Effects of Sweet Potato (*Ipomea batatas*) Vines Inclusion to Napier Grass (*Pennisetum purpureum*) on the Chemical Composition and Physical Properties of Silage Mixtures

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Abstract

Napier grass (*Pennisetum purpureum*) is renowned for its high yield as forage and is primarily cultivated by small-scale farmers to nourish their livestock. When harvested at the recommended age, it can offer premium-quality feed. Conversely, sweet potato vines (SPV) are often treated as agricultural residue due to being underutilized, despite their potential nutritional benefits. This disregard for Sweet Potato vines stems from a lack of interest in further processing them into feed. This study aimed to assess the chemical composition and physical attributes of ensiled napier grass mixed with different proportions of Sweet Potato vines for 30 days. The experimental groups included 100% NG, 75% NG:25% SPV, 50% NG:50% SPV, 25% NG:75% SPV, and 100% SPV. The research utilized ordinary Napier grass and Bukit Naga Sweet Potato vines, both harvested at 6 weeks old during the second harvesting cycle. The quality of silage was evaluated through physical characteristics such as colour and pH. All treatments displayed optimal pH levels for quality silage, falling within the range of 3.5 to 4.0. The colour assessment indicated that all treatments had a greenish-brown hue with a discernible structure. Chemical composition analysis was performed using proximate analysis procedures. In conclusion, incorporating SPV elevated OM and CP content, demonstrating the potential benefits of combined ensiling.

Keywords: Napier grass, Sweet potato, silage mixture

Introduction

Napier grass (*Pennisetum purpureum*) is widely employed in Malaysia as livestock feed, owing to its well-established nutrient content and cultivation practices by livestock farmers. To achieve optimal dry matter yield and nutritional value, it is recommended to utilize Napier grass between 6 to 8 weeks of growth (Lounglawan *et al.*, 2014). Beyond 8 weeks, the digestibility of Napier grass decreases due to increased lignocellulosic material. However, overly young Napier grass has low dry matter content despite its high crude protein content (Zailan *et al.*, 2016). To counteract the decline in nutritional value caused by maturity constraints, ensiling is a common practice to preserve the nutrient content of Napier grass.

Conversely, Sweet potato (*Ipomoea batatas*) is primarily cultivated as a root crop for food purposes (Ruiz *et al.*, 1981). In Malaysia, there are plans to expand Sweet potato cultivation by an additional 300 hectares to meet the demand for its tubers (DAN, 2011). Despite having potential protein content, the Sweet potato vine is often disregarded as agricultural waste due to underutilization (Phuc, 2000; Dung, 2001). This neglect stems from farmers' lack of interest in effectively utilizing crop residues for feed production. Sweet potato is a robust plant that can withstand up to four harvests per growing season and can be conserved through ensiling (Lebot, 2009).

Silage, a feed material produced through successful anaerobic fermentation, holds significance in regions where animals cannot obtain sufficient energy or nutrients through grazing throughout the year due to unfavourable climates that restrict hay production (McDonald *et al.,* 2010). Thus, this study aimed to assess the chemical composition and physical attributes of ensiled Napier grass mixed with different proportions of Sweet potato vines for 30 days.

Materials and Methods

Experimental design, location and procedure

A study was conducted using a completely randomized design (CRD) to investigate the effects of five different treatments, as follows: (1) 100% Napier grass (control), (2) 75% Napier grass: 25% Sweet potato vines, (3) 50% Napier grass: 50% Sweet potato vines (4) 25% Napier grass: 75% Sweet potato vines, and (5) 100% Sweet potato vines.

The forage preparation and sample collection took place at Farm 15, Universiti Putra Malaysia (UPM). Napier grass (NG) and Sweet potato vine (SPV) were intercropped and vegetatively planted at Farm 15. The NG was established from stem cuttings, while Sweet potato vines were planted from vine segments. Both NP and SPV were harvested at the 6-week of growth, chopped into 2 to 4 cm lengths, followed by wilting for 4 hours. The wilted NG and SPV were weighed and then mixed with 0.3% molasses following the designated treatments, later ensiled for 30 days in airtight plastic containers. Each treatment was replicated three times, resulting in a total of 15 plastic containers used throughout the study.

Chemical analysis determination

All laboratory analysis was performed at the Nutrition Laboratory of the Department of Animal Science, Faculty of Agriculture, UPM.

The pH values of the silages were assessed and measured. A 25 g silage sample was combined with 25 ml of distilled water in a plastic container and mixed vigorously before recording the pH using a pH meter (Mettler Toledo). The dry matter (DM) was determined by drying the samples at 105 ℃ for 24 hours, and the organic matter (OM) was determined by combusting at 550 ℃ in a muffle furnace for 4 hours. The crude protein (CP) content was determined using the Kjeldahl method (AOAC, 2012), lipid content was extracted using a Soxhlet apparatus and Van Soest’s method was employed to determine neutral detergent fibre (NDF), acid detergent fibre (ADF), and acid detergent lignin (ADL).

Statistical analysis

The statistical significance of each treatment was assessed using analysis of variance (ANOVA) with the PROC GLM procedure of SAS software. The significant differences ($P< 0.05$) were used to distinguish the least square means. Tukey’s Multiple Range Test of SAS software was applied as a post hoc test to confirm significance levels (SAS, 2012).

Results and discussion

Effect of ensiling on chemical properties of the Napier grass and Sweet potato vine

The chemical properties of pre-ensiled (fresh) and ensiled of NG and SPV is presented in Table 1. The DM content of pre-ensiled NG and SPV was significantly lower ($P<0.05$) compared to their ensiled counterparts. This disparity arises because the forages were wilted for 4 hours before ensiling to achieve a 30% DM content. This finding diverges from studies by Lutwama *et al.* (2016), which observed DM reduction during ensiling. This discrepancy may be attributed to microorganisms fermenting naturally occurring sugars, promoting metabolic activity (He *et al.*, 2022). The higher DM content in ensiled forages in this study may be influenced by the addition of 0.3% molasses.

The OM content exhibited no significant differences ($P>0.05$) within each species but showed inter-species variability between pre-ensiled and ensiled forages. Ash content, indicative of mineral content, was determined by eliminating moisture and minerals from the treatments. Soil contamination, often due to silica, can elevate silage pH and soil-derived minerals, influencing silage quality (McDonald *et al.*, 2010; Arbabi & Ghoorchi, 2008).

The CP content of ensiled NG and SPV was significantly lower ($P<0.05$) than their pre-ensiled counterparts. This underscores the impact of ensiling on CP content in both forages. The CP of pre-ensiled use in the study is the same as reported by Lutwama et al. (2016) but the ensiled CP lower then reported by the same study. Proteolysis during fermentation producing NH_3, along with plant protease activity, could contribute to CP reduction. Crude protein degradation occurs when nitrogen demands of organisms are low, serving as an energy source and for cell substance synthesis (He *et al.*, 2022; Arbabi & Ghoorchi, 2008).

In terms of lipid content, there was a noteworthy decrease ($P<0.05$) in ensiled NG and SPV when compared to their pre-ensiled counterparts. Lipid content is intricately tied to lipoxygenase activity, particularly present in maturing plants. Unlike fresh forage, which mainly contains esterified fatty acids, silage often encompasses free fatty acids that are susceptible to oxidation (Elgersma *et al.*, 2003; Kim *et al.*, 2021). The transition from an aerobic to an anaerobic environment during ensiling curtails lipoxygenase activity, consequently leading to a reduction in lipid content.

The composition of DM relies on cell wall and cell content proportions, notably cellulose, hemicelluloses, and lignin. While hemicellulose, cellulose, and lignin levels are influenced by maturity, ensiling showed no significant difference in hemicellulose, cellulose, and lignin content for both forages.

However, significant variation in cellulose content for ensiled forages was observed.

Table 1. The chemical properties of pre-ensiled (fresh) and ensiled of Napier grass and Sweet potato vine (% dry matter basis)

Parameters	Napier grass		Sweet potato vine	
	Fresh	Ensiled	Fresh	Ensiled
DM (%)	25.74[a]	26.40[b]	31.04[a]	31.29[b]
OM (%)	6.59	5.35	9.14	7.62
CP (%)	13.23	9.70	24.27	17.56
EE (%)	3.6	2.51	3.84	3.20
Hemicellulose (%)	27.22	25.68	23.74	22.63
Cellulose (%)	46.97	44.48	34.41	30.90
ADL (%)	1.44	0.97	0.78	0.61

The incorporation of 0.3% molasses in ensiling might account for the non-significant impact on these components in this study.

Effect of ensiling on fermentative characteristics Sweet potato vine inclusion

Dry matter content and pH

The pH value and DM percentages of the silages increased with an increase in the SPV inclusion (Figure 1). The pH value of treatments varied, with 100% NG, 75% NG, 50% NG, 25% NG, and 100% SPV demonstrating significant differences ($P<0.05$). The pH values of 100% NG and 100% SPV were the lowest and highest, respectively. The optimal pH range for silage preservation is 3.5 to 4.0, where anaerobic conditions favour lactic acid bacteria (McDonald *et al.*, 2010; Liu *et al.*, 2012).

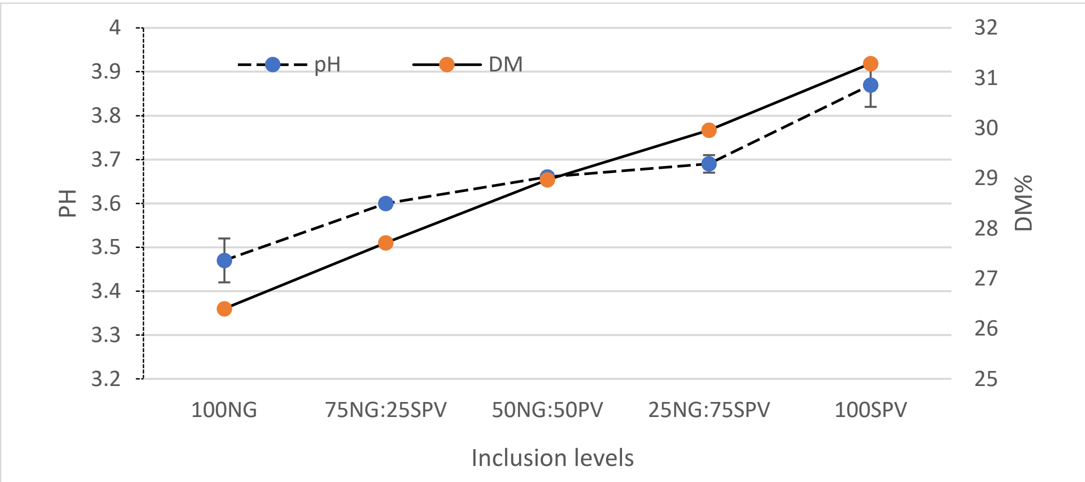

Figure 1. The pH of Napier grass silage prepared with different inclusions of Sweet potato vine at 30 days of sampling. NG: Napier grass; SPV: Sweet potato vine; 100NG: 100%NG; 75NG:25SPV: 75% NG+25%SPV; 50NG:50SPV: 50% NG+50%SPV; 25NG:75SPV: 25% NG+75%SPV; 100SPV: 100%SPV

Table 2 provides information on the chemical properties of ensiled Napier grass (NG) with different inclusion levels of Sweet potato vine (SPV). The DM content increases with higher levels of Sweet potato vine inclusion, ranging from 26.40% for 100% NG to 31.29% for 100% SPV. The organic matter content follows a similar trend, increasing from 5.35% for 100% NG to 7.62% for 100% SPV. The crude protein content increases as the proportion of Sweet potato vine in the mixture rises. The highest crude protein content is observed in 100% SPV (17.56%), and the lowest is in 100% NG (9.70%). The ether extract content shows a slight increase with higher levels of Sweet potato vine inclusion, ranging from 2.51% for 100% NG to 3.20% for 100% SPV.

NDF content decreases with increasing Sweet potato vine inclusion. The highest NDF value is for 100% NG (71.13%), and the lowest is for 100% SPV (54.14%), and ADF content follows a similar trend as NDF, decreasing with higher levels of Sweet potato vine inclusion. The highest ADF value is for 100% NG (45.45%), and the lowest is for 100% SPV (31.51%). However, the ADL content decreases with higher levels of Sweet potato vine inclusion. The highest ADL value is for 100% NG (0.97%), and the lowest is for 100% SPV (0.61%).

Table 2. The chemical properties of ensiled Napier grass (NG) with different inclusion levels of Sweet potato vine (SPV)

Parameter (on DM basis)	Inclusion Level				
	100% NG	75%NG: 25%SPV	50%NG: 50%SPV	25%NG: 75%SPV	100%SPV
DM	26.40±0.01[e]	27.71±0.01[d]	28.97±0.01[c]	29.96±0.01[b]	31.29±0.01[a]
OM	5.35±0.03[b]	6.73±0.10[a]	6.78±1.09[a]	7.11±0.18[a]	7.62±0.09[a]
CP	9.70±0.10[e]	10.52±0.29[d]	11.71±0.05[c]	13.45±0.46[b]	17.56±0.33[a]
EE	2.51±0.23[a]	2.53±0.58[a]	2.79±0.20[a]	2.99±0.06[a]	3.20±0.20[a]
NDF	71.13[a]±0.82	60.25[b]±1.90	58.21[b]±3.97	56.75[b]±2.24	54.14[b]±4.29
ADF	45.45[a]±0.82	39.87[b]±0.53	36.91[c]±0.14	36.12[c]±1.26	31.51[d]±1.11
ADL	0.97[a]±0.03	0.92[a]±0.04	0.87[a]±0.06	0.82[a]±0.08	0.61[b]±0.09

[a,b,c] different alphabet in the same row showed significant differences by Tukey Test (P<0.01); NG: Napier grass; SPV: Sweet potato vine; 100NG: 100%NG; 75NG:25SPV: 75% NG+25%SPV; 50NG:50SPV: 50% NG+50%SPV; 25NG:75SPV: 25% NG+75%SPV; 100SPV: 100%SPV.

Incorporating SPV in ensiling NG significantly enhanced OM content (Table 2). SPV possesses crude protein content comparable to leguminous forages (Dung, 2001), contributing to elevated CP levels at 25% NG:75% SPV inclusion. This suggests that the inclusion of Sweet potato vine has a significant impact on the chemical composition of the ensiled mixture (Table 2). Microorganisms, particularly lactic acid bacteria, ferment sugars in plants, producing acids that lower pH and inhibit undesirable microbial activity, contributing to successful ensiling (McDonald *et al.,* 2010, Kim *et al.,* 2021).

Ensiling had a notable impact on the chemical properties of Napier grass and Sweet potato vine. The DM content increased, likely due to molasses addition during ensiling. Ensiling led to a decrease in CP, lipid and cellulose content, attributed to proteolysis and reduced lipoxygenase activity. Hemicellulose, cellulose, and lignin remained relatively unaffected. The pH values of ensiled forages were optimal for silage preservation. The inclusion of SPV elevated organic matter (OM) and CP content, indicating potential benefits from combined ensiling. These findings contribute valuable insights into the impact of ensiling on forage properties, providing knowledge for improved livestock nutrition.

Conclusion

In conclusion, ensiling influenced the chemical properties of NG and SPV. DM content increased due to ensiling, possibly attributed to molasses addition. CP, lipid, and cellulose content decreased upon ensiling, primarily due to proteolysis and reduced lipoxygenase activity. Hemicellulose, cellulose, and lignin were relatively unaffected by ensiling. The pH values of ensiled forages were optimal for silage preservation. Incorporating SPV elevated OM and CP content, demonstrating potential benefits of combined ensiling. These findings contribute to a deeper understanding of ensiling's impact on forage properties and offer insights for enhanced livestock nutrition.

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