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Research Article

EFFECT OF GRASS SPECIES AND DIFFERENT LEVELS OF MOLASSES ON SILAGE QUALITY

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ABSTRACT

The experiment was conducted to investigate the effect of grass species and different levels of molasses on silage quality in smallholder dairy farms. Elephant, guatemala and rhodes grasses were established and harvested when they were at the age of 120, 63 and 56 days respectively. The harvested grasses was chopped into 4cm and subdivided into three portions each of which was treated with different levels of molasses (0, 3 and 5), packed in 5kgs plastic bag silo and stored in thatched barn. Treatments were assigned to a completely randomized design in factorial arrangement (3x3) with two replications. The silage was opened after 60 days, analyzed for sensoric qualities; chemical composition, *in vitro* DM digestibility and fermentation. Elephant grass silage produced higher quality and preserved better than guatemala and rhodes grasses as indicated by higher sensoric qualities, crude protein, ash, lactic acid, acetic acid and stability but lower DM, pH, NH_3N and butyric acid. Silages produced from molasses at 5% level had higher quality than silages mixed with molasses at 0 and 3% levels as indicated by higher DM, CP, WSC, ash, IVDMD, lactic acid, acetic acid and stability but lower NDF, pH and NH_3N. The interaction of elephant grass and 5% level of molasses showed highest CP and WSC but lowest pH and NH_3N. Elephant grass with molasses at 5% level was the most optimal techniques to achieve high quality silage fermentation under smallholder farmers.

INTRODUCTION

Dairy production has contributed significantly to poverty alleviation and reduction of malnutrition among the smallholder dairy farmers particularly in rural areas (Kayunze *et al*., 2001 and Kurwijila *et al*., 2002). Despite this, it has not expanded substantially in the tropical countries due to lack of quality pastures particularly during the dry season. In Tanzania, lack of quality pastures constraint the overall productivity of the smallholder dairy cattle (Lyimo, 2010). Conservation of forage in form of silage for later use in periods of feed shortage could be way out of this problem. Elephant, guatemala and rhodes grasses are high-yielding grass species that have been grown by smallholder dairy farmers in Tanzania and can be used to produce silage.

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

The mode of action of the additive applied to the herbage during silage making can include limiting respiration or proteolysis by plant enzymes, manipulating fermentations, inhibiting the activity of clostridia and aerobic micro-organism such as yeast and moulds (Laitila *et al*., 2002; Rooke and Hatfield, 2003 and Kung *et al*., 2003). Good silages have been observed when molasses were applied at different additive levels i.e. 3-5% (Manyawu *et al*., 2003), 4% (Aminah *et al*., 2000), 5% (Lyimo, 2010; Mtengeti *et al*., 2013). However, the effect of different levels of molasses and grass species on silage quality is rarely documented. Therefore, the study was conducted to investigate the effect of fodder grass species and different levels of molasses on silage quality in smallholder dairy farms.

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MATERIALS AND METHODS

Study area

This study was conducted at Magadu dairy farm in Department of Animal, Aquaculture and Range Sciences, College of Agriculture, Sokoine University of Agriculture (SUA). It is located between 6^{o} and 7^{o} South and 37^{o} and 38^{o} east within an altitude of about 500 to 600 m above sea level at the foot of Uluguru plateau mountains within Morogoro Municipality in Eastern part of Tanzania. It is characterized by ambient temperature between 20-27 ^{o}C in the coolest months of April to August and 30 - 35 ^{o}C during the hottest month of October to January. The annual rainfall ranges from 600-1000mm.

Experimental design and treatments

The experimental design was completely randomized design. The experiment had a 3 x 3 factorial arrangement for three grass species (elephant, guatemala and rhodes grasses), three molasses levels (0 (control), 3 and 5%). The experiment had 9 treatments designated as elephant grass mixed with molasses at 0% level, elephant grass mixed with molasses at 3% level and elephant grass mixed with molasses at 5% level. Guatemala grass mixed with molasses at 0% level, guatemala grass mixed with molasses at 3% level and guatemala grass mixed with molasses at 5% level. Rhodes grass mixed with molasses at 0% level, rhodes grass mixed with molasses at 3% level and rhodes grass mixed with molasses at 5% level.

Source, Harvesting, Preparation of Ensiled Grasses and Ensiling Procedure

The ensiled grass species used in study were elephant grass (*Pennisetum purpureum*), guatemala grass (*Trypsacum laxum*) and rhodes grass (*Chloris gayana*). All ensiled grass species were harvested from well established pasture plots (Plate 1 - 3). Each pasture plot for the grass specie covered an area of about 400m^{2}. The elephant grass was harvested at 1.5m. of height (120 days after planting), guatemala grass was at 1.0m of height (63 days) after planting time whereas rhodes grass 0.5m of height (56 days) when it was at flowering stage of growth. Nutritive value declines quickly as plant matures thus were harvested at respective recommended stages of growth for each grass. The grasses were cut using the machete and thereafter each bundle of harvested grass specie was chopped by a machete into 4cm length (Plate 4).

Plate 1 Grasses were planted

Plate 2 Grasses were weeded

Plate 3 Grasses were harvested

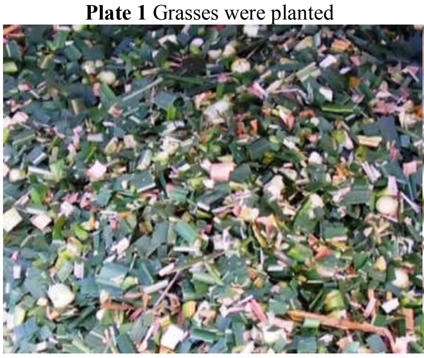

Plate 4 Grasses were chopped

Plate 5 Grasses were mixed with molasses additives

Plate 6 Grasses were ensiled

Plate 7 Grasses were stored

The harvested grass was chopped into 4cm and divided into two portions. One portion of the ensiling material was subdivided into three lots each of which was treated with a different level of molasses (0, 3, and 5%) as additive (Plate 5). Molasses was used as water soluble carbohydrate additive. The molasses was mixed thoroughly with forage material and ensiled in small plastic bag silos of capacities of 5kg (Plate 6). Then, the ensiled material was stored in thatched barn (Plate 7).

The ensiling was done by filling grass materials in the plastic silo bag. The neck of the bags was twisted, turned over and tied with a rubber band. Thereafter, the treatment of plastic bag was labeled for identity**.** Each bag was then inserted into a second empty shopping plastic bag which was also tied and labeled and put in a hessian bag to protect it from rupturing. For each in-bag silo treatment there were four hessian bags each containing two shopping bags. Hessian bags were then stored in thatched barn. Thatched barn is cheaper and can be affordable compared with earth-pit (Lyimo, 2010). In the thatched barn, the hessian bags were carefully stacked on a wooden rack and allow ventilation so as to low temperature. A chicken wire mesh all over so as to protect the bags against rats surrounded the wooden rack, mice and birds especially crow that would view the bags as bin bags full of kitchen waste to consume. In the earth pit the hessian bags were covered by a plastic sheet to protect them from termites.

Molasses availability and affordability

In Tanzania, molasses is cheap, affordable and locally available. For a smallholder farmer with only one cow, a 5kg of grass silage could be appropriate since the animal may require only 5kg of silage per day since it should be combined with other feeds such as hay and concentrates for a healthy rumen. The 5kg of elephant grass silage required 4.75kg of elephant grass mixed with 0.25kg of molasses at 5% level with the price of 0.02US$ /day or 50Tshs (Table 1). The price is affordable considering that, feed is the major cost item among variable costs and accounts for over 70% of the production costs (Norris *et al*., 2002). The productivity of dairy cattle under smallholder farmers has however, been low, producing up to from 6 – 10 liters of milk in the rain season and 3–5 liters in the dry season due to unavailability of adequate quality feeds throughout the year (Kavana and Msangi, 2005., Hall *et al*., 2007 and Njarui *et al*., 2009). This implies that, in average, the lowest income from milk production in dry season could be 3liters/day x 0.4US$/liter = 1.2US/day (1 liter of milk = 0.4US$= 1000Tshs) and the highest income during rainy season could be 10 liters/day x 0.4US$/liter = 4US$/day. Therefore, smallholder farmer with the income of 1.2US$ can afford to make silage using molasses at 5% with the price of 0.02US$ /day even during dry season.

Table 1 Amount of grasses ensiled with different levels of molasses and their prices/day/cow

Grass species and amount ensiled (kg)	Levels of molasses (%) and amount ensiled (kg)			Levels of molasses (%) and price (US$)		
	0%	**3%**	**5%**	**0%**	**3%**	**5%**
EG = 5, 4.85, 4.75	0	0.15	0.25	0	0.012	0.02
GG = 5, 4.85, 4.75	0	0.15	0.25	0	0.012	0.02
RG = 5, 4.85, 4.75	0	0.15	0.25	0	0.012	0.02

EG = elephant grass GG=guatemala grass RG – rhodes grass, price (1kg molasses =200 Tsh=0.08 dollar; 1dollar=2500Tshs year (2016)

Data collection procedures

After 60 days of fermentation, silos were opened and spoiled silage was separated from well preserved silage. Samples (weighing 500g) from each bag were collected placed in polythene bags and immediately placed in a cool ice box and taken to the analytical laboratory. The sample was sub-divided into two samples, for organoleptic test, pH determination and chemical composition analysis. The sub-samples were put in polyethylene bags and stored in a deep freezer at -10 °C until when they was used for laboratory work.

The DM of the fresh ensiling material and silages were determined by drying in an oven at 65°C for 48 h (AOAC, 1984). The silages were freeze-dried in a Lyphilizer maintained at -40 ºC for 24 hrs according to Snowman (1988) so as to get a dry sample for ash, crude protein, neutral detergent fiber (NDF), WSC analysis and *in vitro* dry matter digestibility (IVDMD) determination. Ammonia-nitrogen (NH_3N) was analyzed from fresh silage samples. The ash, CP and NH_3N were analyzed according to AOAC (2005) procedures while WSC was analyzed according to Thomas (1977). The NDF was analyzed according to Van Soest *et al. (*1991). A pH meter (model 219-MK 2; Pye Unicam) was used to measure the pH of the fresh silages samples. Samples of 40g from each silo were soaked in 200 ml of cool distilled water for 12 hours then filtered and the supernatant used for the determination of the pH. The *in vitro* dry matter (IVDMD) of the silages were determined according to the two stage technique developed by Tilley and Terry, (1963) and modified by Salabi *et al*. (2010). The silages were analyzed for volatile fatty acid according to Shirlaw‘s (1967) procedure. Gas Chromatograph analyses were performed on a wide bore fused silica Cp-sil 19CB column, gas chromatograph equipped with a flame ionization detector (FID) $512x10^{-12}$ Afs. The technique used was gas chromatograph capillary column (10 m, 0.53 mm fused silica WCOT Cp-Sil 19CB (2.0 µm catalog number 7647). The injector and detector temperatures were 275°C and 300°C respectively. The carrier gas was H_2 40kPa (0.4bar) 170 cm/s. The analyses were performed using a temperature programme: a linear gradient from 80°C to 280°C at 25°C min^{-1}. In each case a 0.1µLof sample was injected (a flow splitting 1:10). Silage stability was determined by observing the change of pH value of exposed silage after sixty days of fermentation. Each day the pH of each treatment was recorded for 7 days consecutively.

Organoleptic Test

The organoleptic test was carried out at the Department of Animal, Aquaculture and Range Sciences, Undergraduate and Postgraduate Students. Each assessor assessed the silage from each treatment and scored its physical characteristics in terms of appearance, texture and smell (Lyimo, 2010).

In this study, each of the factors including smell, color and texture has given a number based on Otieno *et al.* (1990). Appearance score No.1 (poor) indicated spoiled silage which was dark brown in color with mould growth, score No.2 (moderate) greenish in colour with some mould growth, score No.3 (good) yellowish green to brown colour and score No.4 (very good) indicated well pickled yellowish green to light brown colour silage. Smell score No.1 (poor) indicated foul smell associated with putrefaction, score No.2 (moderate) pungent smell of ammonia, score No. 3 (good) pleasant aroma and score No.4 (very good) vinegar fruity, estery aroma typically silage smell. Texture score, No.1 (poor) slimy and watery, score No.2 (moderate) less slimy and wet No.3 (good) non-slippery and wet No.4 (very good) non-slippery and slightly wet. The test was carried once after 60 days of fermentation, when ensiling bags (silos) were opened and spoiled silage separated from well preserved silage.

Data analysis

Collected data were entered in coded excel sheets then transferred to SAS for General Linear Model procedure of Statistical Analysis System (SAS, 2008) for analysis of variance of means. Means of factors were then separated using Multiple Duncan Range test. The model used to study effects of molasses additive levels of elephant, guatemala and rhodes grasses was: The statistical model:- $Y_{ijkl} = \mu + Gi + L(A)_{jk} + (GA)_{ij} + E_{ijkl;}$ whereby Y_{ijkl} = observation taken on the l^{th} replicate sample taken from the k^{th} level of the j^{th} additive applied on the i^{th} grass species; μ= general mean common to all observation; Gi= effect of the $_i{}^{th}$ grass species; A_j = effect of the j^{th} additive; $L(A)_{jk}$ = effect of the k^{th} level of application of the j^{th} additive; $(GA)_{ij}$ = interaction between the i^{th} grass specie and j^{th} additive; $L(A)_{jk}$ and $(GA)_{ij}$ are two-factor interactions involving grass species and additive level as indicated by corresponding symbols; $E_{ijkl=}$ random effect peculiar to each observation.

RESULTS

Chemical composition and digestibility of fodder grasses at the time of ensiling

The results revealed that, elephant grass had higher CP and ash but lower DM and digestibility than guatemala and rhodes grasses (Table 2). Molasses had relative higher WSC but lower CP than grasses.

Table 2 Mean chemical composition and digestibility of the grasses material at the time of ensiling

Parameter (%)	Elephant grass	Guatemala grass	Rhodes grass	Molasses
DM	19.9	29.3	21.8	65.30
CP	10.1	8.45	7.8	2.17
WSC	3.19	3.40	3.01	4.88
Ash	13.5	9.5	9.2	10.60
NDF	73.9	73.2	66.4	52.9
IVDMD	59.3	66.3	58.1	61.40

DM–Dry matter, CP-Crude protein, WSC-Water soluble carbohydrates, NDF-Neutral detergent fibre, IVDMD-in-vitro dry matter digestibility

Effect of grass specie and different levels of molasses on organoleptic of silage quality

Elephant grass silage had higher sensoric scores than guatemala and rhodes grass silage (Table 3). Silages with molasses at 5% level had higher sensoric scores than silages with molasses at 3% and 0% levels.

Table 3 Mean effect of grass specie and different levels of molasses on organoleptic of silage quality

Parameter (%)	Factors			SEM	p-value
	Effect of specie				
	Elephant grass silage	Guatemala grass silage	Rhodes grass silage		
Appearance	3.33^a	2.67^b	2.00^c	0.192	0.0001
Smell	3.17^a	2.67^{ba}	2.17^b	0.193	0.0001
Texture	3.33^a	2.50^b	2.00^b	0.215	0.0001
	Effect of additive levels				
	MOL 0%	MOL 3%	MOL 5%		0.0001
Appearance	1.83^c	2.67^b	3.50^a	0.192	0.0001
Smell	2.00^b	2.50^b	3.50^a	0.193	0.0001
Texture	1.67^c	2.67^b	3.50^a	0.215	0.0001

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

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

Elephant grass silages had higher CP and ash but lower DM and WSC than guatemala and rhodes grass silages (Table 4). There was no difference among elephant, guatemala and rhodes grass silages on NDF. Silages with molasses at 5% level had higher DM, CP, WSC, ash, IVDMD but lower NDF than silages with molasses at 3% and 0% levels.

Table 4 Mean effect of grass species and different levels of molasses on chemical composition and *in vitro* dry matter digestibility

Parameter (%)	Factors			SEM	p-value
	Effect of specie				
	Elephant grass silage	Guatemala grass silage	Rhodes grass silage		
DM	18.1^c	26.5^a	22.1^b	0.116	0.0001
CP	9.1^a	6.8^c	7.4^b	0.052	0.0001
WSC	1.68^b	1.76^a	1.4^c	0.014	0.0001
Ash	13.8^a	9.58^c	12.1^b	0.059	0.0001
NDF	68.8^a	68.5^a	68.9^a	0.147	0.0001
IVDMD	54.8^b	62.3^a	53.9^b	0.323	0.0001
	Effect of additive levels				
	MOL0%	MOL3%	MOL5%		
DM	21.5^c	22.3^b	22.9^a	0.116	0.0001
CP	7.70^b	7.73^b	7.98^a	0.052	0.0001
WSC	1.13^c	1.75^b	1.95^a	0.013	0.0001
Ash	11.9^b	12.1^b	12.5^a	0.059	0.0001
NDF	69.8^a	68.5^b	67.4^c	0.147	0.0001
IVDMD	56.2^b	56.7^b	58.2^a	0.323	0.0001

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

Table 5 Mean effect of interaction of grass specie and different levels of molasses on composition of silage quality

Parameter	MOL (%)	Elephant grass	Guatemala grass	Rhodes grass	SEM	P-value
CP	0	8.99^c	6.8^a	7.31^b	0.091	0.0001
	3	9.06^c	6.8^a	7.33^b	0.091	0.0001
	5	9.21^c	6.81^a	7.35^b	0.091	0.0001
WSC	0	1.02^a	1.35^d	1.03^b	0.023	0.0001
	3	1.67^e	1.75^f	1.84^g	0.023	0.0001
	5	2.35^i	2.18^h	13.4^c	0.023	0.0001

MOL - molasses, SEM- Standard error of means. Means within row and column with different superscript letters are significantly different (P < 0.05).

Interaction effect of grass specie and different levels of molasses on composition of silage quality

The interaction of elephant grass and 5% level of molasses showed that elephant grass produced silage with higher CP and WSC than guatemala and rhodes grasses (Table 5).

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

Elephant grass silage had higher lactic acid, acetic acid but lower pH, NH_3N, than guatemala and rhodes grass silages (Table 6). Silages with molasses at 5% level had higher lactic acid and acetic acid but lower pH and NH_3N than molasses at 3% and 0% levels.

Table 6 Mean effect of specie and additive levels on fermentative quality of grass silages

Parameter (%)	Factors			SEM	p-value
	Effect of specie				
	Elephant grass silage	**Guatemal agrass silage**	**Rhodes grass silage**		
pH	4.30^c	4.53^b	4.57^a	0.0091	0.0001
NH_3N	3.44^c	4.13^b	4.22^a	0.0085	0.0001
Lactic acid	1.39^a	1.08^b	0.47^c	0.0119	0.0001
Acetic acid	0.69^a	0.55^b	0.22^c	0.0041	0.0001
Butyric acid	0.0067^a	0.008^a	0.011^a	0.0019	0.008,0.0029, 0.0003
	Effect of additive levels				
	MOL0%	**MOL3%**	**MOL5%**		
pH	5.09^a	4.28^b	4.07^c	0.0091	0.0001
NH_3N	4.18^a	2.95^b	2.74^c	0.0085	0.0001
Lactic acid	0.49^c	0.97^b	1.48^a	0.0119	0.0001
Acetic acid	0.26^c	0.463^b	0.741^a	0.0041	0.0001
Butyric acid	0.024^a	0.0013^b	0.00033^b	0.0019	0.0001, 0.52, 0.87

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

Interaction effect of grass specie and different levels of molasses on organoleptic of silage quality

The interaction of elephant grass and 5% level of molasses produced silage with lowest pH and NH_3N (Table 7).

Table 7 Mean interaction effect of grass specie and different levels of molasses on fermentative of silage quality

Parameter	MOL (%)	Elephant grass silage	Guatemala grass silage	Rhodes grass silage	SEM	p-value
pH	0	4.28^h	5.1^h	5.27i	0.016	0.0001
	3	1.78^b	4.35^f	4.26^e	0.016	0.0001
	5	1.5^a	4.14^b	4.18^c	0.016	0.0001
NH_3N	0	4.28^h	3.94^e	4.33^i	0.015	0.0001
	3	1.78^b	2.85^d	4.22^g	0.015	0.0001
	5	1.50^a	2.6^c	4.12^f	0.015	0.0001

Mol - molasses, SEM- Standard error of means. Means within row and column with different superscript letters are significantly different (P < 0.05).

Effect of species and different levels of molasses on grass silages stability during feed out

Stability prevents silage from spoiling when exposed to air and by doing so; it can improve the efficiency of a farm by preserving forage as high quality silage that is palatable to cows. The results showed that, elephant grass silage was more stable than guatemala and rhodes grass silage as indicated by pH (Table 8). pH is one of the simplest and quickest way of evaluating silage quality. However, pH may be influenced by the moisture and the buffering capacity of the original materials. Silage that has been properly fermented will have a much lower pH (be more acidic) than the original forage. The pH value of the silages which ranges of 3.5-5.5 classified to be pH for good silage (Menesses *et al.,* 2007). According to Lyimo, (2010) silage with pH below 5 was considered as stable silage. In this present study, Elephant grass silage was stable up to the fourth day. Guatemala grass silage up to third day and rhodes grass silage up to second day.

Silages with molasses at 5% level were more stable (in terms of maintaining low pH value (<5) for longer period than those from molasses at 3% and 0% levels. The control silages had the pH values greater than 5 even before the feed out trial. The silages with molasses at 3% level maintained the pH values < 5 up to the third day of feeding out and silages with molasses at 5% level maintained the pH values < 5 up to the fourth day of feeding out.

Table 8 Effect of specie and molasses additive levels on stability of grass silages

Parameter (%)	Factors			SEM	p-value
	Effect of specie				
	Elephant grass silage	**Guatemala grass silage**	**Rhodes grass silage**		
Phdy0	4.28^c	4.39^b	4.45^a	0.0089	0.0001
Phdy1	4.47^c	4.64^b	4.85^a	0.0124	0.0001
Phdy2	4.54^c	4.79^b	4.96^a	0.0112	0.0001
Phdy3	4.78^c	4.92^b	5.23^a	0.0112	0.0001
Phdy4	4.99^c	5.48^b	5.50^a	0.0078	0.0001
Phdy5	5.79^c	5.92^b	6.26^a	0.0238	0.0001
Phdy6	5.83^c	6.08^b	6.35^a	00.011	0.0001
Phdy7	5.40 ^{b}	5.43^b	5.60^a	0.0131	0.0001
	Effect of molasses additive levels				
	MOL0%	**MOL3%**	**MOL5%**		
Phdy0	5.19 ^{a}	4.03^b	3.94^c	0.0089	0.0001
Phdy1	5.30^a	4.49^b	4.16^c	0.0124	0.0001
Phdy2	5.37^a	4.62^b	4.33^c	0.0112	0.0001
Phdy3	5.51^a	4.85^b	4.57^c	0.009	0.0001
Phdy4	5.94^a	5.28^b	4.75^c	0.008	0.0001
Phdy5	6.66^a	5.85^b	5.45^c	0.024	0.0001
Phdy6	6.6^a	5.98^b	5.67^c	0.011	0.0001
Phdy7	5.79^a	5.39^b	5.25^c	0.013	0.0001

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

DISCUSSION

Effect of grass specie and different levels of molasses on organoleptic of silage quality

Higher sensoric scores from elephant grass than those of guatemala and rhodes grass silage might have been caused by improved fermentation condition in elephant grass silages than in guatemala and rhodes grass silages (Table 3). Good silage usually preserves the original colour of the pasture or any forage. The olive green color obtained from elephant grass in the present study was in order. It was close to the original colour of the grass which was an indication of good quality silage that was well preserved (Oduguwa *et al*., 2007). Kung and Shaver (2002) reported that pleasant smell is accepted for good or well-made silage. The pleasant smell could be attributed by good aroma from molasses of well fermented silages. The texture of the elephant grass silages was firm which was expected to the best texture of good silage (Kung and Shaver, 2002).

Higher sensoric scores observed in silages with molasses at 5% level than silages with molasses at 3% and 0% levels possibly was due to increased substrate for lactic bacteria which enhanced more lactic acid production resulted to good fermentation process(Table 3). This implied that, molasses at 5% is optimal level which secured good fermentation compared to other levels. This was in agreement with observation reported by Manyawu *et al*. (2003), Mtengeti and Urio (2006) and Lyimo (2010) who found well fermented silages after molasses was applied at 5% level.

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

Higher CP and ash but lower DM and WSC found in elephant grass silages than guatemala and rhodes grass silages (Table 4) was related to the original chemical composition of individual grass specie before ensiling.

More DM recovery with molasses at 5% level (Table 4) compared to level 0 and 3% may be due to the addition of WSC that improves the fermentation characteristics. Once the silage gains the stability then there is no more fermentation and at very low pH the microbes become the part of medium and reduction in DM is prohibited. The results were inconsistence with Mtengeti *et al*. (2013). Observed high CP may be due to increased level of molasses. Molasses had small amount of CP (2.17%), for this reason, any addition of CP leads to increase in CP content. The results were in agreement with those found by Adesogan *et al*. (2004) who found higher CP in treated silages than in untreated silages. Observed high WSC could be attributed by increased energy for lactic bacteria due to increased substrate resulted to more lactic acid production, leads to rapid pH reduction and when the process stops WSC remains as recovery substrate. This was in agreement with McDonald *et al*. (2002) who observed good fermentation after adding more WSC to the herbage with high water and low WSC. In cases where forage has an insufficient amount of WSC, it is difficult to ensile satisfactory. Observed high ash could be attributed by high minerals found in molasses that can increase ash. This result was inconsistence with (Gofoon and Khalifa, 2007, Aksu *et al*., 2006, Donmez *et al*., 2003) who found higher levels of ash after addition of molasses to the grasses. Increased IVDMD could be attributed to the provision of useful energy substrate for ruminal microbes and thus improve their effectiveness in digesting feed particles. The importance of molasses as useful energy substrate for ruminal microbes have been documented by McDonald *et al*. (1973). Low NDF could be attributed to increased acidity which stimulated further hydrolysis of linked sugar molecules in the cell wall causing further breakdown of hemicelluloses. Breakdown of up to 50% of hemicelluloses during silage fermentation has been documented by McDonald *et al*. (1991).

Interaction effect of grass specie and different levels of molasses on composition of silage quality

Higher CP from interaction of elephant grass and 5% level of molasses than other interactions (Table 5) is related to the original CP of elephant grass compared to those of guatemala and rhodes grass. Higher WSC possibly was due to increased molasses level at 5% than molasses at 3% and 0% levels. Thus, the interaction of elephant grass and molasses at 5% level resulted to efficient fermentation than other interactions in this study. The results implicated that nutrient contents of the grass silage vary depending on the specie and silage additives levels. The results are related to those of Baytok and Muruz (2003) who found that, both nutrients and pH of the grass silage vary depending on the specie, vegetation period and silage additives. Thus, from this study, consideration of grass specie and silage additive level can be useful tools to improve silage quality.

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

Higher lactic acid, acetic acid but lower pH, NH_3N found in elephant grass silage than guatemala and rhodes grass silages (Table 6) indicated that, elephant grass was better option for silage preservation compared to guatemala and rhodes grasses. Low pH and NH_3N could be due to higher lactic acid in elephant grass which allows fermentation and increases acids that could preserve grass well.

The observed higher lactic acid and acetic acid but lower ($p \leq 0.05$) pH and NH_3N in silages with molasses at 5% level than molasses at 3% and 0% levels probably, could be due to additional energy supplied by the increased molasses which created more conducive environment for the anaerobic fermentation bacteria ('t Mannetje, 2000). According to Yang *et al*. (2004), attainment of low pH is one of the important determinants for final silage fermentation quality. The addition of any level of molasses could lower pH and it enhances the lactic acid and improves the fermentative quality of silage. Silage that has been properly fermented will have a much lower pH (be more acidic) than the original forage. This fermentation characteristic is maximized when sugars are primarily fermented to lactic acid. The addition of WSC additives (molasses or maize bran) at the ensiling process as a source of energy could stimulate the pH drop during ensiling. The results are in agreement with Aminah *et al*. (2000) and Baytok *et al*. (2005) who observed improved fermentation after applied high levels of molasses. Deamination process decreases in low pH (Slottner and Bertilsson, 2006). The reduced NH_3N were observed for good grass silage by Kung (2009). These could be due to readily satisfactory available energy provided by molasses at 5% level to the fermenting bacteria (Lyimo, 2010, Mtengeti *et al*., 2013) to produce lactic acid which rapidly lowers pH and stops proteolysis resulted to reduced NH_3N. The proteolytic activities were merely restricted when the pH of the fermented silage is 4.3 or lower and in good silage the process will stop earlier and limit the loss of protein (Man and Wiktorsson, 2002). Molasses has high concentration of soluble carbohydrate that can stimulate heterofermentation process in silage but could not inhibit proteolysis (Aksu *et al*., 2006). Butyrate was negligible at 5% level and indicated that high restriction of the development of yeast which could increase butyric acid. Clostridia can grow in silage that has high soluble carbohydrate. They can degrade protein to ammonia (Ward *et al*., 2001).

Interaction effect of grass specie and different levels of molasses on organoleptic of silage quality

Lowest pH and NH_3N produced from the interaction of elephant grass and 5% level of molasses (Table 7) possibly was due to improved fermentation condition in elephant grass mixed with molasses at 5% level which leads to efficient fermentation than in the other interactions.

Effect of species and different levels of molasses on grass silages stability during feed out

Higher stability observed from elephant grass silage (Table 8) than those of guatemala and rhodes grass silage possibly was due to good condition in elephant grass which allows fermentation and increases acids that could preserve grass and prevent growth of yeasts which could cause early deterioration of silage. According to Wilkinson and Davies (2012), aerobic deterioration of silage occurs mainly during the feed out phase due to greater activity of yeasts and molds, which develop on the residual carbohydrates and lactic acid as substrates, increasing the pH and favoring the growth of spoilage microorganisms in addition to yeasts, and decreasing the nutritional value of the silage. Achieving a good silage fermentation that is dominated by the production of lactic acid will increase the stability of silages during the feed out.

The higher stability found in silages with molasses at 5% level than those of molasses at 3% and 0% levels that adding molasses in higher levels affects silage stability. According to Jaurena and Pichard (2001) molasses, a source of WSC, is often used to help preventing silage instability. Molasses has high concentration of soluble carbohydrate that can stimulate heterofermentation process in silage but could not inhibit proteolysis (Aksu *et al*., 2006). Heterofermentation is a kind of fermentation which produce butyric acid and acetic acid, they have antimicrobials activity and eliminate growing fungi, mold and yeast but increase aerobic stability in feed out phase. The aerobic stability of the silage with molasses was increased thereby potentially preventing the growth of spoilage organisms (Danner *et al*., 2003). This was in consistence with other workers elsewhere (Lyimo, 2010; Mtengeti *et al*., 2013) who found high stability after application of molasses at 5% level to the fodder grass. Thus, the inclusion of molasses at 5% level may be a successful strategy for improving grass silage stability.

CONCLUSION

- Elephant grass silage had higher appearance, smell and texture score, CP, ash, lactic and acetic acids, stability but lower DM, pH, NH_3N and butyric than guatemala and rhodes grass silage.
- Grass silages treated with molasses at 5% level had higher appearance, smell and texture score, DM, CP, WSC, ash, IVDMD, lactic and acetic acids, stability but lower NDF, pH and NH_3N compared to silages with molasses at 3% and 0% levels.
- The interaction between grass specie (elephant, guatemala and rhodes grasses) and different molasses levels (0%, 3% and 5%) showed that, the interaction of elephant grass and molasses at 5% produced best silage as indicated by highest CP, WSC but lowest pH and NH_3N.

Therefore, it was concluded that, elephant grass mixed with molasses at level 5% was the most optimal technique to achieve high quality silage under smallholder farmers.

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