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# EVALUATION OF NUTRITIONAL QUALITY OF SILAGE FROM SWEET POTATO VINES, NAPIER GRASS AND THEIR MIXTURES AS FEED FOR LIVESTOCK

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## ABSTRACT

The present study investigated the nutritional and fermentative characteristics of silage from sweet potato vines (SPV), Napier grass (NAP) using maize bran as a source of fermentable carbohydrates. Chopped SPV, Napier grass NAP and their 1:1 mixture (SPV-NAP) were thoroughly mixed with finely ground maize bran followed by hand compacting into 1 kg laboratory sized plastic micro-silos in three replicates. Three laboratory micro-silos for each treatment were opened after a 60 day fermentation period. The means were compared using PROC GLM procedures of SAS (2003). The chemical composition of silage significantly ($P<0.05$) varied with the type of material ensiled. Silage dry matter (DM) content varied ($P<0.05$) with type of material ensiled. The DM content of SPV and SPV-NAP silage was higher ($P<0.05$) than that of NAP silage. Crude protein was higher ($P<0.05$) in SPV-NAP silage as compared to SPV and NAP silage. Silage pH of 3.84 for the SPV and SPV-NAP silages was lower ($P<0.05$) than the pH (4.73) NAP silage. The ammonia-Nitrogen content of the silage followed a similar trend with that of pH, with the highest ammonia yield recorded for NAP silage. The lactic acid content was significantly ($P<0.05$) higher in SPV silage (6.1%) than the 4.5% on DM basis for NAP and SPV-NAP silage. The lactic acid: acetic acid ratio did not significantly differ ($p<0.05$) across the ensiled material. These results indicated that SPV can be ensiled together with NAP under circumstances where neither of the two is insufficient quantities for silage production without compromising the silage quality and storability.

**Keywords**: Nutrient composition, Silage, Silage quality, Sweet potato vines and Napier grass

  

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## INTRODUCTION

Dairy production in Uganda is still dominated by smallholder farmers who keep a small number (1-5) of cattle especially in the urban and peri-urban areas where land remains a scarce resource. Under this system, the cattle are commonly stall-fed with Napier grass as the main basal diet alongside sweet potato vines (SPV) and a protein supplement like calliandra (Mugerwa et al., 2013). Napier is preferred due to its high biomass yield which ranges between 10 to 25 tonnes/ ha dry matter and relatively good crude protein content (Kabirizi et al., 2014). During the rainy season farmers may have excess herbage yield of the Napier which cannot be utilised in feeding cattle. Similarly, sweet potato vines are high in crude protein content and with high dry matter yield. In Uganda, farmers tend to feed their cattle on fresh Napier and SPV which are harvested a few hours prior to being served to the animals.

However, as the dry season approaches, the nutritional quality of both Napier grass and SPV if not harvested at the right time continues to decline. This further results into a reduction in the crude protein content and an increase in the fibre content as they approach maturity. This therefore necessitates the use of feed conservation strategies (climate change adaptation measures) like hay making and silage production to guarantee availability of these feed resources during the dry season when farmers are experiencing a lot of feed scarcity.

Napier grass and sweet potato vines are characterised by low dry matter content, low water soluble carbohydrates (WSC) and high buffering capacity due to the high crude protein content at early stages of maturity (Bureenok et al., 2012) which in turn makes it difficult to achieve good silage when these materials are ensiled alone. Moreover, high moisture content of pre-ensiled materials facilitates the activity of undesirable silage spoilage microbes like clostridia and enterobacteria which are associated with poorly preserved silage (McDonald et al., 1991). To achieve good silage quality from Napier grass and SPV, farmers mostly use sugarcane molasses as a source of WSC. However, due to difficulties in wilting Napier and SPV during the rainy season, the use of sugarcane molasses as a silage additive during the rainy season increases the effluent production from silos, which represents a significant loss of nutrients from the ensiled biomass. Use of maize bran as a source of WSC and absorbent minimises effluent production when high moisture materials are to be ensiled.

Although some dairy cattle farmers have picked interest in making silage from Napier, they have observed and argued that Napier silage is of inferior quality and palatability as feed for dairy cattle. On the other hand, good quality silage can be made from SPV due to their high crude protein content, high digestibility and palatability as a livestock feed (Kabirizi et al., 2015). However, where farmers don’t have sufficient quantities of SPV to ensile alone, there is need to

  

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explore the possibility of making silage from a mixture of SPV and Napier. Hence, there is need to explore potential benefits such as: improved crude protein content, increased digestibility and palatability that could accrue from making silage from a mixture of SPV and Napier silages. This can be an alternative for utilising more elephant at early maturity because the SPV can act as an absorbent in addition to increasing the crude protein content and lowering the crude fibre of silage. We therefore, hypothesized that silage from a mixture of SPV and Napier is of better quality than silage from Napier alone but comparable to that from SPV alone. Therefore the objective of this study was to evaluate and compare fermentative and nutritional quality of silage from SPV; and a mixture of SPV and Napier as well as silage from sole Napier grass as feed for livestock.

## MATERIALS AND METHODS

The forages utilised included: Napier grass and sweet potato vines which were grown at two different smallholder farmer's plots in Wakiso district, Central Uganda (Table 1). The experiment was completely randomised with three treatments and three replicates. Napier grass (NAP) was replaced at 50% by sweet potato vines (SPV) on a natural matter basis. The Napier (7days growth) and sweet potato vines were manually harvested with a sickle during the rainy season and separately chopped into 2-3 cm fragments through a motorised chopping machine.
A total of nine (9) micro-silos each of 1.0kg average weight were prepared into two batches.
Chopped NAP grass and SPV and their mixture (NAP-SPV) were separately mixed with 10% (w/w) maize bran per weight of chopped forage on a clean tarpaulin to obtain homogeneity. The NAP, SPV and NAP-SPV were compacted in 1.0 kg transparent micro-silos. The materials were rapidly hand compacted to expel as much oxygen as possible and tightly sealed with a lid. An adhesive tape was used to further ensure air tight conditions. The micro-silos were then stored at 25°C for a period of 60days during which turning of the micro-silos was frequently done to ensure even distribution of effluent.

### Sample preparation for analysis

At the end of the 60 day ensilage period, the silos were subjected to organoleptic inspection. The silage from each micro-silo was again thoroughly mixed on a clean plastic surface and a representative sample of 400g was obtained. Of this representative sample, 300g was dried in a forced drought oven at 60 °C for 48-72 hours for future determination of the proximate fractions (chemical analysis). Fifty (50g) of the remaining sample was blended in a high speed Philips blender for 1 minute followed by filtration through a Whatman No. 1 filter paper. The filtrate was placed in a well labeled plastic 200ml bottle and frozen at sh-20°C until needed for the determination of Ammonia-N, lactic acid and volatile fatty acids (VFAs).

  

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**Chemical analysis**

The silage samples were analysed for pH, organic acids (Lactic Acid, Acetic and Butyric), Dry ;; Matter (DM), Crude Protein (CP), Neutral Detergent Fibre (NDF), Acid Detergent Fibre (ADF), Ether Extract (EE) and Ash. The pH was measured using a calibrated pH electrode meter (Xu et al., 2007; Wang et al., 2011); organic acid content (lactic acid, acetic acid and butyric acid) was determined by HPLC (Xu et al., 2007) and Ammonia-N was determined by steam distillation of filtrates (Xu et al., 2003; Filya, 2003) using the 2200 Kjeltech auto distillation (Foss Tecator, Sweden), without the previous digestion step.

Dry matter (DM), crude protein (CP), ether extract (EE) and ash of the silage and ingredient samples were determined by standard AOAC (1990) methods; 967.03, 984.13, 920.39 and 942.05, respectively. The DM was corrected for VFA loss ($DM_{corr}$) according to Weissbach and Kuhla (1995) as cited by Sonja et al. (2012): DMcor = 2.08 + 0.975DM (g/100g). Neutral detergent fibre (NDF) exclusive of residual ash (NDFom) was determined without addition of alpha amylase or sodium sulphite. The same sample was sequentially analysed for acid detergent fibre (ADF) exclusive of residual ash (ADFom) using the procedure by Van Soest et al. (1991).

**Statistical analysis**

Analysis of variance (ANOVA) was used to test for statistical significance of the type of material ensiled on silage chemical composition and fermentative characteristics using the PROC GLM procedure of SAS (2003). When the *F* test indicated a significant difference ($P<0.05$) due to type of material used in silage making, the LSMEANS statement was used to separate the least square means using the PDIFF option of SAS (2003).

**RESULTS**

**Chemical composition of pre-ensilage materials**

The chemical composition of the ensiled material (Table 1) showed that Napier grass (NAP) had a lower DM content than the SPV and maize bran (MB). These differences were not significant ($P>0.05$). Numerically, NAP had lower crude protein as compared to SPV and maize bran but the mixture of NAP and SPV (NAP-SPV) had the highest CP although the variation did not have statistical significance ($p<0.05$). The NDF significantly ($p<0.001$) varied with the material to be ensiled. Significantly (0.0001), the ADF and ether extracts (EE) varied across the feed resources.

  

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**Table 1: Chemical composition of pre-ensiling feed resources**

| Parameter | NAP | SPV | NAP-SPV | MB | SEM | *P-value* |
|---|---|---|---|---|---|---|
| DM | 169.4 | 222.0 | 197.7 | 958.6 | | 0.1602 |
| CP | 131.5 | 120.8 | 141.5 | 100.3 | 8.77 | 0.1057 |
| NDF | 590.2 | 468.4 | 514.0 | 247.3 | 15.73 | 0.0016 |
| ADF | 319.0 | 355.5 | 351.9 | 65.7 | 9.59 | <0.0001 |
| EE | 8.0 | 17.3 | 10.4 | 56.4 | 0.40 | <0.0001 |

NAP Napier, SPV sweet potato vines, NAP-SPV Napier-Sweet potato mixture (50:50), MB maize bran.

## Chemical composition of silages

Napier grass silage had the most significantly ($p<0.01$) lowest DM while SPV silage had the highest DM (Table 2). The crude protein (CP) content of silage varied ($P<0.01$) with type of material ensiled. Silage from NAP-SPV had the highest CP content compared with SPV and NAP silages. NDF content of silage ranged from 372.1 g/kg DM to 461.6 g/kg DM in NAP-SPV silage and NAP silage, respectively. The Ash content of the silage varied ($p<0.01$) with the type of material. The NDF and ADF content of the silage did not significantly ($p<0.05$) vary with the type of material used for silage making. The ether extract (EE) at $p<0.0001$ varied with the type of silage material with NAP having the highest and NAP-SPV with the lowest.

**Table 2: Chemical composition of silage after 60 days ensiling period**

| Parameter | SPV | NAP | NAP-SPV | SEM | P-value |
|---|---|---|---|---|---|
| DM (g/kg DM) | 262.1$^{a}$ | 163.9$^{c}$ | 228.2$^{b}$ | 10.2 | 0.0145 |
| Crude protein (g/kg DM) | 113.2$^{b}$ | 103.4$^{b}$ | 130.6$^{a}$ | 4.55 | 0.0112 |
| Ash (g/kg DM) | 98.8$^{b}$ | 129.3$^{a}$ | 113.2$^{b}$ | 4.52 | 0.0045 |
| Neutral detergent fibre (g/kg DM) | 407.9 | 461.6 | 372.1 | 25.49 | 0.0937 |
| Acid detergent fibre (g/kg DM) | 271.5 | 272.2 | 255.8 | 4.62 | 0.0710 |
| Ether extract (g/kg DM) | 42.4$^{b}$ | 58.5$^{a}$ | 39.5$^{b}$ | 1.25 | <.0001 |

DM = Dry matter. values with $^{abc}$ were significantly different at $P<0.05$, NAP Napier, SPV sweet potato vines, NAP-SPV Napier-Sweet potato mixture (50:50),

## Fermentative characteristics of silages

The pH of the silage varied ($P<0.05$) with the type ensiling material (Figure 1). SPV and NAP-SPV silage had similar pH values while NAP silage had a higher pH of 4.73. Ammonia-nitrogen

  

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yields in silage followed a similar trend to that of pH (Figure 2). Ammonia-nitrogen in Napier grass silage tripled the amount found in the SPV and mixed (NAP-SPV) silage.

**Figure 1: pH of silage as influenced by type of material ensiled**

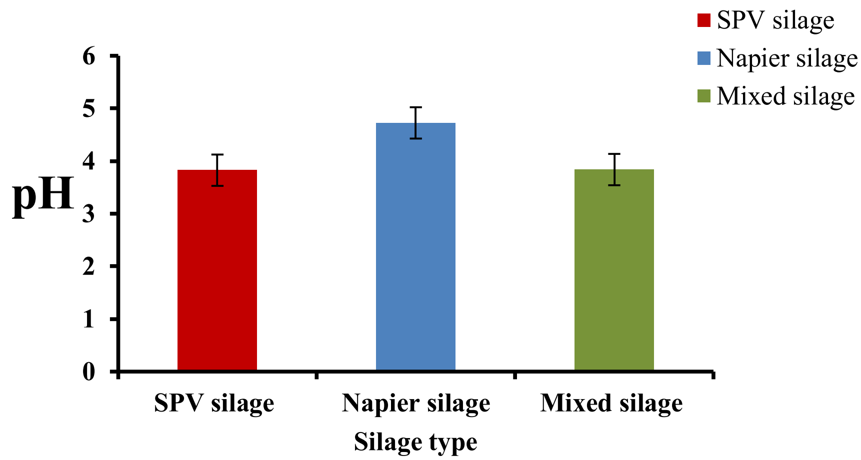
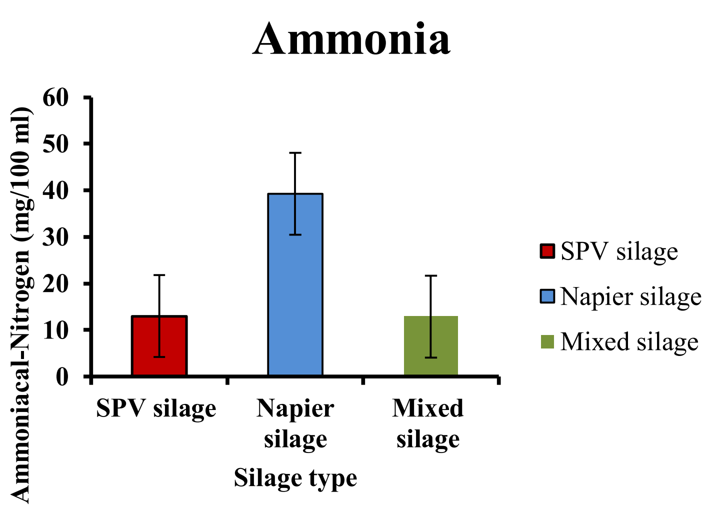



**Figure 2: Ammoniacal-Nitrogen yield in silage as affected by type of material ensiled**



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**Organic acid content of silage**

Lactic acid was dominant ($p<0.05$) among the three organic acids evaluated in the different silages (Table 3). It varied significantly ($P<0.05$) with type of material ensiled; SPV silage had the highest content while NAP and NAP-SPV had comparable ($P<0.05$) concentrations of lactic acid. The amount butyric acid produced in the treatments did not significantly differ at $p<0.05$. The lactic acid: acetic acid ratio indicated that it was highest in SPV and NAP-SPV and lowest in NAP although the differences were not statistically significant at $p<0.05$.

**Table 3: Organic acid content of the different silages**

| | SPV | NAP | NAP-SPV | Significance | |
|---|---|---|---|---|---|
| Parameter | | | | SEM | P-value |
| Lactic acid (%)[1] | 6.1[a] | 4.3[b] | 4.7[b] | 0.42 | 0.0372 |
| Acetic acid (%)[1] | 3.1 | 2.8 | 2.3 | 0.64 | 0.6497 |
| Butyric acid (%)[1] | 0.0 | 0.0 | 0.2 | 0.08 | 0.1909 |
| Lactic: Acetic ratio | 2.4 | 1.7 | 2.4 | 0.47 | 0.4902 |

[1] DM = Dry matter, values with [abc] were significantly differ at P<0.05, NAP Napier, SPV sweet potato vines, NAP-SPV Napier-Sweet potato mixture (50:50),

## DISCUSSION

### *Chemical composition of the silage and ensiled material*

The DM content of the NAP (169.4 g/kg DM) used in this study was very low because the forage was harvested during the rainy season. High moisture content in the pre-ensilage materials would increase nutrient loss through effluent loss resulting into reduced nutritional quality of silage. In addition, The NDF content of the Napier grass (590.2 g/kg DM) was lower than that reported by Kabirizi et al. (2006) of 657 g/kg DM. This was probably due to differences in stage of maturity at which the grass was harvested. The CP content of the pre-ensilage NAP (131.5 g/kg DM) was higher than the 107 g/kg DM reported by Mbuthia and Gachuiri (2003) and Kabirizi et al. (2006) probably due to differences in maturity of the Napier grass. In the present study, the NAP was harvested at 7 weeks while in the study by Mbuthia and Gachuiri (2003), the forage was harvested at 8 weeks hence the difference could be attributed to stage of maturity since crude protein content of forages is known to decline with maturity. However, the CP content of Napier grass silage was lower than that of 146 g/kg DM reported by Mgheni et al. (2013) at 7 weeks of maturity. This could possibly be due to the differences in soil fertility where the forage was

  

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planted since nutrient content of forage is usually closely related to the available nutrients in the soil. The crude protein (CP) content of SPV prior to ensilage was comparable to the average of 120 g/kg DM reported for mature SPV in East Africa (Mgheni et al., 2013). The CP content of the mixed Napier grass and SPV silage was higher than that of silage from sole Napier grass silage.

The lower crude protein content could be due to extensive protein degradation in the Napier grass silage as evidenced by the high ammonia-nitrogen production (Table 3).

***Fermentative characteristics***

Ensiling of forage is intended to preserve forage nutrient quality through the production of volatile fatty acids and lactic acid which inhibit activity of aerobic microbes in silage which are known to result into silage DM losses. The pH of silage is significantly dependent on the DM content in the ensiled material (Woolford & Pahlow, 1998). This explains why the ensiled material with the highest DM had the lowest pH. The observed high pH (>4.7) in NAP silage was due to the higher moisture content which resultantly led to production of effluent that counteracted the preservative effect of the fermentation acids (Woolford & Pahlow, 1998). McDonald (1982) observed that such high pH impairs growth of lactic acid bacteria while supporting multiplication of Enterobacteriaceae and clostridium (McDonald et al., 1991) which have been implicated in the protein and carbohydrate degradation ( Henderson, 1991;Charmley, 2001) and eventually lead to production of Ammonia-N (Woolford & Pahlow, 1998) as observed in the NAP silage. And this further explains the high pH observed in NAP silage (Kung and Shaver, 2001; Voss, 1966) as a result of an inefficient fermentative process. Consequently, the crude protein content was lowered by the high ammonia concentration which is often associated with high concentrations of other undesirable silage end products like amines that are known to depress intake in livestock (Charmley, 2001; Kung and Shaver, 2001). Just like in this study, other researchers have attributed lower pH to higher concentrations of lactic acid (Wang et al., 2011). It is therefore necessary to have a higher DM and a rapid pH drop, an environment which can arrest action of plant and microbial proteases that would otherwise drive protyelysis (Rooke and Hatfield, 2003) which result in loss of the protein content.

The low pH obtained in the SPV and NAP-SPV (pH<4.2) is attributable to a weak aerobic stability and high water-soluble carbohydrate content of the ensiled material (Wang et al., 2016). The observed relatively low pH in this study was attributable to the high concentration of lactic acid, an observation made by other authors (Yokota et al., 1991; Yokota et al., 1992; Wang et al., 2016). The fall in pH is argued to be dependent upon water soluble carbohydrate (WSC)

  

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concentration. The lower the pH, the more stable the silage becomes and the more the conducive the environment is for lactic acid bacteria to thrive (Wang et al., 2011).

In this study, it was observed that the acetic acid was secondary to lactic acid production in the ensiled material and its concentration did not vary with type of material ensiled. A similar trend of results has been observed before (dos Santos et al., 2012; Woolford & Pahlow (1998); Tamada et al. (1999). This can probably emanate from differences in populations of lactic acid producing bacteria and acetic acid producing bacteria as discussed by Wang et al. (2011); Henderson, (1993). As earlier reported by Tamada et al. (1999), butyric acid is produced at temperatures higher than 30℃ , the results of this current study were in conformity with earlier results. Since quality of silage is judged basing on the ratio of products of primary fermentation (lactic acid) and secondary fermentation (Acetic acid) acids (wood, 1998), SPV and NAP-SPV were of higher quality than NAP although the difference was not significant ($p<0.05$).

## CONCLUSION AND RECOMMENDATIONS

From the data presented in this study with respect to fermentation characteristics and nutrient content of the Napier silage, we conclude that sweet potato vines had an effect on improving the nutritional quality of Napier silage. Therefore, silage can be made from a Napier-sweet potato vines mixture (NAP-SPV) under circumstances where either Napier grass (NAP) or sweet potato vines (SPV) are inadequate in supply but the moisture content of the Napier grass needs adjusting before ensiling to minimise the level of proteolysis.

More research is needed to establish the optimum addition rate of sweet potato vines for enhancing the fermentation characteristics and inhibiting protein degradation of Napier silage. Further still, the economic benefits of using sweet potato vines vis-à-vis maize and Napier grass for silage production needs to be evaluated.

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