wall due to rapid rate of achieving maturity (Minson, 1980). At advanced maturity, forages are characterized by high levels of cell wall fiber of NDF, ADF, lignin, and low nitrogen which resulted in low animal performance (Van Soest, 1982).

Harvesting too early is associated with high quality, crude protein, digestibility and other nutrients, DM yield, however, is very low. On the other hand very late harvesting is associated with low (poor) quality of the forage material. There is also low sugar content since most sugar is converted to starch which gives poor quality silage (Li *et al* 2010). The high temperature in tropical countries changes the nutritive values of the grass component rapidly during the late growth stages of the grassland and harvesting management is predominantly responsible for these changes (McDonald *et al*., 2002). Changes of quality during the growing period of grasses are particularly high under tropical climatic conditions due to the physiological, biochemical and anatomical adaptation of the tropical grasses to utilize high temperature and high solar radiation regime prevailing in the tropics (Nelson and Moser, 1994).

Desho grass harvested at young age had excellent nutritional value, particularly high CP concentration, a limiting nutrient in tropical forages. As would be expected, the highest CP concentration was obtained at the earliest stage of harvesting; with values declining as harvesting was delayed. Bayble *et al*. (2007) and Ansah *et al*. (2010) reported for Napier grass a decreasing trend of CP with increase in harvesting age (60>90>120 days). This phenomenon is referred to as a growth dilution effect with increase in structural carbohydrate content of forage materials harvested at late maturity reducing the percentage of protein in the forage

As would be expected, neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) concentrations all increased significantly as harvesting time was delayed. While increase in stem percentage and increased lignification with maturity would account for the age effects. In desho grass the increasing trend of NDF concentration with increase in harvesting age were NDF concentration increased from 72.8% at 90 days to 77.7% at 150 days of age (Asmare 2016).

2.6.2. Fermentation quality

Most of the tropical forage crops have high dry matter yields potential; they are characterized with rapid deterioration of protein, lower sugar contents and high buffering capacity (Yahaya *et al*., 1999). Furthermore the population of the indigenous epiphytic microorganism particularly LAB essential for good fermentation is affected by higher tropical weather condition. According to Gourley and Lusk (1978), 60 to 80 g/kg DM of soluble carbohydrates are required for efficient ensiling and the formation of good quality forage. The soluble carbohydrate content is critical for the production of good quality silage because it is the main source of nutrients for the growth of microorganisms that produce lactic acid. McDonald *et al*. (1991) suggested that the potential of a plant for silage depends on the content of WSC, with desired levels above 8% in DM. However, it is well known that tropical grasses have a low content of soluble carbohydrates. The target WSC (plant sugar) level for the successful preservation of forages is >2.5% in the fresh forage. Additives containing sugars will improve the fermentation in forages with WSC levels of <2.5% in the fresh crop (e.g. low DM forages such as legumes, nitrogen fertilized grasses, kikuyu grass and other tropical grasses) (Pettersson & Lindgren 2006). The result is increased lactic acid production, lower ammonia-N content and lower silage pH. The risk of the fermentation being dominated by undesirable bacteria is reduced and DM losses during storage are also reduced

2.7. Management strategies to reduce deterioration of silage

2.7.1. Silage additives

The purpose of silage additives is to control the preservation process so that by the time of feeding it has retained as many of the nutrients present in the original fresh forage as possible and to ensure that the growth of lactic bacteria predominates during the fermentation process, producing lactic acid in quantities high enough to ensure a good silage (Oliveira 1995). The additives decreased cell wall contents (NDF, ADF and ADL) which could be due to their low cell wall contents and improved silage fermentation resulted from higher sugar contents (Baytok et al., 2005). It is widely accepted that silage additives can increase animal intake and animal performance through their effect on silage quality (Merry, 1993). It is important to remember that silage additives will not make poor quality forage into good silage but they can help make top quality forage into excellent quality silage (Kenilworth, 2012). Many different silage additives are available and are used for different reasons. It includes fermentation stimulants, fermentation inhibitors, aerobic deterioration inhibitors, nutrients and absorbents (McDonald, 1991). Their main functions are to either increase nutritional value of silage or improve fermentation so that storage losses are reduced. Lactate-utilizing yeasts are the primary microorganisms responsible for initiating aerobic deterioration in most silage (Pahlow *et al*., 2003).

2.7.1.1. Molasses

Some green forage such as legumes and certain grasses have rather low sugar contents. Adding molasses as sugar source improve acid production and thus improve quality and preservation. In addition to the direct feeding, i.e. by mixing it into the basic fodder or into commercial feeds, molasses has special importance as a safety additive in the preparation of fermented feeds, the so called silage. Sugar-containing food supplements increase the concentration of fermentable carbohydrates and provide the indispensable nutrients to the lactic acid bacteria, so that they grow rapidly and produce adequate amounts of lactic acid. The occurrence of acetic and above all butyric, acid infection can be prevented as well as undesirable decomposition of protein. In addition to the advantageous fermentation, a favorable ratio of protein and starch units is also achieved.

For use as silage additives the molasses must be as uniformly distributed as possible over the green fodder. The material to be soured is sprinkled in layers during filling of the silo with the molasses, which should be diluted as little as possible. Molasses is the most common sugar additive and has been used for many years. Molasses contains 20.6% water, 60.8% total sugar, 3.2% CP, 2.2% soluble gums, 8.2% ash and 5.0% free acids (Sindhu *et al*., 2002). Tjandraatmadja *et al*., (1994) tested the effects of 4% and 8% molasses added at the ensilage of *Panicum maximum cv. Hamil*, pangola grass (Digitaria decumbens) and Setaria (*Setaria sphacelata cv. Kazungula*) harvested at 4, 8 and 12 weeks of growth. The results from a laboratory trial with 500-g vacuum-sealed silo bags kept in a dark, temperature controlled room led to the conclusion that 4% (w/w) molasses should be sufficient to achieve effective preservation. Typical application rates for molasses are 20-40 kg/ton fresh crop, although experience indicates that 50-60 kg/tone may be more appropriate for forages such as kikuyu grass that have a very low WSC application rates can be varied to match the crop's expected WSC content (Wilkinson, 1990). About 11.6 liters molasses per ton fresh crop is required to raise the WSC content in the crop by 1% unit (Wilkinson, 1990). Addition of molasses improved silage fermentation (as indicated by lower pH and ammonia-N levels, and higher lactic acid), resulting in increased intake and animal production.

Recently, Keady (1996) reviewed the published literature on molasses as silage additives and concluded that molasses treatment improved silage preservation, but did not significantly alter the silage digestibility or animal performance although silage DM intake was improved. Sugarcane molasses added at the rate of 3% (w/w, fresh basis) to Napier grass (12.9% DM, 6.6% WSC) produced silages of reasonably good fermentation quality (Smerjai *et al*., 2012)**.**

2.7.1.2. Urea

Urea when added to high DM, low buffering forages (maize or sorghum grain) increase crude protein content and are claimed to improve aerobic stability of silage at feed out (Yitbarek & Tamir 2013). The use of urea as a silage additive for elephant grass it was concluded that with low DM forage and in the absence of additives rich in WSC such type of product should not be recommended when aiming an improvement of fermentation (Yitbarek & Tamir 2013).

Generally, pH value, ammonia-N and acetic and butyric acid contents are increased. Singh *et al*. (1996) registered the highest pH values and ammonia-N levels associated to higher anaerobic proteolytic bacterial populations in Sorghum bicolor silages (34% DM) made with 0.5% urea. During ensiling period urea decomposes to ammonia by urease, therefore, decrease on pH level is delayed because of alkaline character of ammonia (Filya, 2000). For this reason, fermentation products increase because of continuing micro- organism activity such as acetic acid level but it doesn't affect butyric acid level. Bolsen *et al.* (1999) notified that addition of urea to silages causes increase in lactic, acetic and total organic acid levels, on the other hand, Hinds *et al*. (1992) indicated that addition of urea plus molasses to silages doesn't affect silage quality negatively, except causing an increase in pH level. The increase in acetic acid depends on either hetero fermentation or acetic acid production from lactic acid. Addition of molasses to silages suppress formation of butyric acid (Turemis *el al*., 1997) and it affects fermentation positively (Hinds *et al*., 1992), besides, addition of urea plus molasses to silages doesn't affect fermentative quality negatively (Hinds et al., 1992). Addition of urea and molasses to silages affects dry matter digestibility positively and molasses increases degradation (Bingol and Baytok, 2003). There is a positive relationship between decrease of pH level and silage quality (Deniz *et al*., 2001).

2.8. Preference and dry matter intake of silages

Ruminant animals have been shown to generally select for foods on the basis of their nutrient content (Burrit and Provenza, 1992) and to avoid feeds containing plant secondary compounds, e.g. tannins (Provenza and Malechek, 1984). Free choice intake and acceptability study is a quick assessment of physical quality of a feed. Coefficient of Preference (CoP) is a direct measure of acceptability and nutritional capability of feedstuff or forage. In recent times cafeteria techniques have been used to assess the acceptability of some forage (Babayemi *et al*., 2006). The feed intake or the palatability of forage is regulated by many factors: harvesting, physical and metabolic feedback and secondary metabolites. Preservation method may affect these factors, especially in reducing the secondary compounds or anti-nutritional substances.

This choice is assumed to be based on the association between sensory components of the feed (e.g. taste, smell, touch and sight and the post-ingestive consequences example positive and negative gastrointestinal feedback (Kyriazakis *et al*., 1997).

Grass silage is major forage used in ruminant feeding, but due to the impact of crop management and weather, strong variations of the nutritional value and fermentation quality can occur (McDonald et al., 1991). Huhtanen *et al*., (2002) showed that variation in fermentation quality affects voluntary feed intake of cattle. However, it is difficult to attribute changes in DM intake to a single fermentation product as some of them are strongly interrelated example ethanol and the ethyl esters of acetate and lactate (Weiß and Auerbach, 2012)). Mo *et al*., (2001) identified more than 50 different fermentation products in grass silages. Since a majority of them, especially esters, are known to be odorous, they all may have (to a greater or lesser extent), an effect on the smell and taste of feed and, consequently, feed intake. For un spoilt silages, attempts have been made to find a relationship between silage quality and intake (Huhtanen *et al*., 2003).

There are number of factors that may influence acceptability of a forage or feed by small ruminants: plant physical structure and chemical composition are the most important factors that influence preference (Van Soest, 1994). The 100% ensiled grass without cassava peels were rejected, this could be due to poor silage properties such as pungent smell which could repel the animals and moldy growth which could dwarf goats fed different proportions of Ficus poisonous (McDonald et al., 1985). It was observed that the inclusion of cassava peels enhanced the acceptability of the grass silage, because cassava peels has being regularly used to feed them. Acceptance of 4 week silage could be due to its low fiber content and it is less coarse. Grasses 100% ensiled without cassava peels that should serve as control was discarded because of its poor silage characteristics and rejection by the animals.

Correlation between silage DM and DM intake was strongly positive. In case of the low DM silages fed, the negative impact of DM on feed intake may also be a side effect of the components having developed during mal-fermentation. Some of the fermentation products, especially those indicating poor fermentation qualities, were consequently negatively correlated to DM intake. These were especially butyric acid, 1-butanol and 2-butanol and NH_3-N with correlation coefficients ranging between −0.50 and −0.59. The NH_3-N had limited intake either directly or indirectly due to correlation with some other end-products of silage proteolysis or amino acid degradation (Huhtanen *et al*., 2002) proposed that the NH_3-N concentration was not directly responsible for reduced intake, but a possible relationship between ammonia and other products.

Buchanan-Smith and Phillip (1986) concluded from their experiments that soluble constituents in silages can inhibit intake but no single component was primarily responsible. It seems that goats can detect subtle differences between silages and have also shown in other studies to prefer forages based on small changes in plant chemistry that are difficult to detect in chemical analyses (Burritt *et al*., 2005). In a meta-analysis on the relationship between silage characteristics and feed intake of dairy cows, Eisner *et al*. (2006) did not find any influence of NH_3-N on intake; instead the importance of protein quality was emphasized.

Protein degradation products like biogenic amines were suggested to limit silage intake (Buchanan-Smith and Phillip, 1986). As concentrations of NH_3-N and butyric acids represent good indicators for biogenic amines ($r=0.67$ and $r=0.80$, $P<0.05$; There might have been high concentrations of biogenic amines in the low-DM silages used in the preference trials, which may have negatively affected DM intake

The positive effect of acetic acid on DM intake contradicts Eisner *et al.* (2006) who concluded from a large meta-analysis that acetic acid had a strong negative impact on feed intake when offering silages and concentrates separately. This might be due to the fact that the level of acetic acid in the eight trials was generally lower than in studies where intake reductions took place. For example, silage DM intake was depressed at acetic acid concentrations of 54g/kg DM that were added to a basal silage containing 21g/kg DM (Krizsan *et al*., 2012), therefore exceeding our values three fold. Concentrations of 10–30g/kg DM that are typically found in well-fermented grass silages (Kung and Shaver, 2001) were not exceeded, consequently the negative impact on feed intake might only be relevant at higher levels.

2.9. Digestibility of grass silage with different additives

With advancing the maturity of grasses silage, their digestibility dramatically drops because the tensile strength of stems increases to support the weight of the plant, besides the LSR declines (Yang and Beauchemin. 2007). In grass silage, organic matter digestibility dropped from 79% in early growth to 73% in late growth, and NDF digestibility decreased from 73% in early growth to 66% when the plant maturity reached late growth stage (Thiago *et al*., 2017)

The addition of urea and urea plus molasses to silages decreased IVDMD compared to the control. This result can be attributed to increasing organic matter (soluble carbohydrates) losses in the urea and molasses groups. Additives did not affect digestible DM yield. The addition of 0.5% urea and 0.5% urea plus 4% molasses to sorghum silages, harvested at the milk stage, improved the CP content of silages, but had no positive effects on silage quality, IVDMD or digestible DM yield.

The use of molasses as a silage additive was associated with a significantly higher DM digestibility compared to the silage without additive. The digestibility of organic matter (OM), CP and NDF was similar for the silage without additive and the silages treated with fermented juice of epiphytic lactic acid bacteria or cassava meal. The intake of silage treated with molasses resulted in significantly higher digestibility of OM, CP and NDF compared to silage without additive and the silage treated with fermented juice of epiphytic lactic acid bacteria. The digestibility of ADF was not affected by treatment (Smerjai *et al*., 2012).

IVTDMD of Vines of four sweet potatoes were increased with increased level of additives, highest IVTDMD were found at the higher levels of additives and this may be attributed to improved fermentation and low cell wall contents of the additives (Gebreegziabher *et al*., 2015). In vitro DM digestibility in the order of; hay < silage without additive < fresh sorghum forage (Snyman and Joubert, 1995) and in vivo DM and organic matter digestibility by dairy cows in the order of; hay < silage < freeze dried Master Graze (Salamone *et al*., 2012) were reported.

3. MATERIALS AND METHODS

3.1. Description of the Study Area

The field trial, forage establishment, silage making, preference and digestibility experiment were conducted in 2019/2020 at Assosa agricultural research center which is located in Benishangul Gumuz Regional State, western Ethiopia. Assosa town is located at 670 km west of Addis Ababa, the capital city of the country. It is located at latitude of 10°30'N and 034°20'E longitude and at an altitude of 1565 meters above sea level. In the region the pattern of rainfall is uni-modal. Based on analysis of data from 1966-2017G.C the annual minimum rainfall is 340.9 mm in 1996 and maximum rainfall is 2417.5 mm in 2000 and the annual mean rainfall of 1146 mm was recorded. The minimum mean temperature varies between 16.8°C and 20.6°C and the maximum mean temperature ranges from 27°C to 35.1°C (NMA, 2017). The soil type in the experimental field is reddish brown nitisols having a pH of 5.3, total N content of 0.24%, P content of 15.4 ppm, organic matter content of 2.42% and cation exchange capacity (CEC) of 10.0 meq/100g soil.

Woodland and shrubs are dominant forest resources covering 77% of the region. Grasslands cover 3% of the total area of the region and the cultivated area occupies 5% of the region's area (AsARC, 2006). As in the other parts of the country, farming system of Benishangul Gumuz Regional State is dominated by mixed crop-livestock production system (WBISPP, 2003). In the region grazing is the dominant feeding system where communal grazing is normal and managed as a common property.

3.2. Field experiment layout and design

Two separate experiments were carried out using *A.gayanus* and *P.pedicellatum* (*Kulumsa* ecotype desho grass). Desho grass (*P.pedicellatum)* and *A.gayanus* were established in mid July 2019.

At the beginning of the experiment, the experimental area (402.5 m^2) was prepared for each grass and divided into six blocks (11.5 x 5 m^2) and three plots (3.5 x 5 m^2) with a total of 18 plots total for each grass for morphological, laboratory silage making and chemical analysis of the silage. Six random plots from the 18 plots (one replicate in each block) were used for morphological data collection and silage preparation at each harvesting stage/height. Each harvesting stage/heights were assigned to each plot randomly by using lottery method of randomization. Spacing between the blocks was 1 m and 0.5 m between the plots for both grasses (Genet *et al*., 2017). From each block randomly selected plots were harvested for each harvesting stage for *A.gayanus* (i.e. vegetative, boot and full bloom). The stages are identified as vegetative stage leaves, stem not elongated, no seed heads; boot stage of the grass means seed bearing stem elongated, top of stem swollen and at full bloom stage all seed heads emerged and peak pollen sheded (Guretzky *et al*., 2013). But due to desho grass phenology plant height is excellent indicator of DM yield and nutritional quality and is easily measured on-farm as a guideline for pasture management (Ribeiro *et al*., 2014). So to determine desho grass morphological data and harvesting was based on height of plant at 70, 90 and 110 cm (Birmaduma *et al*., 2019).

For preference test and digestibility experiment an additonal area of 450 m^2 (12 m x 36 m) was prepared in a similar manner to harvest *A.gayanus* at boot stage and desho grass at 90 cm of height.

3.3 Plot preparation and experimental materials

The land was ploughed and prepared using tractor. The layout was prepared as per the specification and each plot was leveled and ridged manually. The planting material (seed for *A. gayanus* and split for desho grass) were obtained from Assosa Agricultural Research Center. *A.gayanus* grass seed was broadcasted at 15 kg seed/ha on to the appropriate plots and lightly covered with soil to ensure adequate emergence. At sowing, 100 and 50 kg/ha DAP and urea, respectively, was broadcasted on to plots.

Desho grass were planted by using two vegetative root splits per hole on well prepared soil with spacing between plant and rows of 25 cm and 50 cm, respectively (Worku *et al*., 2017). Then the required amount of fertilizer was broadcasted at the rate of 100 DAP and 25 kg/ha at the time of establishment for each plot and 25 kg/ha urea 21 days after establishment (Leta *et al*. 2013). Weeding and related management practices were applied according to the recommended management practices (Leta *et al*. 2013).

3.4. Morphological parameters and yield determination

Before harvesting of the grasses for ensiling purpose field data on morphological parameters, leaf to stem ratio (LSR) and dry matter yield (DMY) data were collected for *A.gayanus* grass during vegetative, boot, and full bloom stage and for desho grass at 70, 90 and 110 cm height of harvesting from six randomly selected plots.

Desho grass harvesting stage was determined by measuring the height of the grass through continuous monitoring of each harvesting height. To determine the harvesting height, sample measurements were taken from different places of each plot and the average height were taken for harvesting. The plant height was determined by taking the height of five plants per plot from the ground level to the natural standing height. Data such as plant height (PH) and leaf length per plant (LLPP) were measured using measuring tape. The number of tillers per plant (NTPP) and number of leaves per plant (NLPP) were computed as mean of counts taken from five plants that was randomly selected from the middle leaving out the border of each plot for both grasses.

For the determination of DMY and LSR samples were taken from a quadrat of 0.5 m * 0.5 m for the three per plot. During sampling quadrate was randomly thrown in to randomly selected plot and three quadrats were harvested from each plot at each stage/height. Grasses were cut by hand using a sickle leaving a stubble height of 15 cm for *A.gayanus* (Odedire, 2008) and 10 cm for desho grass (Bereket, 2016). A fresh herbage yield of the grass were measured immediately after each harvest and weight was taken in the field soon after mowing using a field balance with a sensitivity of 0.01 g. The LSR were determined for each quadrat by separating 500g of sub-sample in to leaves and stems and then each component was dried and weighed using sensitive balance. The LSR was computed by dividing the leaf to stem estimated based on the dry matter basis of each component. The DMY was calculated after drying sample of 500 g green forage in an oven at 105^{0}C for 24 hours in Assosa agricultural research center laboratory and then expressed per hectare.

After yield and morphological parameter determination at each stage/height, for the silage experiment the required biomass was harvested from each plot and transported to Assosa Agricultural Research Center goat farm during a sunny day. Before ensiling thorough mixing of the chopped grasses harvested at each stage/height, representative sub-samples of 300 g were dried at 65^{0}C for 72 hours and milled through a 1mm screen (Willy mill) and stored in airtight plastic bags to be used for grass chemical analysis.

3.5. Silage Experiment

3.5.1. Treatment and design for laboratory silage

The laboratory experiment to assess silage quality were set in a 3 x 4 factorial arrangement for each grass (3 harvesting stage/height, 4 additve type and 3 replications). The three harvesting stages were vegetative, boot and full bloom stage for *A. gayanus* and the three harvesting height for desho grass were 70, 90, 110 cm. The silage additives for both grasses were without additives, with 0.6 % urea (fertilizer grade, 46% N), with 4 % molasses and both urea + molasses (Yunus *et al*., 2000) in a completely randomized design (Table 2). Plastic bag container which has a capacity of 10 kg was used in three replicates per treatment, making a total 36 plastic bag for each grass species.

Table 2. Treatments layout

Grass type	Stage of Harvesting	Additive type	
		Molasses	Urea
Andropogon gayanus	Vegetative	-	-
"	"	+	-
"	"	-	+
"	"	+	+
"	Boot stage	-	-
"	"	+	-
"	"	-	+
"	"	+	+
"	Full bloom	-	-
"	"	+	-
"	"	-	+
"	"	+	+
Desho grass height(cm)	70	-	-
"	"	+	-
"	"	-	+
"	"	+	+
"	90	-	-
"	"	+	-
"	"	-	+
"	"	+	+
"	110	-	-
"	"	+	-
"	"	-	+
"	"	+	+

without additive (-), with additive(+, 0.6% urea or 4% molasses) and both urea (0.6%) and molasses (4%) additive (+,+)

3.5.2. Apparent digestibility and preference treatment layout

For digestibility and preference determination of silage only boot and 90 cm harvesting stage was selected for *A.gayanus* and desho grass, respectively. Urea and molasses levels were similar with the laboratory experiment (Table 3). It has been shown that *A.gayanus* grass reach its optimum DM yield and nutrient content at boot stage (Ribeiro *et al*., 2014) and *P.pedicellatum* grass at 90cm harvesting height (Bereket *et al*., 2016).

Table 3. Preference and digestibility experimental feed

Silages with different additives types			
Stage/height	Molasses	Urea	Treatment
Boot stage *A.gayanus grass*	-	-	T1
silages	+	-	T2
	-	+	T3
	+	+	T4
90 cm harvesting height	-	-	T1
Desho grass silages	+	-	T2
	-	+	T3
	+	+	T4

Without additive (-), with additive (+, 0.6% urea or 4% molasses) and both urea (0.6%) and molasses (4%) additive (+, +)

3.5. 3. Ensiling Procedure for laboratory, preference test and digestibility determination

Silages were prepared for all harvesting stage/height to determine the physical, fermentative and chemical composition of the silages in laboratory. For preference test and digestibility determination *A. gayanus* was harvested at boot stage while desho grass was harvested at 90 cm height.

For preference test and digestibility experiment ensiling was done using large plastic bag with a capacity of 350 kg. For ensiling grasses were harvested from individual plots at each stage/height and then chopped manually using machete to about 2-3 cm and allowed to wilt for 24 hours (Gebreegziabher *et al*., 2015).

The weight of wilted grass was taken and the required amount of additives were measured based on wilted weight basis of the ensiled chopped grasses. Then wilted grass was ensiled in triplicates for each treatment having a total of 36 plastic bags each 10 kg capacity. Within each bag 5 kg of sample were weighed for each treatment and treated with respective additives: without additives, 0.6% urea, 4% molasses and both 4% molasses and 0.6% urea (% wilted grass). Additives were measured using sensitive balance with a precision level of (0.001g). To avoid viscosity molasses was diluted with warm tap water. Urea was also dissolved with warm tap water at a ratio of 1:1 for uniform distribution (Yusuff *et al*., 2016). When molasses alone, or urea and molasses were applied, the amount of warm tap water used for dilution equals the amount of molasses used by weight (Suárez *et al*., 2011). When a combination of urea and molasses were used molasses was diluted first and urea was added to it and mixed thoroughly. Then the chopped grass was thoroughly mixed with the respective additive (except for control treatment) on polyethylene sheet laid on a concrete floor. Water container with the capacity of 1 liter was used to sprinkle the solution. The chopped grasses were filled into the plastic bag layer by layer, compacted and pressing with a wooden stick. Immediately the bags were tied carefully using rope and placed under ambient temperature in a room. After 21 days of ensiling, the bags were opened and sub samples from each replicate bag (3 replicate per treatment) were taken for the assessment of physical quality, chemical composition and fermentation characteristics silages.

3.6. Assessment of the physical quality of silages

The silages were evaluated for physical attributes by a panel test involving three trained personnel on the scales adopted for silage physical quality characterization. The panelists were from the Department of Livestock Research of Assosa with different professional backgrounds but had experiences in silage making. Observation for mold formation and extent was done during the opening of the silos. After observation for mold, by removing the top part of the silages representative samples were taken several hand grab samples from middle parts of each bag and mixed thoroughly and triplicate sub-samples (from each replicate) were taken where one sample was used fermentative quality evaluation, while the others were used for physical characteristics assessment and chemical analysis.

For physical characteristics determination the scores of each individual for all attributes were used in the statistical analysis. For color evaluation, the scale of 1- 4 were used on the basis of change in green color to dark brown, brown yellow or light yellow; for smell, the scale of 1-4 were used on the basis of repugnant putrid smell to acidic sweet pleasant smell; for structure, the scale of 1-4 were used on the basis of softness of leaves and stem as well as its ability to remain intact after squeezing the silage tightly in hand and then opening from breaking into small pieces to break into two or three pieces.

Table 4. Description of the scale used as indices of silage quality assessment

Scores	Smell	Color	Texture	Moldiness
1 Bad	Rancid and musty smell /pungent/	Dark/deep brown	Slimy	Highly moldy
2 Moderate	Irritative/offensive; alcohol/acidic	Brown/Medium	Slightly viscous /slimy	Medium
3 Good	Light acidic (*pleasant*)	Brown yellow	Medium(*loose and soft, firm*)	Slightly moldy
4 Excellent	Pleasant and sweet-acidic (*very pleasant*)	Light/green yellow/Olive green	Loose and soft, Firm	Without mold

Source: Ososanya and Olorunnisomo (2015)

3.7. Fermentation Characteristics

For silage pH determination, about 20g of silage sample per replication was taken in a beaker to which 100 ml of distilled water was added (AFIA, 2011). The samples were blended using a glass stirrer manually for thirty minutes and then kept for one hour and filtered through cheese cloth. Then silage pH was measured from the extract using a conventional digital pH meter (Hanna's Benchtop pH meter), calibrated with buffer solutions (pH 4, 7, and 9).

3.8. Chemical analysis of silages

About 500g fresh silage sub-samples were taken in triplicates (per treatment) for chemical analyses. The partial DM of silage was determined by drying the samples at 65°C in a forced air oven until a constant mass was achieved (AOAC, 1990) at Assosa Agricultural Research Center. After drying, the samples were ground through a 1mm screen (Thomas Willy mill) for chemical analyses which was done at Debre Brihan agricultural research center. Total Nitrogen (N) content of samples was determined by the Kjeldahl method (AOAC, 1990) and then crude protein (CP) content was calculated as N x 6.25. The ash content of the samples was determined by complete burning in a muffle furnace at 600^0C for 3 hours (AOAC, 1990).

The NDF, ADF and ADL were analyzed by Fibertec® (Tecator, Hoganiis, Sweden) according Van Soest and Robertson (1985).

3.9. Preference of silages

Eight intact male Arab goats (averaging 26 months of age) with initial body weight of 25.32 ± 0.84 kg (mean ± SD) were selected from Assosa agricultural research center goat farm. Four goats were used for each preference experiment of the two grass silage concurrently (Table 3). The two separate grass silage preference experiment were conducted for a total period of 23 days consisting of a 15 day adaptation period to the silage followed by eight days of preference study. During adaptation period animals were vaccinated to common skin diseases, goat pox and sprayed (Diazinon) against external parasites. And also the goats were dewormed using albendazole against internal parasite. The preference experiment was conducted separately in two rooms, one room for each grass. Each room was divided in to four individual pens. Four feeding troughs (plastic box) were provided for each pen and each treatment silages were added *ad libitum* within a pen so that each goat had free access to the four silages. A cafeteria feeding approach was used as described by Larbi *et al.* (1993), thus, permitting free access to the silage of their choice. Additional silage was provided to whenever the amount fell below 100g. No other feed was provided during preference study. The positions of the troughs were randomized each day to avoid "habit reflex" (David *et al*., 2016).

The weight of the silages was determined 10 hours after the offer (8 am) to calculate total DM intake. Silage offered and refused per goat were weighed and recorded daily and DM intake was determined for each animal for each silage. Water and mineral lick (common salt) were provided *ad libitum*. Representative samples of offered silages were taken daily and dried at 105^0C to determine the daily intake of DM for each animal. Finally the DM intake data were used to determine the relative preference of the silage. The relative preference index (RPI) was calculated by dividing the intake of silage by the total intake of the most consumed silage and the results obtained were then multiplied by 100 (Larbi *et al*., 1993). Silages were ranked based on percentage of preference (Olorunnisomo, 2012).

3.10. Apparent digestibility trial

Twenty intact male Arab goats (average 23 months of age) with initial body weight of 24.46 ± 1.05 kg (mean ± SD) were selected from Assosa agricultural research center goat farm for apparent digestibility experiment the two grasses. The age of the goats were determined by using the center recorded data. The apparent digestibility experiments of the two grass silage were conducted on the same experimental animal after one week gap i.e. digestibility experiment was first done for *A. gayanus* using 20 goats followed by digestibility experiment on desho grass silages. And each individual goat was identified through ear tagged. There was no quarantine period because they were taken from the center. Each pen was equipped with feeding and watering troughs. The goats were individually housed in a well ventilated and roofed pen. Cleaning of the pen was done once a day early in the morning. During adaptation period animals were vaccinated to common skin diseases, goat pox and sprayed (Diazinon) to treat external parasites. And also the goats were dewormed against internal parasite using albendazole.

Randomized complete block design (RCBD) was used with four treatments (Table 3) consisting of five replication and four goats in a block which was based on initial live weight. Goats within a block were assigned to one of the four dietary treatments randomly.The treatment feeds were introduced gradually over the two weeks adaptation period for each experiment. Silages were offered twice a day at 0800 and 1600 hours. The silage was provided to all animals *ad libitum* by adding a 15% allowance of the previous day's intake. The experimental goats had free access to water and common salt licks. No other feed was provided except grass silage during the entire digestibility experiment.

The digestibility trial was carried out for each grass silages treatment for 22 days with twelve days of adaptation to the silages and three days of adaptation of carrying the fecal collection bags. After three days of adaptation to fecal bags, daily total fecal output and daily feed offered and refused were weighed and recorded for seven consecutive days. During collection period, at 7:30 am (in the morning), representative grabs of silage samples from each treatment and refusals from each goat was collected each day to make composite feed sample for each feed and refusal for each goat. And the total amount of feces voided were collected and weighed every morning before feeding and stored at a temperature of -20^0C. Out of the daily total fecal output, 20% was sub-sampled to form a weekly fecal composite sample for each animal. On the last day of the collection period, fecal samples were thawed, thoroughly mixed, sub-sampled, dried at 60^0C for 72 hours and ground to pass through a 1mm sieve screen and stored in a plastic bag pending chemical analysis. Finally digestibility of each DM and nutrient was calculated using the following equations:

$$\text{Apparent nutrient digestibility (\%)} = \frac{\text{Feed intake} - \text{Fecal nutrient output}}{\text{Feed Intake}}$$

3.11. Statistical analyses

The data were analyzed using the General Linear Model (GLM) of R version (R4.0.0). Daily RPI values obtained for each treatment were subjected to analysis of variance with feeds as treatments and individual animals as replicates in a completely randomized design. Treatment means showing significant differences at the probability level of $p<0.05$ were compared using Duncan's new multiple range test.

The following statistical models were used to analyze the data.

- ❖ Plant morphological parameters and yield of the two grass response on harvesting stage/ harvest height

  $Y_{ij} = \mu + H_i + B_j + e_{ijk}$ Where; Y_{ij} = the observation on the j^{th} block and i^{th} treatments μ = common mean effect H_i = effect of harvesting stage/height $_{Bj}$ = effect of block j e_{ijk} = experiment error for harvesting stage i and in block j

- ❖ Response(silage physical, fermentative and chemical composition consisting of harvesting stage/ height and additives effect of the two grass silages

  $Y_{ijk} = \mu + H_i + A_j + HA_{ij} + e_{ijk}$ Where; Y_{ijk} is response variable, μ is overall mean, H_i is the fixed effect of harvesting stage/height, i= vegetative, boot and full bloom stage and 70, 90 and 110cm; A_j is the fixed effect of additives, j= additives; HA_{ij} is the interaction of harvesting stage/height i and of silage additive j and e_{ijk} is a random error.

- ❖ Apparent digestibility trial include diet and error effects

  $Y_{ij} = \mu + t_i + b_j + e_{ijk}$, Where, Y_{ij} = is the response variable μ= is the overall mean, t_i= is the treatment effect b_j =is the block effect and e_{ijk} is random error.

4. RESULTS

4.1. Morphological characteristics and dry matter yield of grasses

4.1.1. *Andropogon gayanus* grass

The effects of harvesting stage on morphological characteristics of *A.gayanus* grass are presented in Table 5. The PH was higher (P<0.05) at boot stage and full bloom stage than vegetative stage. The NTPP and NLPP were the highest (P<0.05) during boot stage and while the lowest (P<0.05) count was for vegetative stage. Similarly, the highest (P<0.05) LLPP was during boot stage. The result indicates that the highest (P<0.05) LSR was during vegetative stage. DM yield increased with increasing grass maturity, the highest (P<0.05) being during boot and full bloom stage.

Table 5. Morphological characteristics and DMY of A.gayanus during different harvesting stage

Parameter	Harvesting Stage		
	Vegetative	Boot	Full bloom
	Mean ± SE	Mean ± SE	Mean ± SE
PH(cm)	48.33 ± 2.21[b]	166.30 ± 2.21[a]	172.13 ± 2.21[a]
NTPP(Count)	3.23 ± 0.19[c]	6.30 ± 0.19[a]	4.20 ± 0.19[b]
NLPP(Count)	10.20 ± 1.55[c]	47.43 ± 1.55[a]	17.43 ± 1.55[b]
LLPP(cm)	28.91 ± 1.19[b]	36.87 ± 1.19[a]	24.58 ± 1.19[c]
LSR	1.76 ± 0.40[a]	0.56 ± 0.08[b]	0.50 ± 0.02[b]
DMY(t/ha)	2.34 ± 0.27[b]	8.17 ± 0.68[a]	9.24 ± 0.77[a]

Treatments means with different letters in a raw are significantly different (P < 0.05). SE=Standard error; PH=plant height; NTPP= number of tillers per plant; NLPP= number of leaves per plant; LLPP=leaf length per plant; LSR= leaf to stem ratio; DMY= dry matter yield,

4.1.2. Desho grass

Morphological characteristics and yield of desho grass during the three harvesting stage/height are shown in Table 6. Harvesting at 70 cm resulted in the lowest (P<0.05) NTPP while the highest (P<0.05) was at 90 and 110 cm harvesting height. The NLPP were similar (P<0.05) among treatments. LLPP was the highest (P<0.05) at 110 cm of harvesting. The greatest LSR was at 70 cm of harvesting. The DMY increased (P<0.05) with increased stage of harvesting.

Table 6. Morphological characteristics and yield Desho grass at three harvesting height

	Harvesting Height(cm)		
	70	90	110
Parameter	Mean ± SE	Mean ± SE	Mean ± SE
NTPP(Count)	40.7 ± 2.38[b]	50.20 ± 2.38[a]	49.73 ± 2.38[a]
NLPP(Count)	340.73 ± 26.54	358.46 ± 26.54	323.40 ± 26.54
LLPP(cm)	35.22 ± 0.81[b]	37.78 ± 0.81[b]	47.93 ± 0.81[a]
LSR	0.93 ± 0.04[a]	0.77 ± 0.04[b]	0.55 ± 0.01[c]
DMY(t/ha)	9.66 ± 1.17[c]	13.33 ± 1.16[b]	19.60 ± 0.67[a]

Treatments means with different letters in a raw are significantly different (P < 0.05). SE=Standard error; cm=centimeter; NTPP= number of tillers per plant; NLPP= number of leaves per plant; LLPP=leaf length per plant; LSR= leaf to stem ratio; DMY= dry matter yield.

4.2. Chemical composition of the grass before ensiling

The chemical compositions of *A.gayanus* and desho grass harvested at different stage/maturity before ensiling are shown in Table 7. The CP and NDF content *A.gayanus* grass decreased from vegetative stage to full bloom. The CP content of desho grass decreased with increased height of harvesting while there was an increase in NDF. The ADF and ADL content increased from vegetative to bloom stage for *A. gayanus* and with increased height for desho grass.

Table 7. Nutrient composition (% DM)) of the grass at different harvesting stage/height before ensiling

% constituents	*A.gayanus* grass*			Desho grass*		
	Harvesting stage			Harvesting Height (cm)		
	VEG	BT	FB	70	90	110
DM (%)	25.06	30.55	37.14	24.10	26.10	30.82
CP	9.56	7.31	4.80	10.77	9.63	6.13
Ash	8.70	6.59	6.52	7.69	5.38	5.38
NDF	70.00	68.87	67.40	57.24	60.45	64.92
ADF	42.25	44.17	52.08	38.52	45.53	48.01
ADL	5.57	6.10	9.86	8.82	10.11	10.39

*Mean of three observations/replication

4.3. Silage physio-chemical properties

4.3.1. *Andropogon gayanus* grass silage

Effect of additives and harvesting stage on physical characteristics of silages are shown in Table 8. There were interaction effect of harvesting stage and additive on the smell, color, moldiness and pH of silage. The score for smell, color and moldiness decreased ($P<0.05$) with increasing ($P<0.05$) stage of harvest from boot stage to full bloom which showed that good quality silage could be produced at earlier stage of harvesting. The highest ($P<0.05$) pH was observed at full bloom while the lowest ($P<0.05$) was at boot stage. The score for smell of silage without additive, molasses alone and a combination of molasses and urea was greater ($P<0.05$) than that of urea alone indicating that treatment with urea alone is not good as silage additive. There was no significant difference among additives in the texture of the silages. The lowest ($P<0.05$) moldiness score was for silage without additive indicating that lack of use of additive resulted in silage with moderate quality. The pH for silage treated with molasses alone or urea alone was greater ($P<0.05$) than without additive and a combination of urea and molasses indicating that urea and molasses together reduced pH but similar ($P>0.05$) with that of the control.

Table 8. *A.gayanus* grass silage physio-chemical properties in different stage of harvest

Parameter	HS	Additives(AD)					SEM	P-Value		
		WO	WM	WU	WUM	*Mean		HS	AD	HS*AD
Smell[a]	VG	4.00	4.00	2.67	4.00	3.67[a]				
	BT	4.00	3.00	2.00	4.00	3.25[b]				
	FB	1.00	2.33	1.00	1.67	1.50[c]				
	**Mean	3.00[a]	3.11[a]	1.89[b]	3.22[a]		0.16	0.00	0.00	0.00
Color[a]	VG	3.00	3.00	4.00	4.00	3.50[a]				
	BT	2.00	3.00	4.00	3.00	3.00[b]				
	FB	1.00	1.67	1.00	1.00	1.17[c]				
	**Mean	2.00[c]	2.56[b]	3.00[a]	2.67[b]		0.96	0.00	0.00	0.00
Texture[a]	VG	2.67	3.33	3.33	3.33	3.17[b]				
	BT	4.00	4.00	4.00	4.00	4.00[a]				
	FB	2.00	2.67	2.00	1.67	2.08[c]				
	**Mean	2.89	3.11	3.33	3.00		0.16	0.00	0.29	0.40
Moldiness[a]	VG	2.67	4.00	4.00	4.00	3.67[a]				
	BT	2.33	3.33	3.33	2.67	2.92[b]				
	FB	1.00	1.00	1.00	1.00	1.00[c]				
	**Mean	2.00[b]	2.78[a]	2.78[a]	2.56[a]		0.15	0.00	0.005	0.11
pH[b]	VG	5.55	4.31	5.73	5.51	5.27[b]				
	BT	4.77	4.10	5.07	4.98	4.72[c]				
	FB	5.81	5.08	5.98	5.35	5.54[a]				
	**Mean	5.37[b]	4.48[c]	5.59[a]	5.27[b]		0.11	0.00	0.00	0.009

Means with different superscript letters in the same **row and *column for each parameter differ ($P < 0.05$); [a]score (1- bad; 2-moderate; 3-good; 4-excellent) WM = with 4% molasses; WO= without additives; WU= with 0.6% urea; WUM= with urea 0.6% and 4% molasses; VG= vegetative stage; BT= boot stage; FB= full bloom stage; SE= standard error; [b]pH= silage pH in measured values

4.3.2. Desho grass silage

The effect of harvesting height, additives and interaction effect on the average score values of desho grass silages are presented in Table 9. Better ($P<0.05$) score for smell and texture was recorded for silage produced with the use of molasses alone or a combination of molasses and urea. Lower smell value indicates unpleasant smell. There was no significant difference in the color of silage among additives. The color of silage at 90 and 110 cm of harvesting height was better ($P<0.07$) than that of 70 cm. There was improvement ($P<0.05$) in the texture of silage with increasing height of harvest. The moldiness score for additives were similar ($P>0.05$) but better ($P<0.05$) than without additive. The score for moldiness at 110 cm harvesting was greater ($P<0.05$) than that of 70 cm. The highest ($P<0.05$) pH score was for silage treated with urea followed by silage made without additive. The pH at early stage of harvesting was greater ($P<0.05$) than at the other heights.

Table 9. Physio-chemical properties of desho grass silage

Parameter	HH	Additives(AD)					SEM	P-Value		
		WO	WM	WU	WUM	*Mean		HH	AD	HH*AD
Smell[a]	70	1.00	2.00	1.00	2.33	1.58[a]				
	90	1.00	2.00	1.00	1.00	1.25[b]				
	110	1.00	2.33	1.00	2.67	1.75[a]				
	**Mean	1.00[b]	2.11[a]	1.00[b]	2.00[a]		0.16	0.001	0.000	0.000
Color[a]	70	1.00	2.00	2.66	2.00	1.92[b]				
	90	3.66	3.00	3.00	3.00	3.17[a]				
	110	4.00	3.00	3.33	3.66	3.50[a]				
	**Mean	2.89	2.67	3.00	2.89		0.30	0.000	0.600	0.008
Texture[a]	70	1.00	3.00	1.00	2.67	1.92[c]				
	90	3.33	4.00	3.33	3.66	3.58[b]				
	110	4.00	4.00	4.00	4.00	4.00[a]				
	**Mean	2.78[b]	3.67[a]	2.78[b]	3.44[a]		0.19	0.00	0.00	0.00
Moldiness[a]	70	2.00	3.33	3.33	3.33	3.00[b]				
	90	3.00	3.33	3.33	3.33	3.25[ab]				
	110	3.00	3.33	4.00	4.00	3.58[a]				
	**Mean	2.67[b]	3.33[a]	3.55[a]	3.55[a]		0.25	0.01	0.001	0.22
pH[b]	70	5.41	4.05	5.95	4.86	5.06[a]				
	90	4.97	3.98	5.04	4.68	4.66[b]				
	110	4.67	4.60	5.05	4.71	4.75[b]				
	**Mean	5.01[b]	4.21[d]	5.34[a]	4.74[c]		0.10	0.00	0.00	0.00

Means with different superscript letters in the same ** row and *column for each parameter differ ($P < 0.05$); [a]Physical quality of silage score value (1-bad; 2-moderate; 3-good; 4-excellent); pH[b] = measured value; WM = with 4% molasses; WO= without additives; WU= with 0.6% urea; WUM= with 0.6%urea + 4% molasses; 70= 70 cm height at harvesting; 90= 90 cm harvesting height; 110= 110 cm harvesting height; SE= standard error of the mean.

4.4. Chemical composition of grasses silage

4.4.1. *Andropogon gayanus* grass silage

The effect of harvesting stage, additive and interaction effect on the chemical composition of silages are presented in Table 10. The result shows that with an increase in the age of harvest the DM, NDF, ADF and ADL contents increased ($P<0.05$). There was no significant effect of silage additives on DM and ADL contents. The CP content of silage at vegetative stage was the highest ($P<0.05$) and decreased ($P<0.05$) with increasing stage of maturity. Silage made without additive resulted in lower ($P<0.05$) CP content compared with those made with additives. The NDF content of silage without additive was greater ($P<0.05$) than that of urea alone or a mixture of urea and molasses. The highest ($P<0.05$) ADF was silage produced without additive or a mixture of urea and molasses.

Table 10. Nutrient composition (% DM) of *A.gayanus* grass after ensiled

Constituent	HS	Additives					P-value			
		WO	WM	WU	WUM	**Mean	SE	HS	AD	HS*AD
DM(%)	VEG	23.50	24.05	21.80	24.82	23.54^{c}	0.83	0.00	0.19	0.42
	BT	27.45	29.59	29.15	29.28	28.86^{b}				
	FB	34.38	34.40	33.90	34.50	34.28^{a}				
	*Mean	28.44	29.35	28.27	29.52					
CP	VEG	8.91	9.13	9.38	10.13	9.38^{a}	0.27	0.00	0.00	0.00
	BT	6.36	9.62	8.58	7.42	7.99^{b}				
	FB	5.36	4.44	5.34	5.32	5.11^{c}				
	*Mean	6.87^{b}	7.73^{a}	7.76^{a}	7.62^{a}					
Ash	VEG	7.64	8.54	7.57	7.66	7.85^{b}	0.11	0.00	0.00	0.00
	BT	7.32	8.27	6.30	8.65	7.63^{c}				
	FB	7.24	8.55	8.69	8.61	8.27^{a}				
	*Mean	7.40^{b}	8.45^{a}	7.52^{b}	8.30^{a}					
NDF	VEG	55.00	55.10	54.50	56.60	55.27^{c}	0.61	0.00	0.00	0.00
	BT	60.30	59.70	60.40	58.50	59.73^{b}				
	FB	68.41	65.51	61.00	61.03	63.69^{a}				
	*Mean	61.23^{a}	60.10^{ab}	58.63^{c}	58.72^{bc}					
ADF	VEG	35.48	45.82	42.02	43.49	41.70^{b}	0.25	0.00	0.00	0.00
	BT	42.61	35.50	31.35	40.33	37.45^{c}				
	FB	54.25	45.47	54.05	48.03	50.45^{a}				
	*Mean	44.12^{a}	42.26^{b}	42.47^{b}	43.95^{a}					
ADL	VEG	5.38	5.41	5.26	5.22	5.32^{c}	0.33	0.00	0.21	0.00
	BT	6.53	6.60	7.82	8.56	7.38^{b}				
	FB	9.06	9.09	9.05	8.02	8.82^{a}				
	*Mean	6.99	7.03	7.37	7.28					

Means within Harvesting stage and Additive type with different superscript letters in the same **columns and ^{x}rows differ (P<0.05); SE= Standard error; DM= dry matter of silage; CP= crude protein; NDF/ADF = Neutral/Acid detergent fiber; ADL= acid detergent lignin; WO= without Additives; WU (0.6%) = with urea; WM (4%) = with molasses; WUM= urea (0.6%) + Molasses (4%); SE= standard error; VEG= vegetative stage; BT= Boot stage and FB= full bloom stage

4.4.2. Desho grass silages

Effect of harvesting height and additives a on chemical composition of silages are shown in Table 11. The highest ($P<0.05$) DM content was for silage harvested at 110 cm. Silage treated with urea and molasses had greater ($P<0.05$) DM content than urea alone and without additive. The greatest ($P<0.05$) CP content was at 90 cm of harvesting and silage treated with molasses alone and a mixture of urea and molasses. The NDF, ADF and ADL content were greater ($P<0.05$) at 110 cm of harvesting and silage made without additive.

Table 11. Nutrient composition (% DM) of desho grass silage at different harvesting height

Constituent	HH	Additives						P-value		
		WO	WM	WU	WUM	**Mean	SE	HH	AD	HH*AD
DM(%)	70	22.99	25.15	23.46	26.56	24.54[b]	0.81	0.00	0.001	0.49
	90	24.01	25.45	24.86	26.31	25.16[b]				
	110	26.95	28.29	28.15	28.82	28.05[a]				
	*Mean	24.65[c]	26.30[ab]	25.49[bc]	27.23[a]					
CP	70	6.30	8.71	6.80	8.38	7.55[b]	0.26	0.001	0.00	0.00
	90	7.70	7.83	8.55	8.96	8.26[a]				
	110	6.07	7.50	6.79	8.26	7.16[b]				
	*Mean	6.69[c]	8.40[a]	7.38[b]	8.54[a]					
Ash	70	9.08	9.50	9.52	9.68	9.45[a]	0.30	0.00	0.00	0.001
	90	6.42	7.75	8.71	7.43	7.54[c]				
	110	7.37	9.79	8.53	8.51	8.55[b]				
	*Mean	7.62[b]	8.95[a]	8.92[a]	8.53[a]					
NDF	70	60.30	58.50	56.20	52.00	56.70[b]	0.59	0.00	0.00	0.00
	90	60.70	56.70	55.10	56.20	57.20[b]				
	110	64.00	58.20	53.30	58.50	58.50[a]				
	*Mean	61.70[a]	57.80[b]	54.09[c]	55.60[c]					
ADF	70	43.70	43.60	42.70	38.70	41.80[b]	0.17	0.004	0.001	0.002
	90	44.60	38.10	41.70	41.60	41.50[b]				
	110	48.20	43.10	39.50	47.80	44.70[a]				
	*Mean	45.50[a]	41.60[b]	41.30[b]	42.20[b]					
ADL	70	8.00	8.10	8.00	8.17	8.07[b]	0.08	0.00	0.34	0.01
	90	8.00	7.73	8.14	7.73	7.90[c]				
	110	8.23	8.30	8.42	8.38	8.34[a]				
	*Mean	8.08	8.04	8.19	8.09					

Means within Harvesting Height and Additive type with different superscript letters in the same *rows and **columns differ ($P<0.05$); HH = Harvesting Height; AD = Additives; 70 = Height at 70cm; 90 = Height at 90cm; 110 = Height at 110cm; SE= Standard error; DM= dry matter of silage; CP= crude protein; NDF/ADF = Neutral/Acid detergent fiber; ADL= acid detergent lignin; WO= without Additives; WU (0.6%) = with urea; WM (4%)= with molasses; WUM= urea(0.6%) + Molasses(4%)

4.5. Preference and digestibility of *A.gayanus* grass silages

4.5.1. Chemical composition of *Andropogon gayanus* silages

The chemical composition of *A.gayanus* silage with different additives used for preference and apparent digestibility trials are indicated in Table 12. The lowest (P<0.05) DM content was for T1, silage made without additives. The CP content was greatest for T2 and T3. There was no significant difference in NDF and ADL content among silage additives. The highest (P<0.05) ADF content was for silage without additive.

Table 12. The chemical composition (DM basis except DM %) of *A.gayanus* silage offered during preference and apparent digestibility study

	Treatment				
Constitute	T1	T2	T3	T4	SEM
DM	27.45[b]	29.59[a]	29.15[a]	29.28[a]	0.13
CP	6.36[c]	9.62[a]	9.94[a]	7.42[b]	0.27
Ash	7.32[b]	8.27[a]	6.30[c]	8.65[a]	0.15
NDF	60.30	59.70	60.40	58.50	0.92
ADF	42.61[a]	35.50[c]	31.35[d]	40.33[b]	0.22
ADL	6.53	6.60	7.82	8.56	0.54

T1 = without additive, T2 = with 4% molasses, T3 = with 0.6% urea, T4 = with 0.6 urea and 4% molasses; SE= standard error of mean

4.5.2. Preference and apparent digestibility of *A.gayanus* grass silage

Preference and digestibility of *A.gayanus* silage are presented in Table 13. The highest (P<0.05) DM intake and RPI was for T2 followed by T4 while the lowest (P<0.05) was for T1 and T3 during preference study. Silage from urea additives was least preferred and strongly avoided in cafeteria feeding. .

Goats in T2 and T3 digested more (P<0.05) DM, OM and CP compared with the other treatments while the least (P<0.05) was for T1. Silage treated with urea alone had the highest (P<0.05) NDF digestibility. There was no significant difference in ADF digestibility among treatments.

Table 13. Preference and apparent digestibility of *A. gayanus* grass silage at boot stage of harvest

		Treatments				
Experiments	Items	T1	T2	T3	T4	SE
Preference of silage	[a]DM intake (g/day/goats)	90.37[c]	274.17[a]	74.01[c]	202.30[b]	10.85
	RPI (%)	33.19[c]	100.00[a]	27.49[c]	74.15[b]	2.31
	Preference ranking	3	1	4	2	
Apparent Digestibility	[b]DM intake (g)	633.77[ab]	762.87[a]	503.06[b]	655.79[a]	44.19
	DMI/BW (%)	2.60[ab]	3.13[a]	2.07[b]	2.67[a]	0.17
	Digestibility (%)					
	DM	49.21[c]	63.19[a]	61.65[a]	55.39[b]	1.02
	OM	49.85[c]	63.79[a]	63.26[a]	56.29[b]	1.00
	CP	50.42[c]	73.10[a]	74.44[a]	57.92[b]	0.90
	NDF	40.84[d]	55.46[b]	61.12[a]	47.59[d]	1.14
	ADF	48.00	50.15	43.78	46.99	2.72

Means with a row not common superscript are significantly different; ADF=acid detergent fiber; CP=crude protein; DM =dry matter; NDF=neutral detergent fiber; OM=organic matter; SEM=standard error of mean; T1= without additive; T2= 4% molasses; T3= 0.6% urea; T4= 0.6% urea and 4% molasses; BW = Body weight, SE= standard Error;

[a]DM intake = cafeteria base of the four treatment DM intake per goat ;

[b]DM intake = DM intake per goat per treatment

4.6. Preference and digestibility of desho grass silages

4.6.1. Chemical composition desho grass treated with different additives

Chemical composition of desho grass silage treated with different additives on preference and digestibility are in Table 14. The DM and ash contents of silages were similar (P>0.05) among treatments. The highest (P<0.05) CP content was for T4. The NDF and ADF content for T1 was greater (P>0.05) than the other treatments.

Table 14. Chemical composition of desho grass t (% dry matter, except DM) offered during preference and apparent digestibility

Constitute %	Treatment				
	T1	T2	T3	T4	SE
DM	24.01	24.45	24.86	26.31	0.57
CP	7.70[c]	7.83[c]	8.55[b]	8.96[a]	0.76
Ash	6.42	7.58	8.71	7.43	050
NDF	60.70[a]	56.70[b]	55.10[b]	56.20[b]	0.86
ADF	44.60[a]	38.10[c]	41.70[b]	41.60[b]	0.69
ADL	8.00[b]	7.73[c]	8.14[a]	7.73[c]	0.44

SEM= Standard error of the mean; T1= without additive; T2= 4% molasses; T3= 0.6% urea; T4= 0.6% urea and 4% molasses

4.6.2. Preference and digestibility of desho grass silage

Preference and digestibility of desho grass silage treated with different additives on preference and digestibility are presented in Table 15. Silage treated with 4% molasses (T2) had the highest (P<0.05) DM intake. While the desho silages treated with urea alone resulted in the lowest DM intake.

The digestibility of DM and OM for T2 was greater (P<0.05) than T1 and T4. The highest (P<0.05) digestibility of CP was for T3 and T4. The lowest (P<0.05) digestibility of NDF and ADF was for T1. Treatment of desho grass silage with urea and molasses alone or both had similar digestibility on NDF. A combination of urea and molasses or urea alone resulted in more (P<0.05) digestibility of ADF compared with molasses alone.

Table 15. Preference and apparent digestibility of Arab goat fed desho silage treated with different additives

		Treatments				
Experiments	Items	T1	T2	T3	T4	SEM
Preference of silage	[a]DM intake(g/day/goats)	22.39^{c}	462.24^{a}	3.97^{c}	214.48^{b}	48.99
	RPI (%)	4.60^{c}	100.00^{a}	0.84^{c}	48.36^{b}	5.87
	Preference rank(PR)	3	1	4	2	
Apparent Digestibility	[b]DM intake (g/day)	673.93^{b}	699.51^{b}	614.89^{b}	827.93^{a}	40.75
	DMI/BW (%)	2.58^{b}	2.72^{b}	2.38^{b}	3.27^{a}	0.14
	Digestibility (%)					
	DM	60.36^{c}	67.53^{a}	64.91^{ab}	63.28^{bc}	0.95
	OM	61.38^{c}	68.77^{a}	66.03^{ab}	64.77^{b}	0.93
	CP	61.99^{c}	67.36^{b}	72.30^{a}	74.37^{a}	0.85
	NDF	55.29^{b}	63.97^{a}	65.10^{a}	64.33^{a}	1.02
	ADF	52.89^{c}	60.38^{b}	64.61^{a}	64.75^{a}	1.07

means with a row not common superscript are significantly different; ADF=acid detergent fiber; CP=crude protein; DM =dry matter; NDF=neutral detergent fiber; OM=organic matter; SEM=standard error of mean; T1= without additive; T2= 4% molasses; T3= 0.6% urea; T4= 0.6% urea and 4% molasses.

[a]DM intake = cafeteria base of the four treatment DM intake per goat ;

[b]DM intake = DM intake per goat per treatment

5. DISCUSSION

5.1. Effect of harvesting stage on morphological character and DM yield of grass

5.1.1. *Andropogon gayanus*

The high plant height after vegetative stage in the current study might be due to the stem elongation and very robust growing of the grass at boot and full bloom stage. Grass height increases while the proportion of leaves decrease with increasing grass maturity. The increase in the grass height and DM yield with increasing maturity is mainly due to stem elongation which is consistent with a reduction in leafiness with increasing maturity of grass (Ribeiro *et al*., 2014). The higher NTPP and NLPP during boot stage may be the result of the development of new shoots bearing on plant at boot stage of the plant. During boot stage, the plant height was also high where the leaf length is also which is major adaptive responses to light competition in plants (Gruntman *et al*., 2017).

The low LSR of the grass at boot and full bloom stage may be due to the short life span of grass leaves. Drying and detach of leaves at the bottom part of the grass occurs after boot stage and reduce the number of leaves per plant. Ribeiro *et al*. (2014) indicated that *A.gayanus* grass stem to leaf ratio reaches 0.85 after 84 days of harvest. The DM yield (ton DM/ha) of the grass harvested at vegetative stage is very low which is associated with the high moisture content and low stem that decrease the DM yield of the grass. Increasing DM yield with increasing grass maturity is consistent with other research for tropical grasses (Dore, 2006).

5.1.2. *Desho* Grass

Harvesting based on plant height of desho grass is important because plant height is an important parameter contributing to yield of forage crops (Tessema *et al*., 2002). The low NTPP at 70 cm of harvesting height than the other heights indicates the development of new shoots bearing on each plant as plant matures which could results in greater number of tillers which is in agreement with the study by Asmare *et al*. (2016) who observed largest number of tillers at later stage of harvesting while early harvesting showed a relatively low number of tillers per plant. Also, the larger LLPP of desho grass at 110 cm than the other heights is in line with Asmare *et al*. (2016) who observed greater leaf length at later harvesting than for the earlier periods.

The higher LSR observed at earlier height in the current study is consistent with the findings of Butt *et al*. (1993) who found reduction in leaf proportion and an increase in the stem fraction of grass at the advanced stage of harvesting. Asmare *et al*. (2016) also observed decrease in LSR (1.25, 1.18 and 0.82) with advancement of plant height (72, 101 and 107 cm harvesting) which is consistent with the current study. The lower LSR with advancement of plant height or stage of harvest was also reported by Van Soest (1982) and Seyoum *et al*. (1998) for tropical grasses. LSR is an important factor associated with digestibility (Yasin *et al*., 2003) and have a negative correlation to NTPP, DM, DM yield and NDF (Asmare *et al*., 2016).

The higher DM yield at late stage of harvest height (110 cm) in the current study may be due to an increase in DM content with delayed harvesting because of decreased moisture content in leaves as the plants aged and became lignified (Asmare et al., 2016). Genet *et al*. (2017) also indicated that the total DM yield of desho grass increased progressively from 7.1 t/ha at 75 days of age to 25.5 t/ha at 135 days of age.

5.2. Physical properties and fermentative quality of grass silage

5.2.1 *Andropogon gayanus* grass silages

The physical properties of *A.gayanus* silage (smell, color, texture, moldiness) were affected by the harvesting stage and additive type. Silage with pleasant smell was produced without additive and molasses based additive during vegetative and boot stage. The lower score in physical attributes (smell, color and moldiness) of silages at full bloom stage may be due to the higher stem proportion at late stage of harvest which makes it difficult to pack during ensiling. Urea based additive gave unpleasant smell in all harvesting stage implies that urea might have created undesirable fermentation (growth of clostridia bacteria in the silage, organisms produce butyric acid). Silage treated with urea retained original color of the grass harvested during vegetative and boot stage. Urea additive showed that like a character of good silage usually preserves the original color of any forage but the lower smell score of urea additive contradict with a pleasant and fruity smell which is characteristic of good quality silage which was well preserved (Oduguwa *et al*., 2007).

The mold free silage prepared during vegetative stage (compared with boot and full bloom stage) indicates that the plant had high leaf during these stages which can easily be compacted during the process of silage making. Charley (2008) showed that drier forage is more difficult to pack and keep compacted and is more likely to have higher levels of yeasts and molds.

The pH value of silage treated with urea alone was the highest. Kung and Shaver (2001) indicated that ammonia released from urea is slightly basic, causing a delay in pH drop. Getahun (2019) showed that sole urea additive raised the pH significantly over control (untreated silage) beyond the normal range 3.7-4.5. McDonald *et al.* (2010) indicated that urea might have reduced desirable fermentation and lactic acid production. Similar to the current study, high pH was observed in Napier grass ensiled with 1% urea and 1% urea + 4% molasses leading to poor fermentation of silage (Samanta *et al*., 2001).

The silages prepared without additives had higher pH values than the range suggested by Getahun (2019) at all harvesting stage of harvesting probably due to low WSC content not adequate for satisfactory fermentation without additives like molasses. The addition of soluble carbohydrate may improve the quality of silage and further additives are used to overcome a low content of sugars in tropical grasses. According to early study by Petterson (1988) silage is considered to be of high quality when the pH is below 4.5. In the current study, treatment with 4% molasses resulted in low pH (4.21) indicating very good fermentation of silage. According to Yokota *et al.* (1992) molasses is often added to silage as a sugar additive increasing fermentation and feed quality. Molasses as additive increases the WSC level of the grass and increases lactic acid production. Moreover, silage harvested at full bloom stage the pH of silage without and with additives were beyond normal range which agrees with the findings of van Niekerk et *al*. (2010) who indicated that the concentrations of WSC and buffering capacity for directly cut as well as wilted silage harvested at the early vegetative stage of *Panicum maximum* were higher than that of boot and full bloom stages.

5.2.2 ***Desho grass silages***

There was no consistent trend with regard plant height on smell because 70 cm and 110 cm had similar score but better than that of 90 cm. Use of sole molasses and a mixture of molasses and urea resulted in silage with better smell and texture compared with sole urea. This lower smell of urea additive silages may be when urea is biologically decomposed to ammonia, which can be lost through volatilization and in turn causes significant unpleasant smell. The decrease in moisture content when the harvesting height increases is improve the physical characteristics (color, texture and moldiness) of desho silages. The result in agreement with previous studies by Khan *et al*. (2012) who observed higher values for color, smell and texture of silages at later stage of harvesting than the earlier stage.

Kung and Shaver (2001) stated that good quality grass and legume silage pH values in the tropics range between 4.3 and 4.7. Except at 70 cm of harvesting, the pH of silage in the current study is within this range. Silage made with the use of molasses and a mixture of molasses and urea gave silage within the range reported by Kung and Shaver (2001) suggesting that good quality. Kaizer and Piltz (2004) demonstrated that pH value with range of 3.5-4.2 considered optimal to preserve low DM silages. The high pH value of desho grass without additives in the current study shows the WSC content may be not adequate for the fermentation of the grass. Sufficient amount of fermentable carbohydrates in plant material is necessary for lactic acid production which reduces fermentation pH and guarantees the good quality silage (McDonald *et al*., 2011).

Silage treated with urea alone resulted in the highest pH and the pH was lowered with the use of molasses. Research result shows that adding urea is a common and cheap method of increasing nitrogen supply; however, urea decreases the fermentation quality of silage by increasing pH with the release of ammonia (Pancholy *et al*., 1994). And also Yunus *et al*. (2000) stated that the quality of silage made from tropical herbages are generally of low fermentation quality as silage do not contain large amount of lactic acid but considerable acetic acid.

5.3. Chemical composition of the grass

Study shows that the optimum dry matter content to ensile forages is between 30-35% (FAO, 2010). In our study the grass ensiled only at boot stage of harvest and 110 cm harvest of desho grass DM content within these limits. Increase in ADF and decrease in CP with increasing grass maturity observed in *A.gayanus*. The result confirms nutritive value of forages linearly declines with increasing physiological maturity (Blaser et al., 1986). *A.gayanus* grass CP concentrations were very low at full bloom stage of harvest, a level that is too low to sustain optimal activity by microbes for efficient ruminal fermentation (Van Soest, 1994). The mean CP content of desho grass obtained from the current experiment was within the range of 5.9-13.8% reported for Pennisetum species (Kahindi *et al*., 2007).

5.4. Chemical composition of of grass silages

5.4.1. *Andropogon gayanus* silages

The DM content of the silage increased with increasing stage of maturity which is consistent with the study by Dore, (2006) who showed that DM increases with delay of harvesting in tropical grasses. As plant matures the proportion of leaf decreases which may have an effect on silage quality Ribeiro *et al*. (2014) stem elongation with increasing maturity is consistent with a reduction in leafiness with increasing maturity. Silage DM content is generally not affected by the addition of urea, molasses and urea plus molasses. This result contradict to Keskin *et al*.(2005) shows sorghum silage DM content increased with the addition of urea plus molasses.

The CP contents were similar among the additives but the CP content was lower without additive silages. Study shows that addition of molasses alone do not increases CP content when compared with control silages but ensiled with urea based additives had significantly higher CP content than the treatments without additive sugar cane top silage (Getahun *et al*., 2018). Moreover, the CP content decreased with increasing stage of maturity. The CP content of silage still at full bloom stage was in the current study lower than 60 g/kg DM, a level that is too low to sustain optimal activity by microbes for efficient ruminal fermentation (Van Soest, 1994).The higher ash content with molasses alone or a combination of molasses and urea is in line with Murat *et al*. (2003) who indicated that the increase in ash content due to the decrease in OM due the use of urea and molasses as an additive.

The decrease in NDF of the silage compared with the NDF content before ensiling in the current study could probably be because hemicellulose was utilized for fermentation so as hemicellulose constitutes a portion of NDF, it was expected that NDF would also decrease during fermentation (Salamone *et al*., 2012). Additions of urea or urea plus molasses reduce the NDF content of the silages. Keskin *et al*., (2005) NDF contents of all sorghum silages decreased in the urea and urea plus molasses groups but molasses addition decreased the ADF contents of sorghum silages. May be the reasons for this the addition of molasses to silages increases the number of aerobic bacteria, including the lactic acid bacterium; therefore, the NDF and ADF degradation of silages increases (Bolsen *et al.*, 1996). Second, a decrease takes place because of the lower ADF content of the additives (Bingol and Baytok 2003). Similarly, Baytok *et al*. (2005) reported decreased NDF and ADF contents with increasing level of molasses in corn silage, because of low NDF and ADF contents of molasses and increased fermentation resulted from the high sugar content of molasses. The molasses levels lowered pH, ADF, and NDF percentages and increased *in vitro* DM digestibilities in Bermuda grass silages (Nayigihugu *et al*., 1995).

5.4.2. Desho grass silages

Silage made without additive had low DM content. This implies the minor fermentation losses were occurred ensiled with additives than the control. On the other hand Getahun *et al*. (2018) observed that additives had no effect on DM content of sugar cane top silage. The low CP content at 70 cm harvesting height may be due to the fact that at higher moisture clostridia may have developed and broken down protein and produce butyric acid, which will lower the palatability and intake of silage (Meeske *et al*., 2000). It is well known that vegetative pastures have better nutritional quality than mature pastures, but they also have lower dry matter yield and high moisture content which may result in secondary fermentation, production of silage effluents and spoilage of the silage (McDonald et al., 1991).

The greater CP content at 90 cm harvesting height indicates that harvesting of desho grass at 90 cm height is optimum height of harvest to ensile the grass. Molasses and a combination of molasses resulted in silage with higher CP content which indicates that these additives preserve the silage well and maintain the nutrient content of the silages. It has been indicated that provision of carbon skeleton and energy for microbial growth might have increasing the CP content of forages ensiled (Salem *et al*., 2013).

The lower NDF content due to urea and a combination of urea and molasses in the current study indicates that urea or ammonia addition to silages increases dissociation of CF, therefore, crude fiber content decreases with ensilage (Huhtanen, 2008) and NDF decreases (Islam *et al*., 2001). Bolsen *et al.* (1999) has shown that addition of molasses to silages increases the number of aerobic bacteria, including the lactic acid bacterium; therefore, the NDF and ADF degradation of silages increases. The silage ADF content increased when compared with the material crops that may be caused by the losses of other components during the fermentation (Jaakkola *et al*., 2006). Lignin content was not affected by type of additives but highest at the highest plant height which could be associated with stage of maturity of the grass. Study by Hilla *et al*. (2001) reported that ensiling had no effect on lignin and ADF contents as lignin and cellulose are relatively stable to hydrolysis during silo fermentation.

5.5. Preference and apparent digestibility of grass silages

5.5.1. Prefrence, intake and digestibility of silage made from *A.gayanus* silages

Silage treated with molases alone was more prefered by goats which indicates that addition of molasses to *A.gayanus* grasses silages enhanced its acceptability. Early study showed that molasses treatment increases silage quality and DM intake (Keady, 1996). The end-products of fermentation in silage can affect the intake by animals through its effect on palatability (Krizsan *et al*., 2007). Low preference of silage witout additve and urea treatment might be the result of both sensory characteristics, especially due to lower smell score assocated with urea addition and a negative post ingestive feedback eventually derived from higher amine concentrations or other unidentified silage characteristics (McDonald *et al*.,1985). Generally, the use of urea alone as an additve for *A.gayanus* silage may have resulted in poor fermentation which may contain large concentrations of undesirable compounds not prefered by goats which explain low silage intake in these groups (Oliveira *et al.,* 2016).

The observed simillarity in DM intake between without additive silage and with molasses additive at apparent digestibility study may be average smell of the control silage. With urea additive shows as a main diet for goats good DM intake. But as compared to molasses additive silages still lower DM intake this may be related to the silage fermentative profile can influence on the animal intake. The DM intake of dairy cattle was reduced by feeding a higher pearly millet silage diet due to an increase in acetic acid concentration (Daniel et al., 2018) and change in odor, taste and texture of silage (Rodríguez et al., 2015).

The lowest digestibility of DM, OM and CP without the use of additive (T1) could be due to the lack of supply of energy from molasses and /or nitrogen from urea.The high digestibility of CP for T2 and T3 may be due to high CP content in these two treatments (Keady *et al*., 2008). It has been shown that ensiling of Napir grass (harvested at vegetative stage) with molasses resulted in increased *in vitro* DM digestibility coefficients (Keady, 1996). Morover, study on the use of urea as an additive for silage making showed increased protein content of silage as result of high recovery of nitrogen applied and may reach up 77% recovery (Schmidt *et al*., 2007). Man and Wiktorsson (2001) showed that urea treatment is a conventional method of increasing the nitrogen level of ensiled materials through increasing the protein content and digestibility. In addition the increase in DM and OM digestibility for silages ensiled with molasses are in line with the observed lower NDF content of this silage (Smerjai *et al*., 2012). But the current study contradict with earlier finding (Petit and Veira 1994) which indicated that the use of urea as silage additive did not improve organic matter digestibility of the silages, but addition of molasses into silages have been reported to increase metabolic energy levels by increasing hydrolysis of cell wall. The improvement in apparent digestibility of NDF in urea ureated silages shows that addition of urea to silages affects dry matter digestibility in rumen positively. The ammoniolysis cause lysis on bonds between the structural carbohydrates releasing and increasing the contact surface to the rumen microorganisms (Oliveira *et al.,* 2016).

5.5.2. Preference, intake and digestibility of silage made from desho grass

Relative palatability index (RPI) silages in the current study shows that the use of molasses as an additive increased the preference of desho silages hence had higher DM intake. Tamir and Asefa (2009) observed that DM intake is influenced by palatability, chemical composition and physical attributes of the diet. Study by Smerjai *et al*. (2012) indicated that addition of molasses to Napier grass increased the intake of silage 1.4 times compared with silage made without additive. The increase in silage intake may be explained by the higher residual WSC content in the silage treated with molasses (Murphy, 1999). Desho grass silage made with urea treatment and without additive was the least prefered and hence had the lowest DM intake. Fermentative and physical quality study shows that silage prepared from urea additive and without additive had unpleasant smell and goats discriminated these silages during preference study. Palatability is the property of a feed that affects its taste or smell as perceived by animals with particular experiences under specified conditions and goats past experience with the feed (McDonaled *et al.*,1991). Silage made from urea treatment and without additive had low DM content as compared to the molasses based additive which may have created undesirable fermentation that reduces silage intake. Richardt *et al.* (2011) indicated that high concentrations of biogenic amines in the low DM silages may negatively affect DM intake. It seems that goats can detect subtle differences between silages and have also shown in other studies to prefer forages based on small changes in plant chemistry that are difficult to detect in chemical analyses (Burritt et al., 2005).

The high DM intake of silage made with a combination of urea and molasses during digestibility study is consistent with the study by Mustafa *et al*.(2008) which they attributed to a higher DM and CP content in this silage which are known to improve DM intake and growth rates in ruminants The lower silage DM intake of desho grass with urea additive might be due to some end-products of fermentation such as acetic, butyric acids and ammonia. It has been shown that poorly fermented silages have large concentrations of undesirable compounds that explain the low silage intake that can negatively affect the intake of silages (Oliveira *et al*., 2016).

The better apparent digestibility of DM and OM with urea and molasses treatemnt is consistent with study by Huhtanen (2008) who showed that the use of urea and molasses affects dry matter digestibility positively. Bingol and Baytok (2003) also indicated that molasses increases degradation. It has bee shown that addition of molasses to silages increases number of anaerobic bacteria, including lactic acid bacterium, therefore, NDF and ADF degradation of silages increases (Bolsen et al., 1996). The increase in DM and OM digestibility for silages ensiled with urea and molasses are in line with the observed lower NDF content of this silage in the current study. The higher CP digestibility with urea based additive agree with early study by Bereeba *et al*. (1983). This may be expected due to differences in the nitrogen content of the silages and daily nitrogen intake by goats. The digestibility of NDF and ADF was the lowest for the control treatment as compared to additive based treatment. Research finding has shown that the use of additve mainly urea might have increased the affinity of ammonia to water which promotes expansion and rupture of the cell wall components of tissues of forage treated with urea (Oliveira *et al*., 2016). Urea as a source of non-protein nitrogen, reduce the fibrous portion of forage (NDF), favor the partial solubilization of hemicelluloses, influence the increase in intake and digestibility of silage (Rosa and Fadel 2011).

6. CONCLUSION AND RECOMMENDATION

For *A.gayanus* as the plant height increase leaves to stem ratio was decreased. Higher number of tillers and leaves per plant was recorded at boot stage for *A.gayanus* grass. Highest DM yield was observed at 110 cm harvesting height for desho grass.

For A.gayanus silage experiment good quality silage in terms of smell, color, texture and moldiness were produced by harvesting at vegetative and boot stage with the use of molasses or mixture of molasses and urea. For desho grass the use of molasses or molasses plus urea resulted in silage with good smell and texture but those treatments where silage is produced without and with urea alone as additive resulted in poor smell and texture.

Undesirable pH was obtained with urea additive and control silage at all harvesting stage/height of *A.gayanus* and desho silages.

A.gayanus silage with molasses (T2) and desho grass with molasses and molasses plus urea additive (T4) are the most preferred silage by Arab goats. In both *A.gayanus* and desho silage treated with 4% molasses (T2) had the highest DM intake. While the *A.gayanus* and desho silages treated with urea alone resulted in the lowest DM intake. The digestibility of DM, OM and CP was lowest in both grass silages for control (T1) treatment but highest for when molasses (T2) and urea (T3) alone were used

In conclusion *A.gayanus* and *desho* grass silage experiment the smell, texture moldiness, color, fermentative characteristics, DM and CP content of the silages indicates harvesting at boot stage ensiling with 4% molasses and 90 cm harvest height with a mixture of 4% molasses plus 0.6% urea, respectively, are optimum for silage conservation practice in the study area.

However, researches should be done further on *A.gayanus* grass silage at boot stage with 4% molasses additive and *desho* at 90 cm harvesting height silage with urea 0.6% and molasses 4% mixture feeding of Arab goats as replacements or basal feed

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8. APPENDIX

1. ANOVA Morphological and DM Yield

1.1. *A.gayanus* grass morphological characteristics ANOVA table

A. PH

Dependent Variable: Andro Plant height

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	293237.678[a]	7	41891.097	275.405	.000
Intercept	1495884.544	1	1495884.544	9834.420	.000
Stage	292766.022	2	146383.011	962.368	.000
Block1	471.656	5	94.331	.620	.685
Error	12472.778	82	152.107		
Total	1801595.000	90			
Corrected Total	305710.456	89			

a. R Squared = .959 (Adjusted R Squared = .956)

CV=9.56

B. NTPP

Dependent Variable: Andro Number of tiller per plant

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	151.978[a]	7	21.711	18.549	.000
Intercept	1886.044	1	1886.044	1611.369	.000
Stage	147.489	2	73.744	63.005	.000
Block1	4.489	5	.898	.767	.576
Error	95.978	82	1.170		
Total	2134.000	90			
Corrected Total	247.956	89			

a. R Squared = .613 (Adjusted R Squared = .580)

CV= 23.63

C. NLPP

Dependent Variable: Andro Number of leaf per plant

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	23483.311[a]	7	3354.759	44.989	.000
Intercept	56350.044	1	56350.044	755.678	.000
Stage	23386.422	2	11693.211	156.811	.000
Block1	96.889	5	19.378	.260	.934
Error	6114.644	82	74.569		
Total	85948.000	90			
Corrected Total	29597.956	89			

a. R Squared = .793 (Adjusted R Squared = .776)

CV= 34.51

D. LLPP

Dependent Variable: Andro Leaf length per plant

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	2456.547[a]	7	350.935	8.118	.000
Intercept	81671.385	1	81671.385	1889.341	.000
Stage	2326.760	2	1163.380	26.913	.000
Block1	129.787	5	25.957	.600	.700
Error	3544.651	82	43.227		
Total	87672.583	90			
Corrected Total	6001.198	89			

a. R Squared = .409 (Adjusted R Squared = .359)

CV= 21.82

E. LSR

Table 5. *A.gayanus* leaf to stem ratio

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	14.237[a]	6	2.373	4.839	.002
Intercept	26.767	1	26.767	54.586	.000
Block	4.082	4	1.021	2.081	.116
Stage	10.155	2	5.078	10.355	.001
Error	11.278	23	.490		
Total	52.283	30			
Corrected Total	25.516	29			

R Squared = .558 (Adjusted R Squared = .443)

CV = 74.14

F. DMY

Table 6. *A.gayanus* grass dry matter yield

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	299.150[a]	6	49.858	14.482	.000
Intercept	1302.074	1	1302.074	378.202	.000
Block	23.902	4	5.975	1.736	.177
Stage	275.248	2	137.624	39.975	.000
Error	79.184	23	3.443		
Total	1680.409	30			
Corrected Total	378.335	29			

R Squared = .791 (Adjusted R Squared = .736)

CV=28.17

1.2. Desho grass Morphological Characteristics ANOVA table

1. NTPP

Dependent Variable: Desho number of tiller per plant

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	3141.678[a]	7	448.811	2.664	.016
Intercept	197777.344	1	197777.3	1174.	.000
HH	1720.689	2	860.344	5.107	.008
Block	1420.989	5	284.198	1.687	.147
Error	13813.978	82	168.463		
Total	214733.000	90			
Corrected Total	16955.656	89			

a. R Squared = .185 (Adjusted R Squared = .116)

CV= 27.68

B. NLPP

Dependent Variable: Desho number of leaf per plant

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	260336.800[a]	7	37190.971	1.901	.080
Intercept	10457107.600	1	10457107.600	534.552	.000
HH	18445.867	2	9222.933	.471	.626
Block	241890.933	5	48378.187	2.473	.039
Error	1604113.600	82	19562.361		
Total	12321558.000	90			
Corrected Total	1864450.400	89			

a. R Squared = .140 (Adjusted R Squared = .066)
CV= 41.03

C. LLPP

Dependent Variable: Desho Leaf 93length per plant

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	2919.128[a]	7	417.018	20.350	.000
Intercept	146297.088	1	146297.088	7139.000	.000
HH	2710.338	2	1355.169	66.129	.000
Block	208.791	5	41.758	2.038	.082
Error	1680.398	82	20.493		
Total	150896.615	90			
Corrected Total	4599.526	89			

a. R Squared = .635 (Adjusted R Squared = .603)
CV=11.22

D. LSR

Table 4. Desho leaf to stem ratio

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	.962[a]	6	.160	15.615	.000
Intercept	16.940	1	16.940	1650.560	.000
Block	.215	4	.054	5.231	.004
HH	.747	2	.373	36.385	.000
Error	.236	23	.010		
Total	18.137	30			
Corrected Total	1.198	29			

R Squared = .803 (Adjusted R Squared = .751)

CV= 13.81

E. DMY ton/ha

Table 5. Desho dry matter yield per hectares

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	546.616[a]	6	91.103	8.500	.000
Intercept	6048.830	1	6048.830	564.381	.000
Block	41.667	4	10.417	0.972	.442
HH	504.949	2	252.474	23.557	.000
Error	246.506	23	10.718		
Total	6841.951	30			
Corrected Total	793.121	29			

R Squared = .689 (Adjusted R Squared = .608)
CV= 23.02

2. physico-chemical characteristics of the silage

2.1 *A.gayanus* grass silage

Table 1. Color score ANOVA

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Stage	2	36.22222	18.11111	652	1.21E-21
Additive	3	4.666667	1.555556	56	5.51E-11
S:A	6	5.333333	0.888889	32	2.60E-10
Residuals	24	0.666667	0.027778	NA	NA
C V =	6.52				

Table 2. pH of silage ANOVA

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
S	2	4.187489	2.093744	54.21477	1.26E-09
A	3	6.317875	2.105958	54.53104	7.28E-11
S:A	6	0.8538	0.1423	3.684672	0.009765
Residuals	24	0.926867	0.038619	NA	NA
CV=	3.79				

Table 3 ANOVA for chemical Analysis of silage

Table 3. *A.gayanus* silage DM content ANOVA

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
S	2	692.2101	346.1051	164.1486	9.99E-15
A	3	10.80572	3.601906	1.70829	0.191978
H:A	6	13.08777	2.181295	1.034532	0.42768
Residuals	24	50.60367	2.108486	NA	NA

CV= 5.08

Table 3. *A.gayanus* silage CP content ANOVA

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Stage	2	113.7999	56.89994	243.428	1.16E-16
Additive	3	4.724297	1.574766	6.737126	0.001862
S:A	6	17.61726	2.93621	12.56163	2.17E-06
Residuals	24	5.609867	0.233744	NA	NA
CV =	6.44				

2.2. Desho grass silage physico-chemical characteristics ANOVA

Table 1. Desho grass silage color score ANOVA

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Harvest	2	16.72222	8.361111	30.1	2.88E-07
Additive	3	0.527778	0.175926	0.633333	0.600734
H:A	6	6.388889	1.064815	3.833333	0.008031
Residuals	24	6.666667	0.277778	NA	NA
CV=	18.42				

Table 2. Desho grass silage pH value ANOVA

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Harvest	2	1.047356	0.523678	14.57359	7.19E-05
Additive	3	6.208475	2.069492	57.59253	4.11E-11
H:A	6	2.140067	0.356678	9.926098	1.55E-05
Residuals	24	0.8624	0.035933	NA	NA

CV= 3.92

Table 3. DM content of desho grass silage ANOVA

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
H	2	84.44555	42.22278	34.88893	7.89E-08
A	3	32.87534	10.95845	9.05503	0.000344
H:A	6	5.22505	0.870842	0.719582	0.637763
Residuals	24	29.04493	1.210206	NA	NA

CV= 4.24

Table 4. CP content of desho silage ANOVA

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Harvest	2	7.491106	3.745553	17.30181	2.23E-05
Additive	3	17.26628	5.755425	26.586	8.38E-08
H:A	6	6.501383	1.083564	5.005299	0.001874
Residuals	24	5.1956	0.216483	NA	NA

CV= 6.07

3. Preference and digestibility ANOVA

3.1. Preference of Andro grass silage ANOVA table

Dependent Variable: DM intake

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	113074.891[a]	6	18845.815	40.018	.000
Intercept	410714.357	1	410714.357	872.123	.000
rep	4812.506	3	1604.169	3.406	.067
Feed	108262.385	3	36087.462	76.629	.000
Error	4238.427	9	470.936		
Total	528027.675	16			
Corrected Total	117313.318	15			

a. R Squared = .964 (Adjusted R Squared = .940)

CV= 13.54

3.2. Relative Palatability index

Dependent Variable: RPIP

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	14466.946[a]	6	2411.158	112.696	.000
Intercept	55150.515	1	55150.515	2577.708	.000
rep	190.666	3	63.555	2.971	.090
Feed	14276.280	3	4758.760	222.422	.000
Error	192.557	9	21.395		
Total	69810.017	16			

Corrected Total	14659.503	15

a. R Squared = .987 (Adjusted R Squared = .978)

CV= 7.87

3.3. Apparent Digestibility of Andro ANOVA table

Dependent Variable: DM intake

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	294615.068[a]	7	42087.867	4.309	.013
Intercept	8163327.533	1	8163327.533	835.770	.000
Trt	170665.742	3	56888.581	5.824	.011
Rep	123949.326	4	30987.332	3.173	.054
Error	117209.140	12	9767.428		
Total	8575151.741	20			
Corrected Total	411824.208	19			

a. R Squared = .715 (Adjusted R Squared = .549)

CV= 15.46

3.4. Dry matter intake per body weight of Arab goats

Dependent Variable: DMIBW

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	3.701[a]	7	.529	3.320	.033
Intercept	137.183	1	137.183	861.631	.000
Trt	2.828	3	.943	5.920	.010
Rep	0.873	4	.218	1.371	.301
Error	1.911	12	.159		

Total	142.794	20
Corrected Total	5.611	19

a. R Squared = .660 (Adjusted R Squared = .461)

CV= 15.23

3.6. Apparent digestibility of crude protein ANOVA

Dependent Variable: APCP

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	2078.613[a]	7	296.945	72.995	.000
Intercept	81853.454	1	81853.454	20121.239	.000
Trt	2067.152	3	689.051	169.383	.000
Rep	11.461	4	2.865	.704	.604
Error	48.816	12	4.068		
Total	83980.882	20			
Corrected Total	2127.429	19			

a. R Squared = .977 (Adjusted R Squared = .964)

CV= 3.15

3.7. Apparent digestibility of Neutral Detergent Fiber

Dependent Variable: APNDF

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1194.941[a]	7	170.706	25.842	.000
Intercept	52548.676	1	52548.676	7955.079	.000
Trt	1184.545	3	394.848	59.774	.000
Rep	10.395	4	2.599	.393	.810
Error	79.268	12	6.606		
Total	53822.885	20			
Corrected Total	1274.209	19			

a. R Squared = .938 (Adjusted R Squared = .902)

CV= 5.01

Dependent Variable: APADF

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	232.020[a]	7	33.146	.891	.542
Intercept	44623.849	1	44623.849	1199.402	.000
Trt	105.402	3	35.134	.944	.450
Rep	126.618	4	31.654	.851	.520
Error	446.461	12	37.205		
Total	45302.330	20			
Corrected Total	678.480	19			

a. R Squared = .342 (Adjusted R Squared = -.042)

CV= 12.91

Dependent Variable: APOMD

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	662.944[a]	7	94.706	18.894	.000
Intercept	67981.2	1	67981.2	13562.18	.000
Trt	650.385	3	216.795	43.250	.000
Rep	12.559	4	3.140	.626	.653
Error	60.151	12	5.013		
Total	68704.39	20			
Corrected Total	723.095	19			

a. R Squared = .917 (Adjusted R Squared = .868)

CV= 3.84

4. Desho grass silage preference and digestibility ANOVA

4.1. Desho preference ANOVA

Dependent Variable: DM intake

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	604993.523[a]	6	100832.254	10.503	.001
Intercept	494346.095	1	494346.095	51.494	.000
REP	58564.164	3	19521.388	2.033	.180
FEED	546429.359	3	182143.120	18.973	.000
Error	86400.708	9	9600.079		
Total	1185740.326	16			
Corrected Total	691394.231	15			

a. R Squared = .875 (Adjusted R Squared = .792)

CV= 55.74

Dependent Variable: RPI (Relative palatability index)

Source	Type III Sum	df	Mean Square	F	Sig.
Corrected Model	26188.151[a]	6	4364.692	32.579	.000
Intercept	23659.720	1	23659.720	176.600	.000
REP	403.684	3	134.561	1.004	.435
FEED	25784.467	3	8594.822	64.153	.000
Error	1205.759	9	133.973		
Total	51053.630	16			
Corrected Total	27393.910	15			

a. R Squared = .956 (Adjusted R Squared = .927)

CV= 30.09

4.2. Digestibility of desho grass ANOVA table

1.Dependent Variable: DM intake

Source	Type III Sum	df	Mean Square	F	Sig.
Corrected Model	264220.806[a]	7	37745.829	4.546	.011
Intercept	9914249.054	1	9914249.054	1194.108	.000
Feed	121114.937	3	40371.646	4.863	.019
Block	143105.869	4	35776.467	4.309	.022
Error	99631.719	12	8302.643		
Total	10278101.578	20			
Corrected Total	363852.524	19			

a. R Squared = .726 (Adjusted R Squared = .566)

CV= 12.94

Dependent Variable: DM intake per body weight

Source	Type III Sum	df	Mean Square	F	Sig.
Corrected Model	3.101[a]	7	.443	4.401	.012
Intercept	150.207	1	150.207	1492.084	.000
Feed	2.172	3	.724	7.192	.005
Block	.929	4	.232	2.307	.118
Error	1.208	12	.101		
Total	154.516	20			
Corrected Total	4.309	19			

a. R Squared = .720 (Adjusted R Squared = .556)

CV= 11.57

3.Dependent Variable: Apparent dry matter digestibility

Source	Type III Sum	df	Mean Square	F	Sig.
Corrected Model	170.846[a]	7	24.407	5.324	.006
Intercept	81981.452	1	81981.452	17883.737	.000
Feed	135.310	3	45.103	9.839	.001
Block	35.536	4	8.884	1.938	.169
Error	55.010	12	4.584		
Total	82207.307	20			
Corrected Total	225.855	19			

a. R Squared = .756 (Adjusted R Squared = .614)

CV= 3.34

Dependent Variable: Apparent digestibility of crude protein

Source	Type III Sum	df	Mean Square	F	Sig.
Corrected Model	480.692[a]	7	68.670	18.618	.000
Intercept	95244.842	1	95244.842	25823.536	.000
Feed	457.510	3	152.503	41.348	.000
Block	23.181	4	5.795	1.571	.245
Error	44.260	12	3.688		
Total	95769.793	20			
Corrected Total	524.951	19			

a. R Squared = .916 (Adjusted R Squared = .867)

CV= 2.78

Dependent Variable: Apparent digestibility of NDF

Source	Type III Sum	df	Mean Square	F	Sig.
Corrected Model	357.676[a]	7	51.097	9.724	.000
Intercept	77314.613	1	77314.613	14713.580	.000
Feed	319.357	3	106.452	20.259	.000
Block	38.319	4	9.580	1.823	.189
Error	63.056	12	5.255		
Total	77735.344	20			
Corrected Total	420.732	19			

a. R Squared = .850 (Adjusted R Squared = .763)

CV= 3.68

Dependent Variable: Apparent digestibility of ADF

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	505.439[a]	7	72.206	12.422	.000
Intercept	73593.925	1	73593.925	12661.221	.000
Feed	463.901	3	154.634	26.603	.000
Block	41.538	4	10.384	1.787	.196
Error	69.751	12	5.813		
Total	74169.115	20			
Corrected Total	575.189	19			

a. R Squared = .879 (Adjusted R Squared = .808)

CV= 3.97

Table. Dependent Variable: Apparent digestibility of Organic matter

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	174.836[a]	7	24.977	5.769	.004
Intercept	85062.533	1	85062.533	19647.8	.000
Feed	141.647	3	47.216	10.906	.001
Block	33.189	4	8.297	1.916	.172
Error	51.952	12	4.329		
Total	85289.321	20			
Corrected Total	226.788	19			

a. R Squared = .771 (Adjusted R Squared = .637)

CV= 3.19