Ethiop. J. Agric. Sci. 30(2) 1-12 (2020)

Effects of Additive Type and Ensiling Periods on Fermentation Characteristics of Green Maize Stover

Habte Abebaye[1], Ashenafi Mengistu[2], Berhan Tamir[2], Getnet Assefa[3] and Fekede Feyissa[3]

[1]*Selale University, Ethiopia;* [2] *College of Veterinary Medicine and Agriculture, Addis Ababa University, Ethiopia;* [3]*Ethiopian Institute of Agricultural Research (EIAR), Ethiopia*

አህፅሮት

በቆሎን ለእሸትነት ወይም ለሽያጭ ከተጠቀሙ በኋላ የሚቀረውን ርዓብ አገዳ በገፈራ መልክ ቢዘጋጅና ጥቅም ላይ ቢውል በበጋ ጊዜ ያለውን የመኖ እጥረት ለመታ□ፅ አስተዋፅዖ ይኖረዋል:: ይሁን እንጂ የዚህ መኖ የስኳር □□ቱ □ቅተኛ ሊሆን ስለሚችል ተ□ ማሪ ማብሊ□ (አዲቲቭስ) መጠቀም ቱ□ራው ሳ□በላሽ እንዲቆይ □ረ□ል ተብሎ □ቶመታል:: ይሁን እንጂ በቀላሉ ከሚቶኙ ማብለያ ዓይነቶች የቱ እንደሚሻልና ቱ□ራው በምን ያክል ቲ□ መትረስ እንደሚችል በአገራችን የተደረገ በቂ ጥናት የለም:: □□ህ ጥናት ዓላማም በቆሎው ለእሸትነት/ለሽያጭ ከዋለ በኋላ የቀረውን ርጥብ አገዳ በተለያዩ ማብሊ□ በማ□ል ጥራት ያለው ቱ□ራ በማዘጋጀት ገፈራው የሚደርስበትን ቲ□ ለማጥናት ነው:: በደንብ ለመጠቅጠቅና ለማጀል እንዲረዳ ከ1-3ሣ/ሜትር ከተቀረጠፈ በኋላ በተለ□□ ማብለያዎች (1% አብላይ ባክቴሪ□፣ 1% ከበቆሎ አገዳ የተጨመቀ ፈሳሽ፣ 3% ሞላሰስ እና ምንም ማብለያ □ሌለው በመ□ቀም ለሶስት የተለያዩ ጊዜያት(4 ሳምንት፣ 6 ሳምንትና 8 ሳምንት) ታ□ሎ እንዲቆይ ተደረገ:: □እያንዳንዱ አሰራር ዘዴ አምስት ጊዜ በመደጋገም ከላይ በተጠቀሱት ጊዜያት ናሙናዎችን በመውሰድ የገፈራ ባህሪያትየቀለም ልኬት፣ ፣□ሽ□ታ መጠን እና የልስላሴ መጠን) የአሲድ ይዘት፣ የመፈጨት ደረጃውንና የንጥረ-ነገር ይዘት መጠን በመገምገም □ተሻለውን ማብለያ ዓይነትና የገፈራውን የመድረሻ ጊዜ ለመወሰን ጥናት ተደር□ል:: በመሆኑም ሞላሰስን በመጨመር ለ6 ሳምንት ታ□ሎ □ቆ□ው ገፈራ ሲገመገም አንፃራዊ የቃጫ ይዘት መቀነስ እና የመፈጨት ደረጃው፣ ኃ□ል ሰቾ ነቱ እና የፕሮቲን ይዘቱም ዓ ሩ □ሚባል ዉጤት ያሳያል:: የገፈራ ባህሪያት ፅምገማውም ውጤት ከሌሎች ማብሊያ እና የማጀሊያ ጊዚያት የተለየ ባይሆንም ተቀባይነት ያለው ገፈራ ከሚያሳያቸው ባህሪያት ጋር የሚስተካከል ነው:: ከዚህም አንፃር በሞላሰስ 3% መለወስና ለ6 ሳምንት ማጀል የተሻለ ውጤት ያስገኛል:: □ህን እንስሳትን በመመገብ ማረ□ገጥ □ስ□ል□ል::

Abstract

*This study was conducted to investigate optimum ensiling period and type of additive for making quality silage from green maize stover (GMS). Green maize stover from which the ear was removed for consumption/selling was used for the study. The stover was chopped into 1 to 3cm long to facilitate compaction and consolidation. Treatments were arranged in a 3*4 factorial setup with three ensiling periods and four silage treatment types; without additive (control), 1% EM (effective micro-organisms), 1% FJLB (Fermentative Juice of Lactic acid Bacteria), and 3% molasses on fresh weight basis. The experiment was laid out in a completely randomized design in which except the control group, each of the three groups were treated and ensiled with the respective additives for 4, 6 and 8weeks each with five replications. Physical quality, chemical composition, and in vitro organic matter digestibility of the silages were analyzed. The result depicted that GMS silage made with inclusion of 3% molasses and ensiled for six weeks period showed relatively reduced NDF and ADF contents. On the other hand, GMS silage which was treated with 3% molasses and incubated for six weeks resulted relatively high in-vitro organic matter digestibility(54.47%), metabolizable energy (8.72MJ/kg DM)' and crude protein content (5.9 %). The measured physical characteristics in terms of color, smell, texture and mold coverage, pH and temperature of GMS ensiled using 3% molasses for six weeks were also within the recommended range for quality silage. Therefore, 3% molasses as an additive on fresh weight basis with fermentation period of 6 weeks combination could be used for making quality silage from GMS.*

Introduction

Though there is huge number of livestock resources in Ethiopia, its productivity is extremely low. The major constraint for such low productivity is inadequate feed resources in terms of both quantity and quality especially during dry season of the year (Ahmed *et al.*, 2010).

In the mid and highland areas where mixed farming system predominates, the contribution of grazing land is declining from time to time due to poor grazing land management and ever-increasing human population, and expansion of cropland at the expense of grazing land. In the long dry season, this small grazing pasture land rarely provide sufficient year-round feed of reasonable quality to match the nutritional demands of livestock and support satisfactory livestock production and reproduction (Suttie, 2000). Due to this fact, crop residues become important feed resources in mixed farming systems and provide on average about 50% of the total feed source for ruminant livestock. The contributions of crop residues reach up to 80% during the dry seasons of the year (Adugna, 2007). Nevertheless, crop residues are characterized by low metabolizable energy and low digestible protein contents, which can hardly support animal maintenance requirements unless supplementary feeds are given. The cost of supplementary feeds is increasing from time to time. However, there are potentially available feedstuffs that if properly exploited, can support livestock production. Green maize stover (GMS), after the green maize has been harvested for selling/home consumption, is one of such feed resources largely available in maize growing regions of Ethiopia.

Ethiopia is among the major maize producers in Africa (Abdisa *et al.*, 2001). It is the second most widely cultivated crop grown under diverse agro-ecologies and socioeconomic conditions under a rain-fed production system (Tsedeke *et al.*, 2015). Green maize harvest accounts on average for about 25% of the total maize yield ranging from 12% in Mecha to 52% in Hawassa Zuria (Berhanu *et al.*, 2007). Green maize stover is highly palatable and it is comparable with average hay but it loses quality during drying. The dry stover either left on the field or collected for later use is nutritionally poor (e.g. 3.7% CP as compared to 8.8% in green stover) and less palatable for cattle feeding (Fanos, 2014). Studies have shown that ensiling is a possible option of conserving GMS for later use (Mahadev, 2012). Application of relevant additive at the time of ensiling and maintaining the silage material for appropriate fermentation period is one of the management practices crucial to reduce nutrient loss and improve its nutritive value.

Various types of additives have been used to control undesirable microorganisms (e.g., aerobic bacteria, and fungi) and improve aerobic stability in silages (Pedroso *et al.*, 2008). However, molasses, effective microorganisms (EM) and fermentative juice of lactic acid bacteria (FJLB) are the cheapest and common ones. The effectiveness of these additives also varies on the type of silage materials and fermentation period used.

However, no documented information is available on the ensiling period and type of additive used to produce quality silage from GMS. Therefore, this study was conducted to evaluate the physico-chemical characteristics of green maize stover ensiled for different periods using different additives. The ultimate aim of the study was to identify the appropriate additive type and ensiling duration to make quality silage from GMS.

Materials and Methods

The study site

The experiment was conducted at Holetta Agricultural Research center (HARC), in Holetta town, 29 km West of Addis Ababa at an altitude of 2400 meters above sea level. The average annual rainfall of the area is 1144mm and the average daily temperature ranges from 6^0C to 21^0C.

Treatment and design

The treatments were no additive (control), with EM at 1%, with FJLB at1%, and with molasses at 3% of green maize stover on fresh weight basis and three ensiling/incubation periods (4, 6 and 8 weeks). The levels of application were adopted from research reports studied elsewhere on other silage crops (Bureenok *et al.*, 2005; Bilal, 2009. Completely Randomized Design **(**CRD) was used with factorial combinations of four additive types and three incubation periods with five replications. Sixty mini silos were used in the study.

Additives and ensiling procedures

FJLB

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

Effective microorganisms (EM2)

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

Preparing experimental silages

The maize variety named "Arganie" (a hybrid of Wonchi x Kulani) grown by HARC highland maize research program was used for the experiment. Shortly following the removal of green cob, the stover was harvested and chopped in to 1 to 3 cm long pieces to allow proper compaction and consolidation. Except the control, the chopped green maize stover was weighed and treated thoroughly with respective additive on concrete floor plastered with plastic sheet and each was replicated five times. The additives used were

EM (1%), FJLB (1%) and Molasses (3%) on fresh weight basis of chopped stover. The treated green maize stover was then filled into a plastic bucket lined with plastic sheet and compacted simultaneously. All plastic bags (mini silos) were filled at a similar packing density (1000g per 4liters plastic bucket) by hand and periodic tamping with a wooden stick. The tightly packed plastic bags were immediately closed, and sealed. On the sealed silage, heavy load was placed over the top of the plastic bag to exclude air from the silage and incubated at room temperature for 4, 6, and 8 weeks. Representative fresh sample of GMS was taken immediately prior to ensiling for laboratory analysis.

Silage parameters

Silage pH, temperature, and total dry matter loss (TDML)

At the end of the ensiling periods, the respective mini silos were weighed before opening for evaluation of silage physical characteristics. After observation for mold occurrence, the silage was thoroughly mixed and representative silage samples were taken and kept in refrigerator for determination of pH and chemical composition, while evaluation of silage physical characteristics was undergoing. Twenty g of frozen silage sample per treatment was taken in a beaker to which 100 ml of distilled water was added (AFIA, 2011). The samples were blended using a glass stirrer and kept for one hour before filtering using filter paper. Silage pH was measured from the extract using a conventional digital pH meter (Hanan Bench top pH meter), calibrated with buffer solutions (pH 4 and 7). Immediately as the silage pouch was opened, a laboratory thermometer was inserted in to the silo center to determine the temperature. Total dry matter loss (TDML) was calculated by DM weight loss in the silage (DM of forage - DM of silage)/DM forage*100) (Pedroso *et al.*, 2011).

Visual assessment of silage quality

The silage physical parameters like color, aroma, texture, and moldiness were inspected and subjectively judged by a panel involving five personnel who had experience on silage quality characterization. The panelists were from the Department of Livestock Research and were oriented on how to apply the criteria set (Table 1) and exercised before commencing the actual evaluation, independently. The physical quality characteristics (color, smell, texture, and moldiness) of the experimental silages were scored using a 0-4 scale (Ososanya and Olorunnisomo, 2015). Mold formation assessment was undertaken before and after opening the mini silos while color, smell, and texture were evaluated immediately after silo being opened. The score values of each individual for all attributes were used in the statistical analysis. Four and zero were the maximum and minimum scores for each physical characteristic, respectively and the average sum of scores of all judges were taken as the quality score of each characteristic.

Table 1. Scales used for appraisal sensory characteristics of maize stover silage

Characteristics	Scale				
	0	1	2	3	4
Color	Very dark	Dark	Olive yellow	Light olive green	Olive green
Smell/aroma	Very offensive	Offensive	Almost pleasant	pleasant	very pleasant
Texture	Slimy	Very soft	Soft	Fairly firm	Firm
Mold coverage	Very moldy	Highly moldy	medium	Scattered mold spot	No mold

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

Chemical composition and in-vitro digestibility

Chemical composition and *in-vitro* digestibility of fresh sample and the silages were determined at HARC animal nutrition laboratory. Representative of fresh green maize stover samples were taken prior to ensiling and silage samples were also taken at 4, 6, and 8 weeks of fermentation/incubation periods. The samples were dried in an oven at 65°C for 72 hours. The dried materials were ground to pass through1mm sieve in a Wiley mill and stored in polyethylene bags until chemical analysis. Dry matter, crude protein, and ash contents were determined following AOAC manual (AOAC, 1990). Neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) were determined according to Van Soest and Robertson (1985). *In-vitro* organic matter digestibility was determined using two stage *in-vitro* digestibility technique of Tilley and Terry (1963). Metabolizable energy (ME) content was estimated from the *in vitro* organic matter digestibility (IVOMD) according to MAFF (1984): ME (MJ/kg) =0.16(IVOMD).

Data management and analysis

Data was analyzed using the Statistical Analysis System (SAS, 2004). Significances of differences among treatment means was determined using Duncan Multiple Range Tests at 0.05 significance level. When interaction between the factors was non-significant, only main effect means were presented and discussed

The following statistical model was used for analysis

$$Yijk = \mu + C_i + P_j + CP_{ij} + E_{ijk}$$

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

Results and Discussion

Physical characteristics

There was no significant differences (P>0.05) among the treatments in terms of the observed color in green maize stover ensiled for four weeks (Table 2). However, GMS silages treated with Molasses and FJLB additives and ensiled for eight weeks showed significant (P<0.05) difference compared to the control ensiled for the same period. Other similar studies also showed that additives had positive impact on color characteristics of silage as compared to the control group (Bilal, 2009). GMS silage which was ensiled for eight weeks without additive showed less significant values (P<0.05) in terms of smell compared to GMS silage treated with additives and ensiled for the same period. This agrees with the observation of Getahun *et al*. (2018) and Mulugeta (2015) who reported that addition of molasses and EM to sugar cane top and crop residues, respectively resulted in pronounced alcoholic odor/sweet and strong smell, which is an indicator of better quality silage. The better anaerobic fermentative property of additives might probably be attributed to the presence of lactate and acetate producing microbes and water soluble carbohydrate in adequate quantities (Winters *et al*., 1998). Texture of GMS ensiled for four weeks with additives was significantly (P<0.05) better than that of the control group at the same fermentation period. However, quality of silage without additive (control) showed lower texture with prolonged fermentation period. The Mold coverage of the control that was ensiled for eight weeks was higher than silage, which was treated with additives and ensiled for the same period. As ensiling period, progressed, increased mold coverage was observed on the control group. Mold coverage of green maize stover in the control group was significantly high (P<0.05) compared to silage treated with additives at fermentation period of eight weeks; which could be attributed to low concentration of lactic acid that would arrest proliferation of micro-organisms in the untreated product.

Table 2. Physical properties of green maize stover silage treated with additives for different periods

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

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

Silage pH, temperature, and dry matter loss

Table 3 shows the changes in pH, temperature, and dry matter loss of green maize stover silage as affected by additives and fermentation periods. Relatively, higher pH (P<0.05) was recorded in control group with no significant variation across the fermentation periods. However, a decreasing trend in pH was observed in GMS silage treated with additives with prolonged fermentation periods to week six. Low pH values (<4.5) are believed to increase chemical hydrolysis of the ensiled fibrous polysaccharides (Bolsen *et al.,* 1996). The result of this study was consistent with previous study by Bilal (2009) who reported that grass ensiled with additives showed a decreased pH value due to level of additives and fermentation periods. There was no significant (*P*>0.05) difference in pH among GMS silages treated with respective additives and ensiled for four and six weeks period. The relative high pH values of GMS silage in the control group/silage without additive may be attributed to low concentration of fermentable carbohydrates. In general all silages that had a pH value of ≤ 4.53, was within the acceptable range in quality silage (McDonald *et al*., 2010). The pH value of silage in the control group was within an acceptable quality silage ranges; this probably indicates that GMS had the threshold soluble carbohydrate that could trigger lactic acid production.

The temperature of the silage measured upon opening the silo/plastic bags, was ranged from 16.62 to 19.52°C. Silage temperature was higher ($P<0.05$) in GMS treated with the different additives as compared to the control at 4 weeks fermentation period, however, there was no significant ($P>0.05$) variation in temperature among additive treated silages during similar fermentation period. This may be due to the effect of additives to enhance the fermentation process. The temperature of the control group and EM treated silage were significantly ($P<0.05$) lower than that of molasses treated silage during the six weeks fermentation period. This can be due to sufficient amount of water soluble carbohydrate in molasses to accelerate the fermentation process. The temperature of the control group was also lower ($P<0.05$) than EM and FJLB treated silages but there was no significant ($P>0.05$) difference between EM and FJLB treated silages in the six week fermentation period. However, as the fermentation period increases, the difference in temperature became small and did not significantly differ ($P>0.05$) among all additive treated silages at eight weeks incubation periods. According to Kung (2011), silage temperature of small silos is similar to the ambient temperature or just a few degrees warmer than normal. The result of this study showed that the generated heat was small, indicating the occurrence of minimal aerobic deterioration. Excessive heat production due to aerobic oxidation leads to browning (Millard) reaction, forming protein and carbohydrate complex that inhibits protein and fiber digestion (Bolsen *et al.*, 1996).

The DM recovery was higher due to additives compared to the control (Table 3). A significant (7.55%) dry matter loss ($P<0.05$) was observed in the control group at the fermentation period of eight weeks compared to the green maize stover silage treated with additives for the same and different ensiling durations. Delayed pH drop causes maximum DM loss in grass silage (Kung and Shaver, 2001). This is comparable to Bilal (2009) who reported that higher DM recovery was found due to addition of molasses on grass silage compared to the control/no molasses. This could be attributed to the addition of water-soluble carbohydrates and fermentation starter juice, which could have enhanced the fermentation process. According to Weinberg and Muck (1996) and Sharp *et al.* (1994), increased DM recovery may have been related to homolactic fermentation, which decreased fermentation losses. Lactic acid production reduces the carbon loss and thereby results in more DM recovery.

Table 3. Silage pH, temperature and dry matter loss of green maize stover treated with additives and ensiled for different periods

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

a-g Means with different superscripts within the same column are significantly different (P<0.05); TDML = Total Dry Matter loss ;T^0 =Temperature C= control, EM= Effective Micro-organism, FJLB= Fermentative Juice of Lactic acid Bacteria, Mol= Molasses, Wks= Weeks

Chemical compositions and in vitro digestibility of silage and fresh stover

Though no significant difference was observed among treatments, the GMS silage, which was treated with molasses, showed high DM percentage for the same fermentation periods (Table 4). However, DM was less (P<0.05) in the control group than molasses treated silage at 8 weeks fermentation period. The crude protein content of the silage ranged from 4.85 to 5.9%. The CP content of GMS silages was improved due to use of additives; thereby CP content was increased by (3.53 to 15.7%) as compared to the fresh maize stover. The CP content of green maize stover treated with additives was significantly different (P<0.05) from that of the control during all fermentation periods. This agrees with the findings of Bilal (2009) and Yonatan *et al.* (2014) who reported that molasses and corn addition on grass silage and EM inoculation on coffee husks resulted in higher CP content than that of the control. Zhang (2003) also reported that ensiling green maize stover with additives improved CP contents by (25.51%). However, the present study showed less (3.53 to 15.7%) CP contents increment than the earlier reports. This could be attributed to differences in variety and/ or additive type. The CP contents of silage could be affected by the type additive used and length of fermentation period. The possible reason for an increased CP content of silage could be due to the efficient fermentation and stability; thereby the natural bacteria present in the medium have no chance to act on the product except becoming part of medium (silage). These bacteria are protein in nature and contain more than 75% of their cell mass in the form of true protein (Yang *et al*., 2004).

From the cell wall components, NDF was significantly lower (P<0.05) in silage treated with molasses and ensiled for six weeks than the control and FJLB treated silage across all fermentation periods. The ADF content of GMS silage treated with molasses and ensiled for six weeks was lower than that of the control with fermentation period of four weeks and EM treated silage incubated for eight weeks. However, no significant variation was observed within each additive across the various fermentation periods. According to Zhang (2003), 16.37 and 23.66%, respectively due to the effect of ensiling, decreased the NDF and ADF contents of green maize stover. In this study, however, NDF and ADF contents were decreased only 1.48 and 6.78 percent, respectively, due to ensiling with molasses for six weeks periods. This could be attributed to differences in variety and/ or fermentation periods.

GMS silage treated with additives and incubated for six weeks had lower ($P<0.05$) ADL content than that of the control ensiled for four weeks. However, there was no significant variation across the fermentation periods within each additive used and the control group. This result conforms with Yonatan *et al. (*2014) who reported that use of EM additive resulted in lower NDF, ADF and lignin contents compared to the control in coffee husk. Silage with low pH values (<4.5) are believed to increase chemical hydrolysis of the ensiled fibrous polysaccharides (Bolsen *et al.,* 1996). The IVOMD (*in vitro* organic matter digestibility) and ME (MJ/kg) content was higher in GMS silage, which was treated with molasses and incubated for six to eight weeks than the control during similar fermentation periods.

The ash content did not show significant ($P>0.05$) difference among all treatments. Contrary to the present results, (Yonatan *et al*., 2014) stated that the ash content was increased to some extent in coffee husk ensiled with additives for different fermentation periods. The other reason might be due to high levels of minerals in the additive used and/or soil contamination at the time treating with respective additive could increase the overall ash contents.

Table 4. Chemical Compositions and in vitro dry matter digestibility of the ensiled green maize stover

Additive-period interaction (week)	Parameters							
	DM	ASH	CP	NDF	ADF	ADL	IVOMD	ME (MJ/kg)
C-4	35.48^{bc}	7.50	4.85^{c}	70.66^{a}	43.31^{a}	9.19^{a}	45.64^{abc}	7.30^{abc}
C -6	36.01^{abc}	7.93	4.79^{c}	68.66^{ab}	40.93^{ab}	8.01^{ab}	42.26^{bc}	6.76^{bc}
C-8	34.85^{c}	7.69	4.79^{c}	67.39^{b}	42.31^{ab}	7.97^{ab}	41.99^{c}	6.72^{c}
EM- 4	35.84^{abc}	8.21	5.28^{b}	67.41^{b}	40.41^{ab}	8.40^{ab}	52.87^{ab}	8.46^{ab}
EM-6	36.21^{abc}	8.01	5.83^{a}	66.55^{bcd}	41.24^{ab}	7.83^{b}	50.03^{abc}	8.00^{abc}
EM-8	36.81^{abc}	7.58	5.65^{ab}	67.17^{bc}	43.10^{a}	7.95^{ab}	46.93^{abc}	7.51^{abc}
FJLB-4	35.46^{bc}	7.73	5.60^{ab}	68.60^{ab}	41.36^{ab}	7.89^{b}	46.96^{abc}	7.51^{abc}
FJLB-6	36.01^{abc}	8.37	5.85^{a}	68.20^{ab}	42.36^{ab}	7.91^{b}	47.83^{abc}	7.66^{abc}
FJLB-8	36.69^{abc}	8.52	5.63^{ab}	67.11^{bc}	40.82^{ab}	7.87^{b}	45.13^{abc}	7.22^{abc}
Mol-4	36.97^{ab}	8.36	5.56^{ab}	64.59^{cd}	41.22^{ab}	8.05^{ab}	49.60^{abc}	7.94^{abc}
Mol-6	37.44^{a}	8.59	5.90^{a}	64.33^{d}	39.24^{b}	7.70^{b}	54.47^{a}	8.72^{a}
Mol-8	37.11^{ab}	8.19	5.68^{ab}	66.60^{bcd}	40.21^{ab}	7.65^{b}	53.77^{a}	8.60^{a}
SEM	0.77	0.37	0.035	3.84	2.66	0.34	24.65	0.63
P-Value	0.0004	0.069	0.0001	0.0001	0.008	0.0162	0.0012	0.0012
Fresh green stover	35	7.12	5.1	65.28	41.9	9.79	45.98	7.36

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

Conclusion

Determining an appropriate additive type and fermentation period to silage crops has paramount importance to improve fermentative characteristics and nutritive values of silage. From this study, it is concluded that ensiling green maize stover (after green cob removal) with 3% molasses on fresh weight basis for about six weeks has beneficial effect on the fermentative quality and nutritive of the silage.

Acknowledgements

The author would like to acknowledge Addis Ababa University for granting partial financial support. The author expresses his sincere and heartfelt appreciation to Holetta Agricultural Research Center, Animal Nutrition Laboratory for their technical support in analyzing the chemical composition of feed samples of the study

References

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

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

Ahmed H, E Abule, K Mohammed, and AC Treydte. 2010. Livestock feed resources utilization and management as influenced by altitude in the Central Highlands of Ethiopia. *Livestock research for rural development*. http://www.lrrd.org/lrrd/22/12/cont2212.htm.

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

Australian Fodder Industry Associations (AFIA). 2011. Laboratory Methods Manual. Version 7:80-81.

Berhanu G, S Fernandez-Rivera, H Mohammed, W Mwangi, and A Seid. 2007. Maize and livestock: Their inter-linked roles in meeting human needs in Ethiopia. Research Report 6. ILRI (International Livestock Research Institute), Nairobi, Kenya. 103 pp.

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

Bolsen KK, G Ashbell, and ZG Weinberg. 1996. Silage fermentation and silage additives. Rev. Asian-Aust. *J. Anim. Sci. 9:483-493.* Bureau of Animal Production and Health (BAPH). Criteria for evaluation of maize stover silage. BAPH, Ministry of Agriculture, Bejing, China. FAO.

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

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

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

Kung L. 2011. Silage Temperatures: How Hot is Too Hot? Dept. of Animal & Food Sciences. 531 South College Avenue, Newark, DE 19717-1303.

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

MAFF (Ministry of Agriculture and Fisheries and Food). 1984. Energy allowance and feeding system of Ruminants. Book 413. HMOS, London. 85p.

Mahadev AG. 2012. Effect of drying versus ensiling of maize stover on chemical composition and feeding value to lactating crossbred cows. PhD thesis submitted to the Karnataka Veterinary, Animal and Fisheries Sciences University, Bidar, India.

McDonald P, RA Edwards, JFD Greenhalgh, CA Morgan, LA Sinclair, and Wilkinson. 2010. Animal Nutrition. 7th Ed. Ashford Color Press Ltd., Gosport, England.

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

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

Ososanya TO and OA Olorunnisomo. 2015. Silage characteristics and preference of sheep for wet brewer's grain ensiled with maize cob. *Livest. Res. Rural Dev*. 27:12.

Pedroso AF, AA Rodrigues, WB Júnior, and GB Souza. 2011. Fermentation parameters, quality and losses in sugarcane silages treated with chemical additives and bacterial inoculants. *R. Bras. Zootec*. 40(11):2318-2322.

Pedroso AF, LG Nussio, and DRS Loures. 2008. Fermentation, losses, and aerobic stability of sugarcane silages treated with chemical and bacterial additives. *Sci. Agric*. 65:567-691.

Sharp R, PG Hooper, and DG Armstrong.1994. The digestion of grass silages produced using inoculants of lactic acid bacteria. Grass Forage Sci., 49: 42-53.

Smerjai B, N Tomoyuki, K Yasuhiro, and N Tadashi. 2005. Additive effects of fermented juice of epiphytic lactic acid bacteria on the fermentative quality of guinea grass (*Panicum maximum* Jacq.) silage. *Japanese Society of Grassland Science* ISSN1744-6961

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

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

Tilley JMA and RA Terry. 1963. A Two-stage technique for the *in vitro* digestion of forage crops. *J. Brit. Grassland Soc*. 18:104

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

Van Soest P, and JB Robertson. 1985. Analyses of forage and fibrous foods. A laboratory manual for Animal Science 613. Cornell University, Ithaca, New York, USA.

Weinberg ZG and RE Muck. 1996. New trends and opportunities in the development and use of inoculants for silage. Microbial Rev., 19: 53-68.

Winters AL, RJ Merry, M Muller, DR Davies, G Pahlow, and T Muller. 1998. Degradation of fructans by epiphytic and inoculant lactic acid bacteria during ensilage of grass. *J. Appl.Microbiology*, 84:304-312.

Yahaya MS, M Goto, W Yimiti, B Smerjai, and Y Kawamoto. 2004. Additives effects of fermented juice of epiphytic lactic acid bacteria and acetic acid on silo fermentation and ruminal degradability of tropical elephant grass. *J Anim Vet Adv.*; 3:115–121.

Yang CM, JSC Haung, T Chang, YH Cheng, and CY Chang. 2004. Fermentation acids, aerobic fungal growth, and intake of Napier grass ensiled with non-fiber carbohydrates. *J. Dairy Sci.*, 87: 630-636.

Yonatan K, D Solomon, T Taye, and G Yehenew. 2014. Effect of Effective Microorganism (EM) On the Nutritive Quality of Coffee Husk Silage. *International Journal of Scientific & Technology Research* Volume 3, Issue 7, July 2014

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