Characteristics of silage prepared from different ratios of *Andropogon tectorum* Schumach. and Thonn. and *Calopogonium mucunoides*

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Abstract

Decline in fodder quality and availability has direct impact on the animal protein output from ruminants. Conserving excess forage during the period of abundance through silage production could ameliorate the challenges. Hence, the need to study the characteristics of different proportions of grass-legume silage. The silage comprised of Andropogon tectorum and Calopogonium mucunoides in ratios 100:00 (T1), 80:20 (T2), 60:40 (T3), 40:60 (T4), 80:20 (T5) and 00:100 (T6). The experiment was laid out in a completely randomized design. A. tectorum and C. mucunoides were harvested, partially wilted, chopped and filled in a 20-litre paint buckets. At end of a 52-day forage fermentation, the silo was opened for silage evaluation for colour, aroma, texture, mouldiness, pH and temperature in addition to proximate fractions. Result showed that the silage textures were firm across the treatment means while the pleasant aroma depreciated with increasing ratio of C. mucunoides. Apart from T6 which recorded dark brownish green colouration, all the other treatments were greenish brown. Treatments 1 – 6 had no mould. The temperatures ranged from 19.00°C – 21.13°C while pH values were below 6. With the exception of ether extract which recorded 0% value across all the treatment means, all the proximate fractions evaluated varied significantly (P<0.05). The dry matter and crude protein values for T1, T2, T3, T4, T5 and T6 were 57.90, 8.75; 54.02, 12.25; 59.77, 8.75; 58.19, 9.33; 57.62, 11.6; 55.32 and 14.58, respectively. The T2 recorded the highest (71.98%) neutral detergent fibre (NDF) while, T6 had the least (60.47%) NDF value. Similarly, acid detergent fibre (ADF) value in T2 (47.92%) was the highest while T6 had the least value (30.01%) of ADF. It can be inferred that the different proportions of A. tectorum and C. mucunoides conserved as silage did not compromise quality even though the 80% grass and 20% legume appeared to be the most suitable combination to provide dry season feed for ruminants.

Keywords: silage, grass, legume, ruminants, fodder

Running title: Characteristics of silages from *Andropogon tectorum* and *Calopogonium mucunoides*

Caractéristiques de l'ensilage préparé à partir de différents ratios d'Andropogon tectorum Schumach. et Thonn. et Calopogonium mucunoides

Résumé

La baisse de la qualité et de la disponibilité du fourrage a un impact direct sur la production de protéines animales chez les ruminants. La conservation des excédents de fourrage pendant la période d'abondance grâce à la production d'ensilage pourrait atténuer ces difficultés. D'où la nécessité d'étudier les caractéristiques de différentes proportions d'ensilage d'herbes et de légumineuses. L'ensilage était composé d'Andropogon tectorum et de Calopogonium mucunoides dans des proportions de 100:00 (T1), 80:20 (T2), 60:40 (T3), 40:60 (T4), 80:20 (T5) et 00:100 (T6). L'expérience a été conçue selon un plan complètement randomisé. A. tectorum et C. mucunoides ont été récoltés, partiellement flétris, hachés et placés dans des seaux de peinture de 20 litres. À la fin d'une fermentation du fourrage de 52 jours, le silo a été ouvert pour évaluer l'ensilage en termes de couleur, d'arôme, de texture, de moisissure, de pH et de température, en plus des fractions approximatives. Les résultats ont montré que la texture de l'ensilage était ferme dans tous les traitements, tandis que l'arôme agréable diminuait avec l'augmentation de la proportion de C. mucunoides. À l'exception du traitement T6, qui présentait une coloration brun foncé tirant vers le vert, tous les autres

traitements étaient brun verdâtre. Les traitements 1 à 6 ne présentaient aucune moisissure. Les températures variaient entre 19,00 °C et 21,13 °C, tandis que les valeurs de pH étaient inférieures à 6. À l'exception de l'extrait éthéré, qui a enregistré une valeur de 0 % pour tous les traitements, toutes les fractions immédiates évaluées variaient de manière significative (P < 0,05). Les valeurs de matière sèche et de protéines brutes pour T1, T2, T3, T4, T5 et T6 étaient respectivement de 57,90, 8,75 ; 54,02, 12,25 ; 59,77, 8,75 ; 58,19, 9,33 ; 57,62, 11,6 ; 55,32 et 14,58, respectivement. Le T2 a enregistré la teneur la plus élevée (71,98 %) en fibres détergentes neutres (FDN), tandis que le T6 avait la teneur la plus faible (60,47 %) en FDN. De même, la teneur en fibres détergentes acides (FDA) dans le T2 (47,92 %) était la plus élevée, tandis que le T6 avait la teneur la plus faible (30,01 %) en FDA. On peut en déduire que les différentes proportions d'A. tectorum et de C. mucunoides conservées sous forme d'ensilage n'ont pas compromis la qualité, même si la combinaison 80 % d'herbe et 20 % de légumineuses semblait être la plus appropriée pour fournir du fourrage aux ruminants pendant la saison sèche.

Mots-clés : ensilage, herbe, légumineuses, ruminants, fourrage

Introduction

Shortage of good quality forage needed to sustain livestock growth, especially during the dry season has been a perennial problem in Nigeria (Falola *et al*., 2013) as native pasture deteriorates rapidly, especially in the dry season. As a result, ruminants in the tropics are raised predominantly on grasses which are inherently poor in digestibility, nutritive value and invaluable in the off-season (Babayemi, 2009).

All year round availability of fresh forages for ruminant nourishment cannot be guaranteed due to changes in weather and climatic factors. Often, there is abundance of free growing fresh and nutritious forages which are underutilised during clement weather conditions in the rainy season. As the dry period approaches, the forage quantities and qualities deteriorate. Olorunnisomo (2013) reported that the dry season pose a serious problem of feed scarcity resulting to insignificant decline in cattle production. Hence, it is necessary to conserve these forages to sustain their nutritive quality, and availability on and off-season.

The gap in feed supply can be filled by making silage from forages produced during wet season (Wong, 2000) since silage can be stored for months or years and used at any time it is required (Koon, 1993). Ensiling is a general method of forage preservation and also a form of treatment to occasionally salvage the under-utilized pasture for better acceptability and degradability. Babayemi and Igbekoyi (2008) reported that silage production in the tropics is a sustainable means of supplementary feed for ruminants during the dry season.

Silage characteristics depends largely on a number of factors which include but not limited to plant species, agronomic practices, preparation time, composition of the plant matter, silage additives, agro-ecological zone, as well as the stage of plant growth. McEniry *et al*. (2014) identified the two important pre-ensiling factors responsible for the quality of silage as plant species and stage of plant development at the time of harvest. At certain stages of development, plants are characterized by different chemical compositions (Bijelić *et al*., 2015).

As an important source of protein for ruminants, legume forages are very difficult to ensilage as a result of their high buffering capacity and low concentrations of soluble carbohydrates unlike the grasses. However, their fermentation characteristics improve when mixed with grasses.

This study was designed to establish the silage characteristics of different ratios of *Andropogon tectorum* and *Calopogonium mucunoides* harvested from uncultivated pasture irrespective of the stage of the plant's growth.

Materials and Methods

Experimental location

The research was carried out in the Pasture Section of the Teaching and Research Farm of Michael Okpara University of Agriculture, Umudike, Abia State Nigeria. Umudike is located in Abia state, Nigeria; at latitude $05^{0}29^{1}$ North and longitude $07^{0}31^{1}$ East; and at an altitude of

122 meters above sea level. It lies within the tropical rainforest zone of South-Eastern Nigeria, characterized by average annual rainfall of 2,177mm in 148 – 155 rainy days. The average ambient temperature is 25.5^{0}C with minimum and maximum temperature of 22^{0}C and 29^{0}C respectively. Relative humidity ranged from 50 – 95% depending on the location (NRCRI, 2018).

Steps in making different ratios of the grass-legume silage

The green plants from *Andropogon tectorum* and *Calopogonium mucunoides* were harvested within and around the University environment using cutlass from uncultivated sites. The harvested forages were partially wilted under the sun for 45 minutes to reduce moisture content and increase dry matter. The harvested crops were chopped to 2cm length to reduce particles sizes, in order to ensure that air is adequately excluded during the filling process in a 20-litre paint buckets used as laboratory silos. After chopping, both the grass and legume were blended in the following ratios before filling (Table 1).

Table 1: **Different ratios of *Andropogon tectorum* (AT) to *Calopogonium mucunoides* (CM)**

TREATMENT	AT:CM
T1	100:00
T2	80:20
T3	60:40
T4	40:60
T5	80:20
T6	00:100

The mixtures were filled into the laboratory silos according to the different ratios of AT-CM, replicated three (3) times while, 1kg of crushed maize was added per silo by sprinkling at intervals while filling, as a source of soluble carbohydrate to improve anaerobic fermentation by the micro-organisms.

The whole mass was sealed up after filling with nylon bags and compacting the silo with sand to the brim, then kept for the fermentation process to begin.

The ensiling process was completed within 30 days and a stable material called silage obtained. Thereafter, at the 52nd day, the silos were opened for sampling for both physical and chemical qualities evaluation.

Physical quality evaluation

Samples obtained from the different replicates per treatment were evaluated on the basis of colour, aroma, texture, mouldiness and pH. The pH of the silage was determined using a pH meter. The pH meter was switched on and allowed to equilibrate for 10 minutes. Then, pH meter electrode was immersed into the test sample in a beaker. After a minute, pH value was read directly from the screen of the instrument.. The temperature of silage was determined using a thermometer. The bulb of Celsius thermometer was dipped into different portions of the sample and the temperature read directly from the thermometer (AOAC., 2005).

Chemical analyses

Samples from the various replicates according to the treatments (T1, T2, T3, T4, T5 and T6) were analysed following the AOAC (2005) methods. The parameters analysed in the samples include: dry matter, crude protein, crude fibre, ether extract and ash. Nitrogen free extract (NFE) in the samples was calculated from the formula below;

NFE (%) = DM (%) – (CP % + CF % + E.E % + Ash %)

Where;

DM = Dry Matter, CP = Crude Protein, CF = Crude Fibre, EE = Ether Extract.

The method of Van Soest *et al*. (1991) was applied to determine the fibre fractions.

Statistical analysis

Data generated were subjected to Analysis of variance (ANOVA) as applicable to a Completely Randomized Design experiment using SPSS base for windows 2010. Means showing statistical differences were separated using Duncan multiple range procedure of the same package.

Results and Discussion

Physico-chemical characteristics of different ratios of Andropogon tectorum and Calopogonium mucunoides silage

The physico-chemical properties of the different silages are presented in Table 2. All the treatments were firm in texture. Firmness is an indication of a good silage (Kung and Shaver, 2001). The aroma varied from fairly pleasant in 100% *Andropogon tectorum* silage to slightly pleasant in 100% *Calopogonium mucunoides* silage.

The depreciating pleasant aroma as the level of *Calopogonium mucunoides* increases is usually a characteristics of legume silages.

Apart from the dark-brownish colour observed in 100% *Calopogonium mucunoides* silage, the treatments were greenish brown in colour. Good silage will nearly preserve the original colour. The greenish-brown colouration obtained in T1 – T5 was therefore, in order. This was close to the original colour which is an indication of a good quality silage (Oduguwa *et al*., 2007).

All the treatments were without mould. Moulds can grow in wet feeds such as silage, if oxygen is not limiting (Whitlow and Hagler, 2005). Fungi for instance, often thrive well in environments with high humidity, high temperature, and oxygen access during all stages of plant production and storage (Egal *et al*., 2005). Whitlow and Hagler (2005) emphasised that delayed harvesting, slow or delayed filling of silos, inadequate packing and sealing of silos, bridging in silage bags, and damaged plastic wrap, bags, or silo covers can create a conducive micro-climate for mould proliferation and mycotoxin production. These conditions were minimised to the barest, hence, the production of silages without mould.

The silage temperatures were below 37.70℃. According to Adesogan and Newman (2008), silage temperatures should not exceed 37.7^0C because higher temperatures reduce the quality of the silage and enhance protein degradation.

The pH range of 5.13 in T3 to 5.50 in T1 was within the range classified as good pH value for silage (Meneses *et al*., 2007). The acidity of an ensiled material is measured by its pH value as well as the buffering capacity, which determines the degree a sample will resist pH changes. According to Kung and Shaver (2001), all forages have different buffering capacities with legume silages having higher pH values than grass silages.

Table 2: The physico-chemical properties of different ratios of *Andropogon tectorum* and *Calopogonium mucunoides* silage

Properties	TREATMENTS					
	T1 AT:CM (100:00)	T2 AT:CM (80:20)	T3 AT:CM (60:40)	T4 AT:CM (40:60)	T5 AT:CM (20:80)	T6 AT:CM (00:100)
Texture	Firm	Firm	Firm	Firm	Firm	Firm
Aroma	Fairly pleasant	Fairly pleasant	Averagely pleasant	Averagely pleasant	Averagely pleasant	Slightly pleasant
Colour	Greenish brown	Greenish brown	Greenish brown	Greenish brown	Greenish brown	Dark brownish green
Mouldiness	Without mould	Without mould	Without mould	Without mould	Without mould	Without Mould
Temperature (^{0}C)	20.13	19.87	21.13	21.13	19.00	20.20
pH	5.50	5.33	5.13	5.47	5.67	5.27

AT= *Andropogon tectorum*, CM= *Calopogonium mucunoides*

Proximate compositions of different ratios of Andropogon tectorum and Calopogonium mucunoides silage

Table 3 shows the proximate compositions of the different ratios of *Andropogon tectorum* and *Calopogonium mucunoides* silages. All the parameters evaluated were significantly ($P<0.05$) influenced by the different proportions of *Andropogon tectorum* and *Calopogonium mucunoides* except ether extract (EE) with 0% values across the treatments. Numerically, T3 recorded the highest dry matter (DM) similar ($P>0.05$) to T1, T4 and T5 but varied significantly

(P<0.05) from T2 and T6. Ash values in T3 was statistically (P<0.05) higher than the other treatments. Ash in T4 and T5 were similar (P>0.05) but differed (P<0.05) from T1 or T2. The T6 recorded significantly (P<0.05) higher CP when compared to the other treatment means. Crude protein (CP) content in T1, T3 and T4 were similar (P>0.05) statistically but varied (P<0.05) from the values in T2 and T5. Neutral detergent fibre (NDF) and acid detergent fibre (ADF) values were significantly (P<0.05) higher in T2 than the other treatment means.

The DM contents were higher than the values reported elsewhere (Dele *et al*., 2013; and Falola *et al*., 2013) but compares favourably with the findings of Ukanwoko and Igwe (2012).

Ash contents in the silages were higher than the values recorded by Ukanwoko and Igwe (2012) but compares favourably with the records obtained by Seyithan (2019) and Dele *et al*. (2013).

CP contents were above the minimum 7% CP required to support rumen microbial function (Lanyansunya *et al*., 2006) and also above 8% critical CP acceptable for ruminant performance (Norton, 1994). Contrary to the expectation that the CP in the silage will be rising as the ratio of *Calopogonium mucunoides* increased, the CP dropped between T5 – T3. The drop could be as a result of the activities of proteolytic microbes during fermentation. Hydrolysis of protein is expected to occur during the whole fermentative stage, and it has been well accepted because of the plant proteinases and the microbial activities in silages (Wei *et al*., 2020). The authors further stated that plant proteins can be degraded into oligopeptides, free amino acids, ammonia and other forms of non-protein nitrogen (NPN) in silages.

The 0% ether extract values across the treatments could be attributed to the rapid volatilization of the fatty acids in the silages when the silos were opened.

According to Seyithan (2019), the ratio of NDF refers to all the fibre in the plant including hemicellulose while the ADF ratio refers to the amount of cellulose, lignin and insoluble protein in the structure of the plant cell wall. The rate of ADF is a good indicator of feed digestibility and an insight into the animal's energy intake. The NDF values recorded in this study were below the critical level of 75% NDF above which the NDF will inhibit feed intake (Buxton, 1996).

The ADF values from T1 to T5 were slightly higher than the values obtained in grass pea and barley silages (Seyithan, 2019). Carr *et al*. (2004) stated that ADF is an important parameter for feed quality evaluation. Therefore, as the ratio of ADF increases, feed digestibility and nutrient uptake is likely to decrease.

Table 3: The Proximate compositions of different ratios of *Andropogon tectorum* and *Calopogonium mucunoides* silage

Parameters %	Treatments						SEM
	T1 AT:CM (100:00)	T2 AT:CM (80:20)	T3 AT:CM (60:40)	T4 AT:CM (40:60)	T5 AT:CM (20:80)	T6 AT:CM (00:100)	
DM	57.90^{ab}	54.02^{b}	59.77^{a}	58.19^{ab}	57.62^{ab}	55.32^{b}	0.64
Ash	8.48^{d}	6.03^{e}	12.99^{a}	10.34^{bc}	11.12^{b}	9.52^{c}	0.54
CP	8.75^{c}	12.25^{b}	8.75^{c}	9.33^{c}	11.67^{b}	14.58^{a}	0.54
EE	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NDF	58.97^{f}	71.98^{a}	66.00^{b}	61.84^{d}	62.84^{c}	60.47^{e}	1.0
ADF	34.20^{e}	47.92^{a}	37.84^{d}	39.82^{c}	41.46^{b}	30.01^{f}	1.38

[a,b,c,d,e] means across rows with different superscripts differ significantly at P<0.05; S.E.M=Standard error of mean, DM=Dry Matter, CP=Crude Protein, EE=Ether Extract, NDF=Neutral Detergent Fibre ADF=Acid Detergent Fibre, AT= *Andropogon tectorum*, CM= *Calopogonium mucunoides*

Conclusion

The observed physical characteristics and chemical compositions of the different ratios of *Andropogon tectorum* and *Calopogonium mucunoides* silages indicated that the feeding value of these forages conserved as silage were not compromised within 52 days duration of storage, irrespective of the statistical variances observed across the treatment means. However, judging from the results, 80% *Andropogon tectorum* and 20% *Calopogonium mucunoides* is the ideal ratio of this grass and legume that should be combined together to produce suitable dry-season feed for ruminants as silage.

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