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EVALUATION OF *PENNISETUM PURPUREUM* AND ORANGE-FLESHED SWEET POTATO VINE MIXED SILAGE AS DRY SEASON FEED FOR RUMINANTS

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ABSTRACT

Preservation of low quality grass with crop residue (orange-fleshed sweet potato vine) improved the feed value for ruminants during period of forage scarcity. This study evaluated the nutritive value of *Pennisetum purpureum* and orange-fleshed sweet potato mixed silage as potential feed resource for ruminants. *Pennisetum purpureum* (Pp) and Orange-fleshed sweet potato vines (OFSPV) were ensiled using experimental silo bottles at different proportions as follows: 100% Pp ($P_{100}O_0$), 75%Pp +25%OFSPV ($P_{75}O_{25}$), 50%Pp +50%OFSPV ($P_{50}O_{50}$), 25% Pp+75% OFSPV ($P_{25}O_{75}$) and 100%OFSPV (P_0O_{100}). Molasses and lactic acid bacteria inoculants (5% and 1.0 X 10^7 CFU/1000g fresh weight respectively) were added to all treatments as additives and were kept for 14 and 28 days at room temperature in the laboratory. At 14 and 28 days of ensiling, silages were analyzed for chemical composition, microbial population and fermentative parameters. The dry matter (DM), neutral detergent fibre (NDF) and acid detergent fibre (ADF) (35.14%, 41.55% and 27.40%) were highest in silage ensiled for 14 days while those ensiled for 28 days recorded the highest crude protein (CP) (13.45%). Increased in days of ensiling from 14 to 28 days resulted in higher dry matter intake (DMI), digestible dry matter (DDM) and relative feed value (RFV) of the silage. The ratios of Pp to OFSPV influenced ($P < 0.05$) all the chemical composition parameters considered except ether extract. The CP, ash, DMI, DDM and RFV increased as the level of OFPV increased in the silage mixture. Silage containing 100% OFSPV had the highest values for all these. However, silage containing 100% Pp recorded highest DM, NDF and ADF contents. The pH, lactic acid bacteria, coliforms, total bacteria and yeast counts were significantly ($P < 0.05$) affected by the ensiling periods while temperature and concentration of lactic, acetic, propionic and butyric acid were similar ($P > 0.05$). Silage of 28 days had the least ($P < 0.05$) pH value of 4.23 compared to 14 days silage (4.52). Lactic acid bacteria, total anaerobic bacteria and yeast counts were higher in silage ensiled for 28 days while silage of 14 days contained higher coliform bacteria counts. The pH, temperature and butyric acid concentration were more in silage containing 100% Pp (4.81, 28.28°C and 0.03% respectively). Lactic acid concentration and lactic acid bacteria counts increased with increase in OFSPV level. Inclusion of orange-fleshed sweet potato vine in *Pennisetum purpureum* silage of 28 days improved the fermentative, nutritive and feeding values of the silage.

Keywords: Potato vines, *Pennisetum purpureum*, Silage, Nutritive values, Ruminants

INTRODUCTION

Dry season feeds and feeding is a major threat to ruminant animal production in Nigeria. Production of ruminant is based on natural pasture as the major feed source. These natural pastures are available in abundance and are of good quality during the raining season but dry season poses reduction in quality, palatability and acceptability of these forages. *Pennisetum purpureum* (Elephant grass) is one of the main fodders used by smallholder livestock farmers in Nigeria but it contained low crude protein content which is less than the minimum dietary crude protein required by dairy cows for milk production (Muia *et al*., 1999). Meanwhile, there are alternative feed resources such as crop residues which consist of leaves and stems

with high crude protein content and can be utilized by ruminants to produce quality products (meat and milk) for human consumption. These residues can be fed to ruminant alone or in combination with low protein grasses such as *Pennisetum purpureum* to produce quality feed resource. Potato vine is one of such residues which are available in large quantity globally on yearly basis due to increase in the production of various varieties of potatoes. FAO (2014) has reported yearly global potato production of 376.5 million tonnes in 2013. In Nigeria, potato is one of the most important food crops and as a result, large quantities of its residues (vines) are produce and wasted after harvest. The vines have high content of crude protein and low fibre constituent (Dung, 2001). Potato tuber or its by-products have been documented for its nutritive value (Ericksson and Murphy 2004; Ericksson *et al.,* 2009; Noordar *et al*., 2017). Although, greater quantities of these residues are available during the raining season but they can be preserved together with the grass in form of silage which can be used during the period of forage scarcity.

Orange fleshed sweet potato (OFSP) is an improved variety of sweet potato that is grown in large quantities in South Western part of Nigeria due to its health position and nutritional benefits. Therefore, large amount of its residue are available for feeding livestock. Limited information is available on the nutritive and fermentative quality of mixture of *Pennisetum purpureum* and orange-fleshed sweet potato vines silage. This study therefore aims at examining the effect of ensiling Elephant grass with orange-fleshed sweet potato vines on the nutritive value, fermentative quality and microbial population of the silage.

MATERIALS AND METHODS

Experimental site, forage harvest and silage preparation

The study was conducted at the College of Animal Science and Livestock Production Research Farm and Laboratory of Animal Nutrition Department, Federal University of Agriculture, Abeokuta, Ogun State, Nigeria. The orange-fleshed sweet potato vines (OFSPV) were collected after harvesting of tubers at the University crop farm in May, 2018. The OFSPV were immediately chopped into small pieces of about 2-4cm and were spread under a well-ventilated shed for 48 hours in order to attain desirable dry matter for ensiling. *Pennisetum purpureum* was harvested at the Pasture Unit of the University farm and was equally chopped to the same length and allowed to wilt. Wilted OFSPV and Pp were ensiled using experimental silo bottles at different proportions as follows: 100% Pp ($P_{100}O_0$), 75%Pp +25%OFSPV ($P_{75}O_{25}$), 50%Pp +50%OFSPV ($P_{50}O_{50}$), 25% Pp+75% OFSPV ($P_{25}O_{75}$) and 100%OFSPV (P_0O_{100}). Molasses and lactic acid bacteria inoculants (5% and 1.0 X 10^7 CFU/1000g fresh weight respectively) were added to all treatments as additives. Ensiling process was done by first weighing the respective proportion of the *P.purpureum* and OFSPV for the different treatments separately on a clean concrete floor. Each treatment was then thoroughly mixed with the additives and rapidly filled into the respective experimental silos. The materials were well compressed in the silos after which they were tightly covered and sealed to avoid air penetration. Each treatment was replicated six (6) times and was kept for 14 and 28 days at a room temperature (25 – 27°C).

Laboratory analysis for microbial population, organic acids and chemical composition

Three experimental silos per treatment were randomly opened at day 14 and 28 of ensiling. A laboratory thermometer was immediately inserted at opening to determine the silage temperature. Sample was taken from three silos per treatment at each opening day from different points and depths and mixed together. Sample taken was weighed and 10g of the sample was blended with 90mL distilled water and serially diluted from 10^{-1} to 10^{-8} in sterilized water. Numbers of lactic acid bacteria were determined by plate count using MRS agar incubated at 30°C for 48 h under anaerobic conditions. Yeasts were counted on potato dextrose agar incubated at 30°C for 24

h. Coliform was counted on nutrient agar incubated at 30°C for 24 h under aerobic conditions. The colonies were counted as viable numbers of microorganisms in CFU/g FM^{-1}.

To determine the pH, organic acid and ammonia nitrogen concentrations, 25g of each sample was homogenized in 100mL distilled water in a blender at full speed for 1 minute. Four layers cheese cloth was used to filter the homogenate and the filtrate was used for the determination of pH using pH meter. Lactic acid, volatile fatty acids (acetic, propionic and butyric acids) and ammonia nitrogen concentrations were also determined from the filtrate by colorimetric method of Barker and Summerson (1941) as modified by Pryce (1961) and AOAC (2005) respectively.

Part of the samples taken was used for the chemical analyses; samples were dried separately in the oven at 60°C until constant weight was obtained to determine the dry matter. The dried samples were ground and made to pass through 1mm screen. The samples were analysed for crude protein, ether extract and ash contents according to AOAC (2005). Fibre fractions (NDF and ADF) were also analysed using the procedure of VanSoest *et al*. (1991). Other nutritive value parameters such as dry matter intake (DMI), digestible dry matter (DDM) and relative feed value (RFV) were calculated as thus:

$$DMI = \frac{120}{\text{NDF\% dry matter basis}}$$

DDM = 88.9 – (0.779 X ADF% dry matter basis)

RFV = DDM% X DMI% X 0.775

Statistical analysis

All data collected were subjected to two-way Analysis of Variance and significant differences among means were separated using Duncan's Multiple Range Test (SAS, (1999)

RESULTS

The chemical and mineral composition of raw materials (*Pennisetum purpureum* and orange-fleshed sweet potato vine) used in the study is presented in Table 1. *Pennisetum purpureum* contained 36.50% dry matter (DM), 8.71% crude protein (CP), 1.40% ether extract (EE), and 13.69% Ash. The NDF and ADF of the grass were 64.80% and 48% respectively. The concentration of macro and micro minerals in the grass were 3.90g/kgDM, 2.70g/kgDM, 1.76g/kgDM, 8.00mg/kgDM, 13.00mg/kgDM and 284mg/kgDM for Calcium (Ca), Phosphorous (P), Magnessium (Mg), Manganese (Mn), Copper (Cu) and Iron (Fe) respectively. Orange-fleshed sweet potato vine on the other hand contained 29% DM, 16.87% CP, 4.53% EE, and 22.28% Ash. Values obtained for NDF, ADF, Ca, P, Mg, Mn, Cu and Fe contents of the vine were 37.00%, 26.20%, 13.9g/kgDM, 4.30g/kgDM, 4.26g/kgDM, 3 mg/kgDM, 17mg/kgDM and 306mg/kgDM respectively.

Table 2 shows the effect of ensiling periods and ratio of *Pennisetum purpureum* to orange-fleshed sweet potato vines on the chemical composition and nutritive parameters of the silage. Ensiling periods had significant ($P < 0.05$) effect on the DM, CP, NDF and ADF contents of the silage. The DM, NDF and ADF (35.14%, 41.55% and 27.40%) were higher in silage ensiled for 14 days while those ensiled for 28 days recorded the highest CP (13.45%). The dry matter intake (DMI), digestible dry matter (DDM) and relative feed value (RFV) increased ($P < 0.05$) with increase in days of ensiling. Treatments (ratios of *Pennisetum purpureum* to orange-fleshed sweet potato vines) influenced ($P < 0.05$) all the parameters considered except ether extract. The CP, ash, DMI, DDM and RFV increased as the level of OFSPV increases. Silage containing 100% OFSPV had the highest values for these parameters. However, the DM, NDF and ADF contents were highest in 100% *Pennisetum purpureum* silage.

The effect of ensiling periods and treatments on fermentative quality and microbial population of the silage is presented in Table 3. The pH, lactic acid bacteria, coliforms, total bacteria and yeast counts were significantly ($P < 0.05$) affected by the ensiling periods while

temperature, lactic, acetic, propionic and butyric acid concentrations were similar (P > 0.05). Silage of 28 days had the least (P < 0.05) pH value of 4.23 compared to 14 days silage (4.52). Lactic acid bacteria, coliform, total anaerobic bacteria and yeast counts were higher in silage ensiled for 28 days when compared with that of 14days.

The effect of ratio of *Pennisetum purpureum* to orange-fleshed sweet potato vines was evident (P < 0.05) on the pH and temperature, lactic, acetic and butyric acid concentrations of the silage. In addition, lactic acid bacteria, coliform and total anaerobic bacteria counts were also affected significantly (P < 0.05) by the treatments. The pH, temperature and butyric acid concentration were higher in silage containing 100% *Pennisetum purpureum* (4.81, 28.28°C and 0.03% respectively). Lactic acid concentration increased with increase in OFSPV level (4.81 – 6.48%). Lactic acid bacteria counts increased in the silage with increase in the level of OFSPV. Silages containing 100%Pp, 75%Pp25%OFSPV and that of 50%Pp50%OFSPV had similar (P > 0.05) but higher coliform counts. The 25%Pp75%OFSPV silage recorded greater count for total anaerobic bacteria while yeast counts were similar (P > 0.05) across the treatments.

Table 1: Chemical composition (%) and mineral contents of raw materials used for ensiling

Parameters	***Pennisetum purpureum***	**Orange-fleshed sweet potato vines**
Chemical composition		
Dry matter	36.50	29.00
Crude protein	8.71	16.87
Ether extract	1.40	4.53
Ash	13.69	22.28
Neutral detergent fibre	64.80	37.00
Acid detergent fibre	48.00	26.20
Macro-mineral contents (g/kgDM)		
Calcium	3.90	13.90
Phosphorus	2.70	4.30
Magnesium	1.76	4.26
Micro-mineral contents (mg/kgDM)		
Manganese	8.00	35.00
Copper	13.00	17.00
Iron	284.00	306.00

Table 2:Effect of ensiling periods and treatments on chemical composition (%) and nutritive value parameters of the mixed silage

Ensiling periods (days)	Dry matter	Crude protein	Ether extract	Ash	NFC	NDF	ADF	DMI	DDM	RFV
14	35.14^{a}	12.10^{b}	3.30	12.97	30.47	41.55^{a}	27.47^{a}	3.01^{b}	67.50^{b}	158.48^{b}
28	33.74^{b}	13.45^{a}	3.13	13.27	29.64	40.10^{b}	25.48^{b}	3.10^{a}	69.05^{a}	167.35^{a}
SEM	1.36	0.55	0.38	0.46	1.59	2.28	0.78	0.16	0.61	9.51
Treatments										
$P_{100}O_0$	36.61^{a}	9.75^{d}	3.17	11.54^{d}	20.54^{d}	55.00^{a}	30.46^{a}	2.19^{e}	65.17^{e}	110.56^{e}
$P_{75}O_{25}$	31.98^{b}	12.15^{c}	3.08	11.96^{cd}	27.44^{c}	45.38^{b}	28.54^{b}	2.65^{d}	66.67^{d}	136.69^{d}
$P_{50}O_{50}$	31.68^{b}	12.65^{c}	2.67	12.33^{c}	34.61^{a}	37.75^{c}	26.25^{c}	3.19^{c}	68.45^{c}	169.04^{c}
$P_{25}O_{75}$	29.94^{c}	13.39^{b}	2.75	14.00^{b}	36.11^{a}	33.75^{d}	24.63^{d}	3.56^{b}	69.72^{b}	192.16^{b}
P_0O_{100}	26.99^{d}	15.95^{a}	4.42	15.81^{a}	31.58^{b}	32.25^{e}	22.50^{e}	3.73^{a}	71.37^{a}	206.13^{a}
SEM	1.46	0.41	0.55	0.26	1.10	0.67	0.57	0.05	0.45	2.87

^{a,b,c,d,e}Means on the same row having different superscripts are significantly different (P < 0.05)
NDF-Neutral detergent fibre, ADF-Acid detergent fibre, DMI-Dry matter intake, DDM-Digestible dry matter RFV-Relative feed value, $P_{100}O_0$-100% P. purpureum, $P_{75}O_{25}$-75% P. purpureum 25% OFSPV, $P_{50}O_{50}$-50% P. purpureum 50% OFSPV, $P_{75}O_{25}$-75% P. purpureum 25% OFSPV, P_0O_{100}-100%OFSPV

Table 3: Effect of ensiling periods and treatments on fermentative characteristics and microbial population of the mixed silage

	Ensiling periods			Treatments					
Fermentative parameters	**14 days**	**28 days**	**SEM**	**$P_{100}O_0$**	**$P_{75}O_{25}$**	**$P_{50}O_{50}$**	**$P_{75}O_{25}$**	**P_0O_{100}**	**SEM**
pH	4.52^{a}	4.23^{b}	0.09	4.81^{a}	4.40^{b}	4.38^{bc}	4.19^{bc}	4.10^{c}	0.12
Temperature (°C)	27.75	28.17	0.20	28.28^{a}	28.12^{ab}	27.53^{b}	28.07^{ab}	27.82^{ab}	0.26
Lactic acid (%)	6.15	6.25	0.12	4.81^{c}	6.08^{b}	6.23^{ab}	6.40^{a}	6.48^{a}	0.17
Acetic acid (%)	2.60	2.58	0.08	2.55	2.37	2.71	2.66	2.65	0.11
Propionic acid (%)	0.37	0.36	0.03	0.35	0.29	0.40	0.39	0.39	0.04
Butyric acid (%)	0.02	0.02	0.002	0.03^{a}	0.01^{b}	0.02^{b}	0.02^{b}	0.02^{b}	0.002
Ammonia-N (%)	8.16	8.05	0.06	8.79	8.51	7.37	7.94	7.94	0.75
Microbial population									
Lactic acid bacteria ($x10^6$cell/g)	0.27^{b}	0.41^{a}	0.10	0.22^{c}	0.18^{c}	0.32^{b}	0.37^{b}	0.63^{a}	0.15
Coliform bacteria ($x10^6$ CFU/g)	0.39^{a}	0.16^{b}	0.09	0.62^{a}	0.30^{ab}	0.30^{ab}	0.07^{b}	0.01^{b}	0.12
Total anaerobic bacteria ($x10^6$cells/g)	0.48^{a}	1.09^{a}	0.19	0.50^{c}	0.42^{c}	0.82^{b}	1.33^{a}	0.85^{b}	0.31
Yeast ($x10^3$ cell/g)	0.00^{b}	0.05^{a}	0.01	0.02	0.00	0.03	0.07	0.02	0.02

^{a,b,c,d,e}Means on the same row having different superscripts are significantly different (P < 0.05)
$P_{100}O_0$-100% P. purpureum, $P_{75}O_{25}$-75% P. purpureum 25% OFSPV, $P_{50}O_{50}$-50% P. purpureum 50% OFSPV, $P_{75}O_{25}$-75% P. purpureum 25% OFSPV, P_0O_{100}-100%OFSPV

DISCUSSION

Analyzing the chemical composition of animal feedstuffs gives the description of the materials on the basis of specific nutrient which helps in the prediction of some indices of animal performance. The crude protein content of *Pennisetum purpureum* recorded in this study was within the range (8 –11%) reported by Kariuki *et al*. (2001) and Ansah *et al*. (2010). The NDF and ADF were also similar to the values stated by Wijitpahan *et al*. (2009). However, Ridwan *et al*. (2015) reported lower crude protein content of 4.52% and higher NDF and ADF contents (74.62% and 51.01%) compared to what was obtained in this study. The crude protein, ether extract, NDF and ADF contents of orange-fleshed sweet potato vines determined fell within the range stated by Baba *et al*. (2018) for twelve cultivars of sweet potato vines while the ash content was higher than those reported by the same author. Variation observed in the chemical components of the grass and the vines when compared with that of other researchers could be due to differences in the variety, harvested stage and planting location. This was in agreement with Larbi *et al*. (2007) who reported that different agricultural wastes varied in chemical composition. The high crude protein content (16.87%) recorded for orange-fleshed sweet potato vine suggested it as a high quality fodder. Greater ash value in OFSPV is an indication of high mineral content in the vine which reflected in the values obtained for macro and micro minerals of the vines. The high concentration of minerals especially Calcium in the vine showed its potential as forage for lactating ruminants.

Increase in crude protein content, dry matter intake (DMI), digestible dry matter (DDM) and relative feed value (RFV) of the silage as ensiling period increased was in line with Ojo *et al*. (2017) when silage ensiled for 60 days had higher values than those ensiled for 30 days in all the parameters investigated. This may be attributed to decrease in NDF and ADF contents of the silage as ensiling periods advanced. It could also be observed that inclusion of OFSPV in the silage mixture improved virtually all the parameters considered (Table 2). This supported the fact that silages made from tropical grasses alone are poor in nutrients (due to their low protein content) except they are supplemented with protein rich materials such as potato vines (Babayemi and Igbekoyi, 2008). The higher DMI, DDM and RFV observed in silages containing OFSPV when compared with that of *P. purpureum* silage alone could be as a result of comparatively lower NDF and ADF values of these silages as DMI is inversely related to NDF. Furthermore, the relative feed values obtained for silages in this study except that of 100% Pp and 75%Pp25%OFSPV were higher than 151 RFV considered prime in terms of feed quality (Kocer and Albayrak, 2012).

The fermentative characteristics of silage produced in this study indicated that inclusion of OFSPV improved the quality of grass silage. The pH decreased with advance in ensiling periods and addition of OFSPV. Decrease in pH as ensiling period progressed helped in keeping the quality of the silage as observed in other fermentative parameters considered and this was in accordance with the observation of Ojo *et al*. (2017). However, the range of pH obtained was within the range reported by McDonald (1991) for good silage. Lactic acid is an important fermentative quality of silage as it is produced by lactic acid bacteria during ensiling process to lower pH and inhibit the growth of undesirable microorganisms. This is evident in this study as silages with lower pH had higher lactic acid concentration. The high lactic acid concentration (> 6%) recorded in all silages containing OFSPV indicated completion of desirable fermentation as reported by Kung and Shaver (2001) for legume and grass silages. All silages containing OFSPV in this study were well preserved with high lactic acid concentration (>6%). Kung and Shaver (2001) had also submitted that fermentation that resulted in production of lactic acid lowered losses of dry matter and energy during storage. The acetic and propionic acid concentrations of the silage were within the range reported by

Ojo *et al*. (2017) and that considered as normal by Kung and Shaver (2001) in silage of *Pennisetum purpureum* mixed with processed *Enterolobium cyclocarpum* seeds and grass silage respectively. Akinbode *et al*. (2017) also reported similar range for sugarcane tops ensiled with varying level of broiler litter. The butyric acid concentration is however, less than the range (0.5 – 1%) reported by Kung and Shaver (2001).Undesirable microorganism produced butyric acid by breaking down the amino acid thereby resulting in nutritional loss. Therefore, high concentration of butyric acid (>1%) in silage reduces the quality of the silage.

Ammonia nitrogen (NH_3-N) concentration in silage is an important indicator to monitor proteolytic activity during the fermentation process. The range of NH_3-N concentration recorded for silages in this study were less than 100 g/kg of total nitrogen which is an indication of well preserved silage (McDonald *et al*., 2011)

Lactic acid bacteria (LAB) play a critical role in fermentation of silage. Its numbers, species and characteristics are important factors to consider in determining the quality of silage fermentation (Lin *et al*., 1992). Lactic acid bacteria produce lactic acid during ensiling process to lower the pH and inhibit the growth of undesirable microorganisms to yield good quality silage. High lactic acid bacteria counts obtained in silage containing 50% OFSPV and above was similar to those reported by Napasirth *et al*. (2015) for cassava residues silage. As observed in this study, lactic acid bacteria population generally increased the lactic acid concentration and decreased the pH which is an indication of well-preserved silages. Lactic acid organisms could also help to reduce the breakdown of protein to ammonia and increase silage bunker life.

In silage, yeast activity is considered undesirable because under anaerobic silage condition, sugar is fermented to ethanol and CO_2 by yeast (McDonald *et al*., 1991). Yeast counts with respect to this study were below the threshold level which implies that the silages are safe for animal consumption. It has been reported that silage with yeast count above 5.0 log cfu/g of silage sample are more susceptible to deterioration (Woolford, 1990).

CONCLUSION

Inclusion of orange-fleshed sweet potato vines in the *Pennisetum purpureum* silage improved the nutritive, fermentative and feeding values of the silage. Therefore, orange-fleshed sweet potato vines may be included up to 50% and above in its mixture with *Pennisetum purpureum* for better silage. Meanwhile, 25% *P. purpureum* and 75% sweet potato vines (P_{25} O_{75}) mixture ensiled for 28 days or more is highly encouraged in ruminant feeding especially during the dry season when forages are scarce.

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