Influence of forage proportion and ensiling periods on physical characteristics and qualities of *Panicum maximum* (Ntchisi) and *Stylosanthes guianensis* silage

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Abstract

This study was carried out to evaluate the effect of proportion of grass-legume mixtures and ensiling periods on the physical characteristics and qualities of *Panicum maximum* and *Stylosanthes guianensis* silage. The experiment was laid in a 2×3 factorial arrangement which comprised of two (2) forage proportions (100% and 50%:50%) and three (3) ensiling periods (30, 60 and 90 days). Results showed that there was only significant ($p<0.05$) difference on pH as affected by ensiling periods whereby the pH values decline as the ensiling periods increase. The highest ($p<0.05$) CP (10.75%) and NFC (15.33%) contents were observed in equal proportion of *P. maximum* and *S. guianensis* silage. The effect of ensiling period effect on the proximate composition was significant ($p<0.05$) whereby *P. maximum* and *S. guianensis* ensiled for 90 days recorded the highest value for dry matter (DM) (96.88%) and ether extract (EE) (5.50) while *P. maximum* and *S. guianensis* ensiled for 30 days had highest CP content of 12.70%. Effect of proportion was significant ($p<0.05$) on the NDF, ADF and cellulose contents. Sole *P. maximum* silage had higher NDF (59.67%), ADF (33.83%) and cellulose (29.17%) contents compared to other proportion. There was decline in NDF and ADF contents as the ensiling period extended from 30 to 90 days in which silage ensiled at 90 days had the least content of 54.00 and 32.25% respectively. It is therefore concluded that silage made from equal proportion of *P. maximum* and *S. guianensis* silage had the highest crude protein and low structural components.

Introduction

Nutrition is one of the significant management practices in livestock production and it is the bedrock of animal performance; yet in case there are limited forages; and decrease in nutrient composition of the available forages during dry season, this poses a problem (Amole et al., 2011). However, available information shows that small ruminant industry would benefit if the animal received optimal nutrition. In Tropical Africa, majority of ruminants are raised on natural pastures which decrease in quality during the dry season (Bamikole, 1998). Lately, ruminants have likewise been raised on fodder tree and herbaceous legumes foliage since they supply nutrients, especially Nitrogen (N), during the dry season when nutrients from grazing become qualitatively and quantitatively limited for grazing animals. These fodder trees and herbaceous legumes foliage serve as supplements depending on the ability to give essential nutrients to the rumen microbial populace and furthermore to satisfy animal requirements, both might increase the efficiency of feed usage (Elliot and McMeniman, 1987). In such manner, foliage from fodder legumes qualify as supplements to low quality forages.

Forages are the least expensive feed resources for small ruminants yet because of low pasture quality and accessibility they become low during the dry season (Njoya et al., 2005). As indicated by Bamikole et al. (2003) that the bulk of the feeds available to ruminants in the tropics is the grass forage, as this can be sourced inexpensively. In an effort to reduce ruminant feed supply issues, because the grasses are low in crude protein and insufficiently available in dry season, farmers need not to rely solely on natural pastures however need to practice improved pasture management (Bamikole, 1998). Forages are conserved using different methods. Among these methods, silage, hay and haylage making are the most

widely recognized. However, various problems happen when drying forages in certain areas with heavy rainfall. In this way, ensiling and haylage making are significant with regards to conserving the forage.

Earlier research on forage conservation showed that there are innate issues in conservation of forages as hay and the right climatic conditions appropriate for hay making harmonize with when forages are low in nutritive value while making good quality hay during the wet season when the forages are of good quality, is basically impossible because of humid weather conditions (Amodu and Abubakar, 2004). Ensilage is another method of forage conservation during the wet season while retaining nutrient quality of the forage without recourse to the utilization of fuel or solar energy for artificial hay making wet, humid conditions (Kallah *et al.*, 1997). Ensilage involves the use of forages, crop residues or agricultural and industrial by-products preserved by acids either added or produced natural fermentation (Babayemi, 2009). Cowan (2000) also reported that silage had played an uneven role by improvement in pastures and forage crop conservation. He focused on harvesting and storage of excess growth of forage in the growing season for feeding during the dry season is important. Silage technology is preferred in the tropics since it is less subject to climate condition, sun drying and artificial drying than hay. Silage can be stored for quite a long time or years (Wong, 1999) and can be utilized whenever it is required particularly during the dry season (Koon, 1993). Therefore, this study aims to examine the physical characteristics and qualities of *Panicum maximum* (Ntchisi) and *Stylosanthes guianensis* silage at different proportions and ensiling period.

Materials And Methods

Experimental site

The silage making was carried out the Directorate of University Farms (DUFARMS) and the chemical analysis was carried out at the Laboratory of Pasture and Range Management, College of Animal Science and Livestock Production, Federal University of Agriculture, Abeokuta.

Experimental design

The study was laid out a 2 x 3 factorial design comprising two (2) mixing proportions (*Panicum maximum* (Ntchisi) 100% and 50% of *Panicum maximum* (Ntchisi) : 50% of *Stylosanthes guianensis*) and three (3) ensiling periods (30, 60, and 90 days) and which was replicated four (4) times.

Treatments combination

100% of *Panicum maximum* (Ntchisi) at 30 days ensiling period

50% of *Panicum maximum* (Ntchisi) and 50% of *Stylosanthes guianensis* at 30 days ensiling period

100% of *Panicum maximum* (Ntchisi) at 60 days ensiling period

50% of *Panicum maximum* (Ntchisi) and 50% of *Stylosanthes guianensis* at 60 days ensiling period

100% of *Panicum maximum* (Ntchisi) at 90 days ensiling period

50% of *Panicum maximum* (Ntchisi) and 50% of *Stylosanthes guianensis* at 90 days ensiling period.

Sourcing of plant materials

Panicum maximum (Ntchisi) and *Stylosanthes guianensis* were harvested at vegetative stage in an already established field at Directorate of University Farms (DUFARMS) within the University premises.

Silage making

After harvesting the plant materials, the forages was wilted in order to reduce the moisture contents, and then chopped manually.

- Ensiling 100% of *Panicum maximum* (Ntchisi), the silo was weighed, ensiled with grass and reweighed in order to determine the quantity of grass the silo could contain.
- Ensiling 50% of *Panicum maximum* (Ntchisi) and 50% of *Stylosanthes guianensis*, the determined quantity for the ensiled 100% *Panicum maximum* was divided into 2 and ensiled.

Physical evaluation of silage

Physical characteristics (odour, mouldiness and colour) were determined and ranked according to Bates (1998a) ranking.

Determination of silage pH

After each ensiling periods (30, 60 and 90 days), the silos were opened and 10g of each samples were weighed per each replicate and soaked in 100ml of distilled water for 1 hour, the mixture was filtered, then pH was determined using the pH meter.

Chemical analysis

Proximate composition: the dry matter, crude protein, ether extract and ash was determined according to A.O.A.C. (2000) while non-fibre carbohydrate will be calculated as $NFC = 100 - (CP + Ash + EE + NDF)$. Fibre fraction: Neutral detergent fibre (NDF), Acid detergent fibre (ADF) and Acid detergent lignin (ADL) was determined with the procedure of Van soest *et al.* (1991). Cellulose content was taken as the difference between ADF and ADL while hemicellulose content was calculated as the difference between NDF and ADF.

Statistical analysis

Data collected was subjected to Two-way analysis of variance and the treatment means will be separated using Duncan's Multiple Range Test using SAS (1999) package.

Results

The physical characteristics of *Panicum maximum* (Ntchisi) and *Stylosanthes guianensis* silage as affected by forage proportion were not significantly ($p>0.05$) different as shown in Table 1. There was only significant ($p<0.05$) difference on pH as affected by ensiling periods whereby the pH values decline as the ensiling periods increase. Table 2 shows there was no significant ($p>0.05$) difference on the physical characteristics of *P. maximum* and *S. guianensis* silage as affected by interaction between forage proportion and ensiling periods except pH value. The pH values significantly ($p<0.05$) ranged from 4.07 in sole *P. maximum* ensiling at 90 days to 4.73 in the same treatment ensiled at 30 days periods.

Proximate composition of *P. maximum* and *S. guianensis* silage at different proportions and ensiling periods are shown in Table 3. Results showed that there was no significant ($p>0.05$) difference on effect of proportion on the proximate composition of *P. maximum* and *S. guianensis* silage except crude protein (CP) and non fibre carbohydrate (NFC) contents. The highest CP (10.75%) and NFC (15.33%) contents were observed in equal proportion of *P. maximum* and *S. guianensis* silage. Also, the ensiling period effect on the proximate composition was significant ($p<0.05$) whereby *P. maximum* and *S. guianensis* ensiled for 90 days recorded the highest value for dry matter (DM) (96.88%) and ether extract (EE) (5.50) while *P. maximum* and *S. guianensis* ensiled for 30 days had highest CP content of 12.70% and the least content (8.17%) was observed in silage at 90 days. Forage ensiled at 90 days recorded highest (20.83%) NFC content and the least value (10.42%) were observed in silage at 30 days ensiling period (Table 3).

The interaction effect of proportions and ensiling periods on proximate composition of *P. maximum* and *S. guianensis* silage was significant ($p<0.05$) except ash content. Equal proportion of *P. maximum* and *S. guianensis* ensiling at 90 days recorded the highest (97.00%) DM value (97.00%) while sole *P. maximum* ensiled at 60 days had the least value (94.00%). Sole *P. maximum* ensiled at 30 days had the least (3.50%) ether extract content and highest (5.75%) content was observed in the same proportion ensiled at 90 days. The CP content declines in both proportion as the ensiling periods increase (30>60>90) in which the highest (13.17%) content was recorded in equal proportion ensiling at 30 days and the least value (7.80%) was observed in sole *P. maximum* ensiled at 90 days. Equal proportion of *P. maximum* and *S. guianensis* ensiled at 90 days had the highest (21.70%) content of non fibre carbohydrate (NFC) and least (10.26%) content recorded in sole *P. maximum* ensiled at 30 days (Table 4).

The results of the fibre composition of *P. maximum* and *S. guianensis* silage at different proportions and ensiling periods are shown in Table 5. Results obtained showed that there was significant ($p<0.05$) difference on effect of proportion on the neutral detergent fibre (NDF), acid detergent fibre (ADF) and cellulose contents. Sole *P. maximum* silage had higher NDF (59.67%), ADF (33.83%) and cellulose (29.17%) contents compared to other proportion. There was decline in NDF and ADF contents as the ensiling period extended from 30 to 90 days in which silage ensiled at 90 days had the least content of 54.00 and 32.25% respectively although there was no statistical difference in NDF between silage ensiled at 30 and 60 days. There were no specific trends in acid detergent fibre (ADL) and hemicellulose contents and the silage ensiled at 30 days had the highest (30.31%) cellulose content.

The interaction effect of proportions and ensiling periods on fibre composition of *P. maximum* and *S. guianensis* silage was significant ($p < 0.05$) as presented in Table 4. There was a declined in NDF and ADF contents as affected by interaction between proportion and ensiling periods and no specific trends in the ADL, hemicellulose and cellulose contents of the silage. Sole *P. maximum* ensiled at 30 and 60 days recorded the highest (62.00%) NDF content while the same treatment ensiled at 30 and 90 days had highest (35.50%) content of ADF with the lowest (31.00%) recorded in equal proportion of *P. maximum* and *S. guianensis* ensiled at 90 days.

Table 1
Effects of forage proportion and ensiling periods on physical characteristics of *P. maximum* and *S. guianensis* silage

Factors	Colour	Odour	Mouldiness	pH
Proportion (%)				
100	11.67	24.25	9.42	4.40
50 : 50	11.75	24.00	9.17	4.46
S E M	0.23	0.55	0.22	0.07
Ensiling periods (days)				
30	11.13	23.13	9.13	4.64 ^a
60	11.88	24.75	9.38	4.43 ^b
90	11.38	24.50	9.38	4.23 ^c
S E M	0.27	0.63	0.27	0.07
a, b, c :Means in same column for each factor with different superscripts are significantly ($p < 0.05$) different.				

SEM = Standard Error of Mean

Table 2

Interaction effects of forage proportion and ensiling periods on physical characteristics of *P. maximum* and *S. guianensis* silage

Proportion (%)	Ensiling periods (days)	Colour	Odour	Mouldiness	pH
100	30	11.00	23.00	9.25	4.73 ^a
	60	11.75	24.50	9.50	4.41 ^b
	90	10.75	25.25	9.50	4.07 ^c
50 : 50	30	11.25	23.25	9.00	4.55 ^{ab}
	60	12.00	25.00	9.25	4.46 ^{ab}
	90	12.00	23.75	9.25	4.37 ^b
S E M		0.17	0.38	0.15	0.05
a, b, c :Means in same column for each factor with different superscripts are significantly (p<0.05) different.					

SEM = Standard Error of Mean

Table 3

Effects of forage proportion and ensiling periods on the proximate composition (%) of *P. maximum* and *S. guianensis* silage

Factors	Dry matter	Ether extract	Crude protein	Ash	NFC
Proportion (%)					
100	95.58	4.83	10.06 ^b	11.83	13.60 ^b
50:50	96.42	4.91	10.75 ^a	11.83	15.33 ^a
SEM	0.45	0.29	0.56	0.31	1.46
Ensiling periods (days)					
30	95.75 ^{ab}	4.38 ^b	12.70 ^a	12.00	10.42 ^b
60	95.38 ^b	4.75 ^b	10.35 ^b	12.00	12.15 ^b
90	96.88 ^a	5.50 ^a	8.17 ^c	11.50	20.83 ^a
SEM	0.47	0.31	0.13	0.38	0.70
a, b, c: Means on same column with different superscripts are significantly (p<0.05) different					

SEM = Standard Error of Mean

NFC = Non Fibre Carbohydrate

Table 4

Interaction effects of forage proportion and ensiling periods on the proximate composition (%) of *P. maximum* and *S. guianensis* silage

Proportion (%)	Ensiling periods (days)	Dry matter	Ether extract	Crude protein	Ash	NFC
100	30	96.00 ^{ab}	3.50 ^c	12.24 ^b	12.00	10.26 ^c
	60	94.00 ^b	5.25 ^{ab}	10.16 ^d	12.00	10.59 ^c
	90	96.75 ^a	5.75 ^a	7.80 ^f	11.50	19.95 ^a
50:50	30	95.50 ^{ab}	5.25 ^{ab}	13.17 ^a	12.00	10.58 ^c
	60	96.75 ^a	4.25 ^{bc}	10.54 ^c	12.00	13.71 ^b
	90	97.00 ^a	5.25 ^{ab}	8.55 ^e	11.50	21.70 ^a
SEM		0.32	0.20	0.39	0.21	1.03
a, b, c...f: Means on the same column with different superscripts are significantly (p<0,05) different						
SEM = Standard Error of Mean, NFC = Non Fibre Carbohydrate						

Table 5

Effects of forage proportion and ensiling periods on the fibre composition (%) of *P. maximum* and *S. guianensis* silage

Factors	NDF	ADF	ADL	Hemicellulose	Cellulose
Proportion (%)					
100	59.67 ^a	33.83 ^a	4.67	25.83	29.17 ^a
50:50	57.17 ^b	32.33 ^b	4.66	24.83	27.67 ^b
SEM	0.97	0.51	0.38	0.89	0.53
Ensiling periods (days)					
30	60.50 ^a	34.75 ^a	4.44 ^b	25.75 ^b	30.31 ^a
60	60.75 ^a	32.25 ^b	5.12 ^a	28.50 ^a	27.13 ^b
90	54.00 ^b	32.25 ^b	4.43 ^b	21.75 ^c	27.82 ^b
SEM	0.78	0.59	0.18	0.88	0.69
a, b, c; Means on same column with different superscripts are significantly (p<0.05) different					

NDF = Neutral detergent fibre

ADF = Acid detergent fibre

ADL = Acid detergent lignin

SEM = Standard error of mean

Table 6

Interaction effects of proportion and ensiling periods on the fibre composition (%) of *P. maximum* and *S. guianensis* silage

Proportion	Ensiling periods (days)	NDF	ADF	ADL	Hemicellulose	Cellulose
100	30	62.00 ^a	35.50 ^a	3.96 ^e	26.50 ^{ab}	31.54 ^a
	60	62.00 ^a	32.50 ^{bc}	4.18 ^d	29.50 ^a	28.32 ^b
	90	55.00 ^c	35.50 ^a	5.86 ^b	21.50 ^c	27.64 ^{bc}
50:50	30	59.00 ^{ab}	34.00 ^{ab}	4.92 ^c	25.00 ^{bc}	29.01 ^b
	60	59.50 ^{ab}	32.00 ^{bc}	6.06 ^a	27.50 ^{ab}	25.94 ^c
	90	53.00 ^c	31.00 ^c	2.99 ^f	22.00 ^c	28.01 ^{bc}
SEM		0.00	0.58	0.00	0.58	0.58
a, b, c...f; Means on same column with different superscripts are significantly (p<0.05) different						

NDF = Neutral detergent fibre

ADF = Acid detergent fibre

ADL = Acid detergent lignin

SEM = Standard error of mean

Discussion

Silage production is a convention forage conservation strategy which requires the utilization of high yielding forage species per unit area. In mixed grass-legume silage, grass gives the fermentable carbohydrate while the legumes further improve the protein content of the silage. Silage pH is a significant parameter in the long term stability of ensiled forages. For example, forages with low buffering capacity permits a pH drop quickly even when acid production is little (Alli et al., 1983). This however, might be impacted by the moisture content and the buffering capacity of the original materials. Silage that has been properly fermented will have much lower pH (be more acidic) than the original forage. Reduction in pH in this study was similar to value reported by Phillip *et al.* (2007) and Shahabodin

et al. (2014) and this reduction was as a result of increase in ethanol content of the silage as the ensiling periods progressed (Driehuis and Wikselaar, 2000). The pH value recorded in this study as influenced by forage proportion and ensiling periods is higher than that recommended as the normal pH of 4.2 (Kung and Shaver, 2001) and the difference might be as a result of environmental factors such as temperature and ensiling grass with the legume produced silages with moderate pH values (Muhammed *et al.*, 2008).

Incorporation of legumes in silages resulted to increases in the nutritional characteristics (dry matter (DM), crude protein (CP), ether extract (EE) and ash contents) with corresponding decline in structural constituents (Neutral detergent fibre (NDF), acid detergent fibre (ADF) and acid detergent lignin (ADL) in all treatment examined. This suggested that inclusion of 50% legume improves the ensiling quality of grass at full bloom stage of maturity. Dry matter (DM) content declined as the ensiling periods progressed and the reduction could be clarified by a moderate fall in reducing sugar which is similar to the findings of Henk and Linden (1992) and Stokes and Chen (1994) for sweet sorghum and corn silage, respectively. This reduction was attributed to the continued maintenance requirement of the microbial population in the silage.

Crude protein (CP) content of the silage produced from combinations of grass and legume was above the CP critical level of 8% (Norton, 1994) acceptable for ruminant performance and the CP recorded for the silages were well above the threshold of 60g/kg needed by rumen microbes to build their protein body, below this threshold, intake of forages by ruminants and rumen microbial activity would be adversely affected (Van Soest, 1994). The CP content of the silages in this study was higher than the critical value of 70g/kg recommended for small ruminants (NRC, 1981). The silages will also be adequate in providing high quality protein supplement to non-lactating ruminants during the dry season. The CP content of silage in this study fell within the range of 6.54 – 15.15% reported by Ukanwoko and Igwe (2012) and also fell within the report of Anele et al. (2011) for grass and legume silage but higher than that reported by Babayemi (2009) for sole *P. maximum* which might be as a result of nutrient composition of original forage. The CP content also decreased with increase in the ensiling periods from 30 to 90 days after ensiling. The decrease in the CP content of the silage recorded in this study concurred with the reports of Akinola (2008) and Jolaosho et al. (2013) when guinea grass, cassava peel, brewery and pineapple wastes were ensiled at different proportion. Meanwhile, the CP contents of silages in this study as affected by ensiling periods are higher than 7% as the level considered as minimal requirements for ruminant animals according to Van Soest (1994). Non fibre carbohydrate (NFC) recorded in this study fell within the range of 127 - 259 g/kg reported by Anele et al. (2009). This shows that NFC of this grass – legume silage can be easily degraded or fermented as NFC is a crude estimate of the carbohydrate pool that differ in digestibility from NDF. It has also been reported that NFC has positive relationship with ammonia nitrogen (NH₃-N) utilization in the rumen (Tylutki et al., 2008).

The contents of NDF and ADF declined from 30 to 90 days. The reduction in the NDF and ADF contents of the silage with increase in ensiling periods as observed was in accordance with the findings of Akinola (2008) which might be ascribed to degradation of cell wall by the activity of bacterial enzyme (cellulose and hemicellulose) and production of organic acids during fermentation (Yahaya et al., 2001). Kung and

Shaver (2001) suggested that higher content of NDF in silage usually indicated that many of the soluble nutrients have been damaged which reduces the nutritive value of the silage. The higher the ADF, the less digestible the feed and the less energy it will contain (McDonald et al., 1991). The Acid Detergent Lignin (ADL) content of the silages under this study were slightly higher than those reported by Shahabodin et al. (2014) for sweet sorghum silage but lower than the findings of Jolaosho et al. (2013) for silages produced from Guinea grass and agro by-products.

Conclusion

The significance of silage cannot be overemphasized, aside from providing feed to animals particularly during dry season; it also preserves the nutrient in the forage materials. The inclusion of legume in grass silage has beneficial advantages to silage qualities. This study showed that the periods of ensiling changed the qualities of the grass – legume silage and it is therefore concluded that the composite silage made from 50% *P. maximum* and 50% *S. guianensis* was the best in terms of CP content and with relatively least fibre fraction. The silage ensiled for 30 days also had the highest CP value. The CP of the silage being higher than the minimum requirement for maintenance of ruminant animals across the three ensiling periods (30, 60 and 90 days) makes them a good supplement for dry season feeding.

Declarations

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Availability of data and material: Data will be made available on request.

Code availability: Not applicable

Authors' contribution:

Okukenu, O. A. conceived of the study and drafted the manuscript.

Okunogbe, S. O. participated in the design of the study.

Afolabi, R. A. carried out the laboratory analysis

Dele, P. A. was in charge of data analysis

Akinyemi, B. T. helped in field work

Amisu, A. A. helped in the design of the study

Jolaosho, A. O. and Onifade, O. S. coordinated and help in critique the manuscript

All authors read and approved the final manuscript

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