Silage making from mowed grasses and its potential *use* as a feed resource for sheep

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Abstract

This study evaluated silage making from mowed grass on fermentation characteristics and nutrient intake by sheep. Mowed grass was collected from a local stadium in Pretoria and brought to a farm for silage making and animal feeding. The grass was mixed with sugarcane molasses at 5% of the biomass and ensiled in 210 L drums that were lined with plastic bags (900mm x 1200mm; 240 L capacity; 18 microns).. The grass mixture was ensiled for 60 days, opened and sampled for the analysis of nutrient content and silage fermentation characteristics. The animal feeding trial was then conducted whereby two groups of seven animals each (average liveweight of 31.11 ± 0.49 kg) were fed either silage or a feed that was produced on farm (control) for five weeks. The silage group was supplemented with sheep pellet feed at a rate of 200 g daily. Sheep were weighed at the start of the trial and then weekly until the end of the trial. Mixing the mowed grass with sugarcane molasses improved the sugar content of the silage. As can be expected, silage fermentation reduced the pH and produced lactic acid. Feed intake was higher (P<0.05) from the silage group compared to the control group, suggesting that the silage was well accepted by the sheep. Silage from mowed grass can be produced with the addition of sugarcane molasses and can be a good source of feed for ruminants during the dry season especially drought conditions.

Keywords: drums, fermentation, forage, grass, stadium turf
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Introduction

The grazing land, which is the sole provider of feeds to livestock under smallholder operations, is rarely providing adequate (in quantity or quality) year-round feed to support highly productive livestock (Suttle, 2000). This shortage of animal feeds is a challenge faced by smallholder livestock farmers towards achieving profitable livestock production in South Africa (SA), especially during the dry season and or droughts. Drought is a recurring phenomenon in SA that has devastating impacts on the farming community. For instance, during the 2015/2016 drought, farmers lost large numbers of animals (animals (Mare *et al*., 2018; Bahta & Myeki, 2022). It is predicted that Southern Africa will continue to experience severe global warming incidences in the future, and therefore strategies to preserve animal feeds should be put in place to mitigate the potential negative effects. There is a lot of grass from stadiums and agri-parks or open fields that is mowed and dumped without any use during the wet season. These grasses contain nutrients such as protein, fibre, etc. which can benefit livestock production if used for animal feeding. In order to have enough forage for animal feeding during the dry season and especially during droughts, mowed grasses can be ensiled as a forage preservation method to bridge gaps in feed shortages.

However, most of the tropical grasses are in nature, contain low levels of fermentable sugars and high buffering capacity with less sugar content to promote silage making (McDonald *et al*., 2010; Tao *et al*., 2021). One of the guidelines for silage making is that the forage should contain a minimum of 6% soluble sugars to promote efficient fermentation of ensiled forages for the production of quality silage (Lunden-Pettersson & Lindgren, 1990; Piltz *et al*., 2022). With the low content of dry matter (DM) and water-soluble carbohydrate (WSC) from these mowed grasses, farmers need to wilt or use silage additives when ensiling this type of forage. Consequently, the addition of sugarcane molasses has been recommended to increase the sugar content in grasses that have high buffering capacity and low soluble sugars (Zhang *et al*., 2013). The intake of silage by ruminants is one of the factors that determines silage quality because poorly produced silage can reduce intake by ruminants (McDonald *et al*., 2010).

Kikuyu grass (*Cenchrus, clandestinus*), is a creeping, subtropical perennial grass that forms a dense turf, tolerant of continuous heavy grazing and is very persistent (Rautenbach *et al*., 2008). This grass is a popular choice for silage making in South Africa due to its high production potential and palatability, particularly for dairy cows. This grass is mostly cultivated in stadium pitches and agri-parks in South Africa. As the grass grows longer, it is often mowed to keep the condition of the pitch in good shape for sports and relaxing in agri-parks or open fields. The mowed grass is often dumped in pits or bins, causing environmental pollution. It is worth noting that kikuyu grass at vegetative growth stage has *in vitro* digestibility of 54% (de Figueiredo & Marais, 1994), CP content of to 22% DM and a total digestible nutrients (TDN) of 58.6% on a dry matter (DM) basis (Muller, 2017). Kikuyu grass silage can achieve moderate to high quality feed that contains 9-10.5 MJ ME/kg DM (Griffiths & Beale, 2021) and DM digestibility of 65% (Kaiser *et al*., 2004), which can benefit livestock production. However, the CP concentration of kikuyu grass decreased with growth maturity to reach levels of < 6% DM (Rautenbach *et al*., 2008). This means that the nutritive value of this forage declines in winter compared to summer months, hence should be ensiled in summer.

Kikuyu grass contains some anti-nutritional properties such as nitrosamines, a well-known carcinogens which may be absorbed into the blood of the ruminant and transferred to the milk (Marais, 1983) but that can be reduced by the ensiling process due to the low silage pH. In addition, the palatability of this forage can be enhanced by ensiling (Villalobos-Villalobos & Arce-Cordero, 2022). The present study seeks to evaluate the ensiling potential of mowed kikuyu grass from stadiums as an alternative feed resource for livestock feeding by resource poor livestock farmers.

Materials and Methods

Silage production and fermentation

Cenchrus clandestinus (kikuyu) was mowed with a grass mower (Red rhino ride-on lawn mower, model RLM-TTM86H) in 2 - week intervals, which was repeated 3 times before the collection of samples. Batches of mowed kikuyu grass was collected immediately in February 2024 after the third cut (i.e. 3rd interval) of the season from a local stadium in Pretoria, South Africa and brought to the Bronkhorstspruit farm, which lies 30 km east of Pretoria for the making of silage, sampling and sheep feeding. Upon arrival at the farm, the grass weight was recorded and spread on a concrete surface, then mixed with sugarcane molasses at 5% of the total biomass. The mixture of grass with sugarcane molasses was ensiled in ten 210 L drums that were lined with plastic bags (900mm x 1200mm; 240 L capacity; 18 microns). Samples of the freshly mixtures were collected prior to ensiling for the analysis of dry matter (DM), WSC and pH. After 60 days of ensiling, 3 representative drums were opened, sampled and analysed for fermentation characteristics (i.e. DM, WSC, pH and lactic acid (LA) and for nutrient contents (i.e. crude protein, ether extract, gross energy and fibre fractions).

Analysis of the fresh grass and silage

A representative 40 g silage sample of the pre-ensiled forage mixture and that of silage (i.e. day 60 post ensiling) was taken to determine the fermentation characteristics (i.e. pH, DM, WSC and LA). The 40 g silage sample (n=3) was mixed with 360 ml of distilled water in a stomacher bag, homogenized for 4 min and pH was immediately determined with a pH meter (Thermo Orion Model 525, Thermo Fisher Scientific, Waltham, MA, USA). It was then filtered through a Whatman No. 54 filter paper (G.I.C. Scientific, Midrand, Gauteng, South Africa). The extract was used for the determination of pH, water soluble carbohydrates (WSC) and lactic acid (LA). The WSC were determined by the phenol-sulphuric acid method of Dubois *et al*. (1956) and LA was determined by the modified colorimetric method of Pryce (1969).

The DM of pre-ensiled forage mixtures and that of silages was determined by drying the samples at 60°C until a constant mass was achieved, and was corrected for loss of volatiles using the equation of Weissbach and Strubelt (2008). Dry matter recovery was calculated using weights of compacted jars before and after the 60 day ensiling period, and the DM contents. After drying, the samples were ground through a 1 mm screen (Wiley mill, Standard Model 3, Arthur H. Thomas Co., Philadelphia, PA) for crude protein (CP), gross energy (GE), neutral detergent fibre (aNDF) and acid detergent fibre (ADF) analyses. The CP was determined according to the procedure of AOAC (1990, ID 968.06), while the GE was determined with an adiabatic bomb calorimeter (IKA C7000, Staufen, Germany). The aNDF and ADF were determined according to the procedures of Van Soest *et al*. (1991). The aNDF concentration was determined using heat stable α-amylase (Sigma-Aldrich Co. LTD., Gillingham, UK, no. A-1278) with sodium sulphite, and the ADF concentration was determined using the Fibretec System equipment (Tecator LTD., Thornbury, Bristol, UK). Separate samples were used for ADF and aNDF analysis, and both included residual ash.

Animal feeding experiment

This experiment was conducted on a farm that is located in Bronkhorstspruit, which is in the northern region of Gauteng Province, South Africa. A total of 14 ewes with an average liveweight of 31.11 ± 0.49 kg were used in the study. The initial body weights of the ewes were recorded and used to stratify the ewes by weight into two groups of 7 animals per group. These animals were then randomly allocated into two animal feed treatments, which were i) grass silage (referred to as T1) and ii) control treatment (referred to as T2). This was done to minimise bias regarding the initial average weight of the groups. The T1 group was each supplemented daily with 200 g of sheep pellets, while the T2 group was fed a diet (Table 1) that was produced on the farm. The animals were allowed a 14-day adaptation period, and the trial period lasted for 5 weeks post-adaptation. Daily feed offered and orts (feed refusals) were measured and body weights were recorded at the beginning and the end of the feeding period.

The study employed descriptive statistical measures to summarize the fermentation and nutrient composition of the mowed grass and its silage data with the focus on the mean ($\bar{x}$) and standard error of the mean (SEM). The mean ($\bar{x}$) was calculated to provide the measure of central tendency representing the average value of the dataset and is given as follows:

$$\bar{x} = \frac{1}{n} \sum_{i=1}^{n} x_i \; ;$$

where x_i is the individual data points and n is the total number of the observations (Field, 2018).

The mean ($\bar{x}$) assist in understanding the general trend of the dataset.

The standard error of means (SEM) was computed to quantify the precision of the sample mean as an estimate of the population mean and is calculated as follows:

$$SEM = \frac{s}{\sqrt{n}} \; ;$$

where s is the sample standard deviation and n is the sample size (Moore *et a*l., 2021). The SEM gives the variability of the sample mean across repeated sampling. Small SEM indicates more precise estimates of the population mean while larger SEM suggests more variability in the data.

Data on the feed intake were subjected to an appropriate analysis of variance (ANOVA) using GenStat ® (2023). Means of significant effects were compared using Student's t-LSD (least significant difference) at a 5% significance level (Snedecor & Cochran, 1980).

The Model fitted :

$$Y_{ij} = \mu + T_i + \varepsilon_{ij}$$

where Y_{ij} is the general observations, μ is the general mean (feed intake and body weight), T_i is the feed treatment (silage or control feed) effect and ε_{ij} is the random error effect.

Table 1 Feed ingredients nutrient content of feed used as control on farm (n=3)

Parameter	**amount**
Feed ingredient (kg)	
Maize meal	585 kg
Lucerne meal	40 kg
SS200	150 kg
Sugarcane molasses	120 kg
Hominy chop	0 kg
Soya meal	0
diatoms	0 kg
salt	50 kg
Nutrient content	
DM %	91.79+0.304
CP % DM	14.90+0.379
EE % DM	3.87+0.145
Gross Energy MJ/kg DM	16.47+0.193
aNDF % DM	26.84+0.184
ADF % DM	10.27+2.637

DM, dry matter; CP, crude protein; EE, extracted ether; aNDF, amylase treated neutral detergent fibre; ADF, acid detergent fibre

Results and discussion

Silage fermentation and nutrient contents

The fermentation characteristics and the nutritive values of the grass are shown in Table 2. When silage DM content is less than 25%, conditions for *clostridial* activity are favourable, which will result in high losses and silage of low nutritional value (Wilkinson, 2005). Freshly cut kikuyu grass generally contains low DM (Muller, 2017) but that can be improved by wilting the grass before ensiling. In this study, the DM content of freshly mowed kikuyu grass was 51% (Table 2), suitable for ensiling. Water-soluble carbohydrates serve as food for the lactic acid bacteria (LAB) to produce lactic acid (LA), which is a strong acid that reduces silage pH and fights unwanted bacterial organisms (McDonald *et al*., 2010). Kikuyu grass generally contains WSC that ranges 2-7% DM (Kaiser *et al*., 2000), which is consistent with that of our study at pre-ensiling. Lunden-Pettersson & Lindgren (1990) recommended an amount of 6–7 WSC % DM in a forage to achieve a well-preserved silage. The kikuyu grass of the present study had WSC content of more than this threshold, which was sufficient for proper fermentation. This is attributed to the addition of sugarcane molasses which improved ($P<0.05$) the sugar content of the forage, consistent with Zhang *et al*. (2013) when sugar cane molasses was added to *Urtica cannabina* forage at ensiling.

It is well established that tropical forages such as legumes and kikuyu grass have a high buffering capacity (an indicator of the ability of the forage to resist pH change), leading to higher final pH (>4.00) of the silage (McDonald *et al.*, 2010). Kikuyu grass is reported to have a buffering capacity that ranges from 224.7-495.7 mq/kg DM (Kaiser *et al*., 2000). This is one of the reasons we recorded a higher terminal silage pH than commonly recorded in silage made from cereal crops. After adding sugarcane molasses to kikuyu, Piltz *et al*. (2000) reported silage pH of 4.34 which is lower than that of the present study.

Table 2 The fermentation dynamics and nutrient content of ensiled kikuyu grass (n=3)

Parameter	Day 0	Day 60
DM %	51.22+1.610	52.58+3.231
WSC % DM	10.54+1.648	7.92+0.847
pH	6.51+0.347	5.26+0.678
LA % DM	-	13.98+3.922
CP % DM	14.48+0.108	11.85+0.359
EE % DM	3.56+0.228	3.13+0.067
Gross Energy MJ/kg DM	15.75+0.064	16.20+0.089
aNDF % DM	56.81+0.499	49.04+0.154
ADF % DM	29.14+0.153	28.42+0.61

DM, dry matter; WSC, water-soluble carbohydrates; LA, lactic acid; CP, crude protein; EE, extracted ether; aNDF, amylase treated neutral detergent fibre; ADF, acid detergent fibre

In contrast, Villalobos-Villalobos & Arce-Cordero (2016) recorded pH of 8.02 in kikuyu grass silage after 90 days of ensiling, which is higher than that of the present study. This might be attributed to the differences in DM contents, buffering capacity and the type of cultivars used between these studies.

The LA is the strongest of all silage acids and its presence will reduce the pH more effectively than other organic acids (McDonald *et al*., 2010). Silage produced from kikuyu grass that contained 40-50% DM, is expected to produce LA content that ranges between 6-8% of DM (Kung Jr. & Shaver, 2001). However, the LA content of the silage from our study was 14% of DM, higher than this threshold. This increase in LA might be attributed to the addition of sugarcane molasses, which served as food for the LAB to produce LA (McDonald *et al*., 2010). This suggests that the addition of molasses to kikuyu at ensiling exhibited characteristics of a homolactic acid additive by increasing LA, which makes it a stimulant to silage fermentation (Lunden-Pettersson & Lindgren, 1990).

Villalobos-Villalobos & Arce-Cordero (2022) reported average content of CP in kikuyu silage which was similar with that of the kikuyu grass silage in the present study. According to Wilkinson (2005) silages should contain CP of 7-9% DM. The CP content of our kikuyu grass at ensiling was 14% and dropped to 12% DM after 60 days of ensiling. This is an indication that some protein components were lost through proteolytic activity which results in the production of ammonia-N in silage (McDonald *et al*., 2010). However, Villalobos-Villalobos & Arce-Cordero (2016) recorded CP of 8% DM from kikuyu grass silage that was ensiled for 90 days.

After 60 days of ensiling, the kikuyu grass silage of the present study had CP content of 12%, higher than that of Villalobos-Villalobos & Arce-Cordero (2016). This indicates that only a small amount of CP was lost as ammonia-N in the kikuyu silage of the present study. The reduced silage pH in the kikuyu grass had an effect on the reduced loss of protein during ensiling since proteolysis is more rapid at a high pH (Wilkinson, 2005).

Kikuyu grass has a higher NDF and ADF contents, making it a more bulky pasture type (Muller, 2017). According to Table 2, the reduced concentrations of NDF in silages compared to the original herbage reflects the breakdown of hemicellulose during ensiling, which provides additional substrate for the fermentation process (McDonald *et al*., 2010). De Villiers et al. (2002) recorded an average NDF concentration of 82% DM in kikuyu grass, higher than the 57% DM of NDF content in our study. However, ensiling reduced this NDF level to 49% DM after 60 days of ensiling. This can be attributed to the hydrolysis of the fibre constituents by organic acids produced during fermentation.

Effects of feeding Kikuyu grass silage on animal performance

According to Boval & Dixon (2012), the intake of DM and digestible nutrients is an essential driver for livestock productivity. Poor intake of DM combined with less digestible nutrients will render the feed worthless. The effects of feeding the experimental diets (i.e. T1 and T2) on feed intake is shown in Figure 1. There was a significant ($P<0.05$) increase in feed intake from week 2 to week 5 on animals that were fed the silage diet as compared to animals that were fed the control diet. This high feed intake suggests that the silage was well received by animals and could be attributed to the quality of the silage. Sheep are reported to have a high consumption of tropical grasses especially when the digestibility is above 55% (Leng, 1984). The improved feed intake reported in the current study (Table 4) could reflect the palatability of the silage to animals or influenced by the addition of pellets that contain CP of 13% DM (Table 3). Adding or supplementing grass silage with dried pellets was reported to increase both the DM and CP content of a diet, and improved dietary intake in dairy cows (Mogensen & Kirstensen, 2003). This might be the reason for improved feed intake in sheep fed the grass silage diet compared to the control feed in the present study. In addition, Helander *et al*. (2014) reported improve feed intake when ewes and lambs were fed on grass silage that was supplemented with pellets.

Villalobos & Arce (2016) reported that the addition of kikuyu silage to dairy cattle diets improved feed intake compared to the addition of hay. The protein content reported in this silage (Table 2) is above the minimum requirement 6-8% CP/DM for microbial breakdown of ingested feed in the rumen (Mannetje, 1984) and that might influence nutrient digestibility, which then enhance feed intake (Van Soest, 1994). Highly digestible feed have shorter retention period in the rumen and thus increases feed intake (Brask-Pedersen *et al*., 2022; Riesgraf *et al*., 2024). Meissner *et al*. (1991) advised that feed intake is generally reduced when the NDF content of a forage/feed is around 55-60% DM. Our kikuyu grass silage contained less NDF than this threshold, hence improved feed intake by the sheep.

Table 3 Nutrient content of sheep pellets supplemented to kikuyu grass silage (n=3)

Parameter	Nutrients
DM %	80
CP % DM	13
EE % DM	25
Crude fibre g	135
Calcium g	15
Phosphorus g	3
Magnesium g	2.30
Sulphur g	2.30
Potassium g	9.50
Selenium mg	0.18
Manganese mg	35.00

DM, dry matter; CP, crude protein; EE, extracted ether

Table 4 Metabolic feed intake and nutrient intake of sheep that were fed kikuyu silage and the control diet (n=3)

Parameters	**T1**	**T2**	**SEM**	***p-value***
Number of animals	7	7	-	-
CP (g/head/day)	138.66^{b}	180.59^{a}	9.248	0.0125
NDF (g/head/day)	843.81^{a}	325.30^{b}	51.991	0.0001
ADF (g/head/day)	489.01^{a}	124.47^{b}	29.771	<.0001

T1, Grass silage; T2, Control treatment; SEM, Standard error of the mean
CP, crude protein; NDF, neutral detergent fibre; ADF, acid detergent fibre

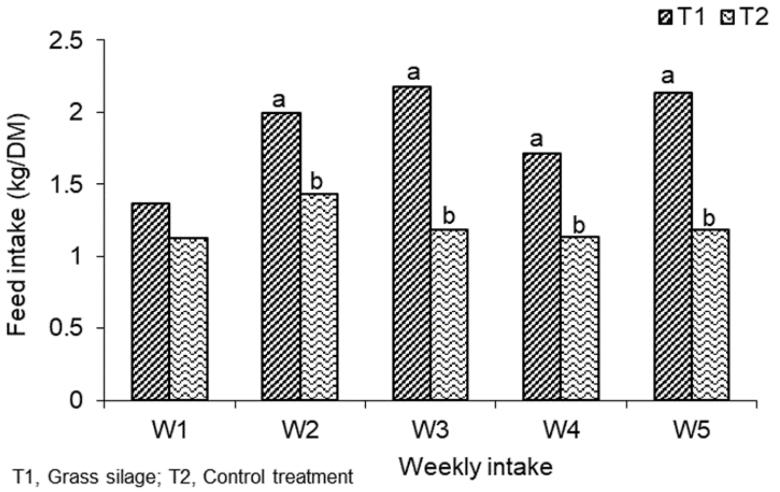

Figure 1 Feed intake per animals per week

Figure 2 shows the animal's initial and final body weight as influenced by treatments. The body weights show no differences (P>0.05) in final body weight. However, high body weights were recorded on animals that were fed the control diet (farmer's diet). These results are contradicting El-Hamid & El-Menem (2008) who reported improved body weights in dairy cattle when kikuyu grass silage was increased in the diet. The lack of significant difference in the weight gain in this study could be attributed to the fact that the control diet have almost similar nutrient composition (Tale 2) with the kikuyu silage and that the animals were already matured.

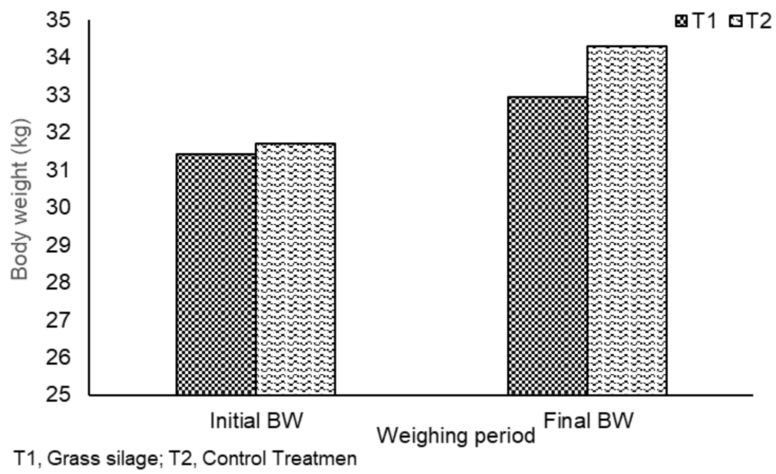

Figure 2 Initial and final body weights of animals that were fed kikuyu grass silage and control diet.

Conclusion

The use of silage additives such as sugarcane molasses can be reliable when ensiling kikuyu grass due to its low DM and WSC contents coupled with its high buffering capacity. However, the addition of lactic bacteria inoculant could further assist in increasing lactic acid production. This will assist to achieve a satisfactory lactic acid type of fermentation. The increase in feed intake of the silage by animals reflects that the silage produced was of good quality and very palatable. The lack of difference in the weight gain could be attributed to the similar nutrient content of the two experimental diets and that the animals were already matured. Feeding kikuyu grass silage to livestock can be a valuable practice, especially during the winter months when the growth of the natural pasture is limited.

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Conflict of Interest

The authors declare no potential conflict of interest.

Author's contributions

Conception: BDN & TDEM. Data collection: TML & NPT. Data analysis: BDN, TDEM & NPB. Critical revision and final approval of version to be submitted: BDN, TDEM, NPB, KC & JM.

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