NATIONAL AGRICULTURAL AND FOOD CENTRE
RESEARCH INSTITUTE FOR ANIMAL PRODUCTION NITRA

Slovak J. Anim. Sci., 49, 2016 (2): 76–84
© 2016 NPPC
ISSN 1337-9984

EFFECTS OF SEASONAL CHANGES ON THE NUTRITIVE QUALITY OF *MORINGA OLEIFERA* AND *PANICUM MAXIMUM* SILAGE

V. O. A. OJO[1]*, E. D. OYEBANJO[1], O. T. OPAYEMI[1], S. O. MUSTAPHA[1], O. O. ADELUSI[2], S. A. ADEOYE[1], U. Y. ANELE[3], A. O. OGUNSAKIN[1], A. O. JOLAOSHO[1], O. S. ONIFADE[1]

[1]Department of Pasture and Range Management, Federal University of Agriculture, Abeokuta, Ogun State, Nigeria
[2]Department of Animal Nutrition, Federal University of Agriculture, Abeokuta, Ogun State, Nigeria
[3]Agriculture and Agri-Food Canada Lethbridge Research Centre, Lethbridge, Alberta, Canada

ABSTRACT

The experiment was carried out to evaluate the effects of season and plant types on the chemical composition and *in vitro* fermentation of *Moringa oleifera* and *Panicum maximum* (local) silage. Leaf samples of *M. oleifera* plants and *P. maximum* were randomly collected during the rainy and dry seasons from Federal University of Agriculture, Abeokuta, Nigeria. The design of this study was 2 × 5 factorial arrangements with 3 replicates (2 seasons and 5 mixture ratios). The forage samples were both chopped into 2-3 cm lengths and divided into different proportions of 100 % : 0 %, 0 % : 100 %, 30 % : 70 %, 50 % : 50 % and 70 % : 30 % and were carefully packed into 30 laboratory bottles (960 ml) silos after mixing thoroughly. Season x plant species interactions were observed for some chemical and *in vitro* fermentation parameters. The CP content of the samples was significantly higher ($p < 0.05$) and ranged from 69.9 to 165.5 g.kg DM^{-1} and fibre concentrations ranged from 246.3 to 710.5 g.kg DM^{-1}, 193.2 to 578.0 g.kg DM^{-1} and 63.5 to 133.3 g.kg DM^{-1} for NDF, ADF and ADL respectively. 100 % Moringa + 0 % Panicum silage recorded the highest ($p < 0.05$; 165.5 g.kg DM^{-1}) CP content in all the silages evaluated. All the silages had high calcium contents (7.0-11.7 g.kg DM^{-1}). Values obtained for the *in vitro* fermentation characteristics of the forage species indicated the presence of potentially degradable nutrients. 100 % Moringa + 0 % Panicum and all the forage mixtures silages have potentials that could be harnessed as feed supplements for ruminants both in the rainy and dry seasons.

Key words: Moringa; nutritive value; Panicum; plant types; season; silage

INTRODUCTION

Forages provide adequate amount of nutritious feed for ruminants in the form of grasses which is preferred by these types of animals. However, in the dry season, there is feed constraint due to seasonal shortages in the quantity and quality of forage from natural pastures that provide most of the feed for animals which result into problems such as sickness and weight loss due to poor dietary profile for the animals and reduction in yield and quality of forages arises. Under this condition, browse plant is of great importance in balancing protein deficiency during the long dry season. They are effective insurance against seasonal feed shortages. The main feature of browse plants is their high crude protein (CP) and mineral contents (Awad and Elhadi, 2010).

Ruminants relish guinea grass (Babayemi and Bamikole, 2006). But such forage becomes very scarce in the dry season. It is commonly used for silage but herbage has been reported to have low content of dry matter and low concentrations of water soluble carbohydrates and crude protein (Zanine *et al.*, 2006). The levels of protein content and fermentable carbohydrates can be improved through various treatments including mixing legumes with cereal crops (Phiri *et al.*, 2007).

Browse plants have special characteristics of high nitrogen value, better metabolizable energy

***Correspondence:** E-mail: ojovoa@funaab.edu.ng
Victoria Olubunmi A. Ojo, Department of Pasture and Range Management,
Federal University of Agriculture, P. M. B. 2240, Abeokuta, Ogun State, Nigeria
Tel.: +2348037178044

Received: May 5, 2015
Accepted: June 2, 2016

and organic matter digestibility when fed with grass supplement (Ajayi and Babayemi, 2008). Forage tree leaves generally have high phosphorus concentrations (McMeniman and Little, 1974).

In dealing with lack of feed during the dry season forage conservation especially as silage is considered to be the preservation technique with the greatest potential for protein rich foliage (Man and Wiktorsson, 2002). Ensiling cereal and legumes together have been reported to be responsible in providing sufficient fermentable carbohydrates for lactic acid bacteria (Koljajic *et al*., 1998) and simultaneously the protein content of silage will be increased (Anele *et al*., 2011). In addition, mixing legumes and grasses increases biomass yield, crude protein (CP) content, nutritive value of resultant silage and soil fertility (Assefa and Ledin, 2001; Nayigihugu *et al*., 2002).

This study will therefore evaluate the chemical composition and *in vitro* fermentation of *Moringa oleifera* and *Panicum maximum* silage at different proportions and seasons.

MATERIAL AND METHODS

Experimental site

The experiment was conducted at the Department of Pasture and Range Management, University of Agriculture, Abeokuta, Nigeria. The site lies within the derived savannah zone of South Western Nigeria on latitude 7°58'N, longitude 3°20'E and 75 m above sea level with average annual rainfall of 1037 mm. Abeokuta has a bimodal rainfall pattern that typically peaks in July and September with a break of two to three weeks in August. Temperatures are fairly uniform with daytime values of 28 to 30 °C during the rainy season (April – September) and 30–34 °C during the dry season (October – March) with the lowest night temperature of around 24 °C during the harmattan period between December and February. Relative humidity is high during the rainy season with values between 63 and 96 % as compared to dry season 55–84 %. The temperature of the soil ranges from 24.5 to 31.0 °C (Source: Agromet Dept., FUNAAB).

Sample collection

P. maximum samples were harvested at 15 cm above ground level at 6 weeks after cut back from the Fadama (wetland areas) located within the University and *M. oleifera* was also harvested by hand cutting the branches followed by stripping off all leaves in July, 2011 for rainy season and December, 2011 for dry season from the Teaching and Research Farm of the University. The grass samples were chopped into pieces of 2-3 cm in length, wilted for 4 hours to reduce their moisture contents at a temperature of 23.4 °C and relative humidity of 71.2 % before ensiling and divided into different proportions of 100 % : 0 %, 0 % : 100 %, 30 % : 70 %, 50 % : 50 % and 70 % : 30 %.

Experimental design

The experiment was laid out in a 2 x 5 factorial design arrangement with 3 replicates consisting of two types of season i.e. rainy and dry, and five forage proportions i.e. 100 % Moringa + 0 % Panicum, 0 % Moringa + 100 % Panicum, 50 % Moringa: 50 % Panicum, 70 % Moringa: 30 % Panicum, and 30 % Moringa:70 % Panicum.

Data collection

The chopped and wilted plant types at different forage proportions and their sole were carefully packed into laboratory (960 ml) bottle silos after mixing thoroughly following the method described by Yokota *et al.* (1995). A total of thirty (30) bottle silos were used in the ensiling process. The forage samples were ensiled for a period of 6 weeks at an ambient temperature of 26 °C. At the expiration of the ensiling, the bottle silos were opened, the pH of the silages was determined and chemical and *in vitro* analyses of the samples were thereafter carried out.

Chemical analyses

Samples of 300 g were taken from each of the bottle silos and oven-dried to a constant weight at 65 °C. The dried foliage samples were milled through a 1mm sieve and crude protein (CP), ether extract (EE), ash and the minerals such as Phosphorus (P), Potassium (K), Calcium (Ca) and Sodium (Na) were analyzed according to the standard methods of AOAC (2000). Neutral detergent fibre (NDF), acid detergent fibre (ADF) and acid detergent lignin were determined according to Van Soest *et al*. (1991). Hemicellulose was calculated as NDF – ADF while Cellulose was calculated as ADF – ADL. Non-fibre carbohydrates (NFC) were calculated as:

NFC = 1000 – CP - ash – EE – NDF, with all variables expressed as $g.kg\ DM^{-1}$.

In vitro gas production was determined according to Menke and Steingass (1988). Rumen fluid was collected from three bulls before morning feeding according to the method described by Babayemi and Bamikole (2006). The animals have been previously fed a mixed diet of *P. maximum* grass and concentrates to fulfil maintenance requirements. The liquor was collected into a pre warmed thermos flasks and was later filtered through three layers of cheesecloth. Two hundred milligrams of ground feed samples were weighed into 100 ml calibrated syringes with pistons lubricated with grease. A buffered mineral solution was prepared. 30 ml of buffered rumen fluid was taken into syringes containing the feeds. The syringes were positioned vertically in a water bath with shaker kept at 39 °C fitted with plungers. Gas production rates were recorded at 3, 6, 9, 12, 24, 36 and 48 hour of incubation and each syringe was gently swirled after reading. Three blank syringes containing only 30 ml of buffered inoculum were also concurrently incubated.

The data obtained were fitted to the non-linear regression equation:

$V\ (ml.200\ mg.DM^{-1}) = b\ (1 - e^{-ct})$

where V = potential gas production at time *t*, *b* = volume of gas that will evolve with time and *c* = fractional rate of gas production. Initial gas production rate (Absg) was calculated as the product of *b* and *c* (Larbi *et al*., 1996).

Organic matter digestibility (OMD) were estimated as:

OMD= 14.88 + 0.889GV+ 0.45 CP + 0.651 ash (Menke and Steingass, 1988).

Short-chain fatty acids (SCFA) were estimated as:

SCFA = 0.0239GV−0.0601 (Getachew *et al.*, 2000).

Metabolizable energy (ME) were calculated as:

ME= 2.20 + 0.1357GV+ 0.0057 CP + 0.0002859 EE^2 (Menke and Steingass, 1988).

Total gas volume (GV) were expressed as ml/200 mg DM, CP and ash as $g.kg\ DM^{-1}$, ME as $MJ.kg\ DM^{-1}$ and SCFA as $\mu mol.g\ DM^{-1}$.

***In vitro* dry matter digestibility (IVDMD)**

After 48 hours digestion, the bottle contents were centrifuged at 15,000 rpm for 10 minutes and residues were decanted into pre weighed crucibles were oven-dried at 105 °C for 24 hours. The dry residues were weighed and digestibility calculated using the equation as follows:

$$\text{IVDMD}\ (\%) = \frac{\text{Initial DM input} - \text{DM residue-Blank x 100}}{\text{Initial DM input}}$$

Data were subjected to two-way analysis of variance using the SAS (2002) package while significant means were separated using Duncan's multiple range test ($p < 0.05$).

RESULTS

Chemical composition

The proximate composition and pH of the silages are shown in Table 1. There were significant differences ($p < 0.05$) in the DM, CP, EE, ash and NFC composition as a result of interactions between plant types and season. 100 % Moringa + 0 % Panicum silage had the lowest DM contents for both the rainy and dry seasons compared with others. Meanwhile, 100 % Moringa + 0 % Panicum silage during rainy season recorded the highest CP value (165.5 $g.kg\ DM^{-1}$) which was closely trailed behind by mixtures of 30 % Moringa : 70 % Panicum silage at rainy (129.4 $g.kg\ DM^{-1}$). 0 % Moringa + 100 % Panicum silage at dry season recorded the least value of EE (10.1 $g.kg\ DM^{-1}$). 100 % Moringa + 0 % Panicum and

Table 1: Effect of season and plant type on the composition and pH of the silage ($g.kg\ DM^{-1}$)

Season	Forage mixture	DM	CP	EE (g.kg DM^{-1})	ASH	NFC	pH
Rainy	100 % Moringa + 0 % Panicum	910.00^{b}	165.50^{a}	32.00^{abc}	80.4^{c}	327.20^{b}	4.48
	0 % Moringa + 100 % Panicum	945.00^{a}	74.10^{c}	25.90^{bcd}	88.9^{abc}	100.60^{e}	4.64
	Moringa 50 %: Panicum 50 %	935.00^{a}	127.90^{b}	47.10^{a}	86.6^{abc}	172.30^{cd}	4.38
	Moringa 30 %: Panicum70 %	945.00^{a}	129.40^{b}	31.20^{abc}	103.4^{ab}	144.70^{d}	4.49
	Moringa70 % : Panicum 30 %	960.00^{a}	83.90^{c}	31.00^{abc}	109.2^{a}	197.20^{cd}	4.60
Dry	100 % Moringa + 0 % Panicum	910.00^{b}	127.00^{b}	37.60^{ab}	90.1^{abc}	499.30^{a}	4.20
	0 % Moringa + 100 % Panicum	950.00^{a}	69.90^{c}	10.10^{d}	108.10^{ab}	60.90^{f}	4.50
	Moringa50 % : Panicum 50 %	940.00^{a}	82.00^{c}	20.90^{bcd}	93.10^{abc}	298.70^{c}	4.70
	Moringa 30 % : Panicum 70 %	935.00^{a}	89.90^{c}	15.40^{cd}	107.60^{ab}	241.60^{c}	4.63
	Moringa 70 % : Panicum 30 %	945.00^{a}	77.8^{c}	36.60^{ab}	84.10^{c}	410.00^{a}	4.80
	SEM	3.50	6.40	2.50	2.70	2.60	0.06

^{abcd}Means along the same column with different subscripts are significantly different ($p < 0.05$)
DM: Dry matter, CP: Crude protein, EE: Ether extract, NFC: Non Fibre Content
SEM: Standard error of mean

mixtures of 70 % Moringa: 30 % Panicum silages both during dry season recorded the highest ($p < 0.05$) overall NFC.

Table 2 shows the effects of plant types and season on the fibre composition of forages. 0 % Moringa + 100 % Panicum silage at rainy and dry seasons had the highest ($p < 0.05$) NDF while 100 % Moringa + 0 % Panicum silage at dry season had the least ($p < 0.05$) NDF, ADF and celluloses levels, respectively.

Table 3 shows the mineral composition of the silages. There were significant ($p < 0.05$) interactions between plant types, forage proportions and season for the phosphorus, potassium, calcium and sodium contents of the silages. Among the interaction of the mineral contents of the forages, P and Ca contents ranged from 2.2 to 3.6 g.kg DM^{-1} and 7.0 to 11.70 g.kg DM^{-1} respectively. Silages produced from legumes and different plant types had higher amounts of these minerals than those from grasses alone. Potassium contents of the forage mixtures during the rainy season were significantly ($p < 0.05$) higher than in the dry season.

***In vitro* digestibility**

There were significant effects of plant types and season on the volume of gas produced at different times for the silages (Table 4). 100 % Moringa + 0 % Panicum and 70 % Moringa : 30 % Panicum silages both at dry season, recorded the highest ($p < 0.05$) gas production at 3 hr of incubation while 0 % Moringa + 100% Panicum and 70 % Moringa : 30 % Panicum silages during rainy season and 0 % Moringa + 100 % Panicum silage at dry season respectively produced no gas at 3 hr of incubation. However, at 48 hr of incubation, 30% Moringa : 70 % Panicum silage at dry season had the highest gas production with 35 % while 50 % Moringa : 50 % Panicum silage at rainy season produced the least gas of 23 % at 48 hr.

Irrespective of plant types and season of ensiling, there was no significant difference ($p > 0.05$) on insoluble but degradable fraction (b) and fractional rate of gas production (c) of the ensiled forages (Table 5). However, 70 % Moringa : 30 % Panicum silage at dry season had the highest SCFA and ME values above all other plant types and season. SCFA content of the silages of different plant types was higher during dry season except for 0 % Moringa + 100 % Panicum silage. Similar trend was noticed with ME.

DISCUSSION

Chemical composition

Higher DM contents as obtained in this study have been reported to concentrate the water soluble carbohydrates and improve the effectiveness of lactate-producing bacteria, and thus improve the quality of silage (Anele *et al.*, 2011).

The CP contents of all the silages of plant types were all above the critical CP level of 8 % acceptable for ruminant performance (Norton, 1994) except the 0 % Moringa + 100 % Panicum silage which was similar to 7.8 % reported by Aganga and Tshwenyane, (2004) and lower

Table 2: Effect of season and plant type on the fibre composition of the silage (g.kg DM^{-1})

Season	Forage mixture	NDF	ADF	ADL (g.kg DM^{-1})	HEM	CELL
Rainy	100 % Moringa + 0 % Panicum	394.90^{d}	347.70^{de}	91.70^{b}	47.20^{d}	256.00^{de}
	0 % Moringa + 100 % Panicum	710.50^{a}	420.20^{bcd}	133.30^{a}	290.30^{a}	286.90^{d}
	Moringa 50 %: Panicum 50 %	566.10^{bc}	467.50^{b}	63.50^{cd}	98.70^{cd}	404.00^{ab}
	Moringa 30 %: Panicum70 %	591.30^{b}	463.70^{b}	66.20^{bcd}	127.60^{bc}	397.50^{abc}
	Moringa70 % : Panicum 30 %	578.70^{b}	347.50^{de}	50.00^{d}	231.20^{a}	297.50^{cd}
Dry	100 % Moringa + 0 % Panicum	246.30^{e}	193.20^{f}	80.10^{bc}	53.00^{d}	119.90^{f}
	0 % Moringa + 100 % Panicum	751.40^{a}	578.00^{a}	130.70^{a}	173.50^{b}	447.30^{a}
	Moringa50 % : Panicum 50 %	505.30^{c}	427.30^{bc}	121.30^{a}	78.10^{cd}	332.60^{bc}
	Moringa 30 % : Panicum 70 %	545.50^{bc}	384.10^{cde}	82.00^{bc}	165.10^{b}	302.00^{bc}
	Moringa 70 % : Panicum 30 %	391.50^{d}	317.00^{e}	133.30^{a}	74.50^{cd}	183.70^{ef}
	SEM	27.3	19.2	6.0	17.0	19.6

^{abcdef}Means along the same column with different subscripts are significantly different ($p < 0.05$)
NDF: Neutral detergent fibre, ADF: Acid detergent fibre, ADL: Lignin detergent fibre, HEM: Hemicellulose
CELL: Cellulose
SEM = Standard error of mean

Table 3: Effect of season and plant type on the mineral content of the silage (g.kg DM^{-1})

Season	Forage mixture	Phosphorus (P)	Potassium (K)	Calcium (Ca) (g.kg DM^{-1})	Sodium (Na)
Rainy	100 % Moringa + 0 % Panicum	3.56^{a}	33.26^{c}	11.72^{c}	2.90^{e}
	0 % Moringa + 100 % Panicum	2.44^{g}	30.57^{e}	7.02	2.71^{g}
	Moringa 50 %: Panicum 50 %	2.51^{f}	34.38^{b}	10.94^{d}	2.08^{j}
	Moringa 30 %: Panicum70 %	2.23^{h}	31.89^{a}	8.52^{f}	2.53^{h}
	Moringa70 % : Panicum 30 %	2.82^{c}	37.06^{f}	7.69^{g}	3.28^{c}
Dry	100 % Moringa + 0 % Panicum	3.05^{b}	31.39^{d}	10.48^{a}	3.13^{d}
	0 % Moringa + 100 % Panicum	2.51^{f}	24.26^{h}	7.76^{g}	2.83^{f}
	Moringa50 % : Panicum 50 %	1.90^{i}	24.07^{j}	11.25^{b}	3.35^{b}
	Moringa 30 % : Panicum 70 %	3.05^{b}	29.71^{i}	11.70^{c}	4.52^{a}
	Moringa 70 % : Panicum 30 %	2.69^{e}	26.35^{g}	7.80^{g}	2.21^{i}
	SEM	0.08	1.39	0.71	0.12
Normal range* (%)		0.33-0.47	0.50-3.10	0.45-1.20	0.20-0.30

^{abcdefghij}Means along the same column with different subscripts are significantly different ($p < 0.05$)
SEM= Standard error of mean
* Normal range. Source: Rogers and Murphy (2000)

Table 4: Effect of season and plant type on the *in vitro* gas production of the silage (hr)

Season	Forage mixture	3	6	9	12 (hr)	18	24	36	48
Rainy	100 % Moringa	2.00^{c}	3.00^{dc}	8.00^{c}	10.00^{d}	12.00^{d}	17.00^{e}	23.00^{f}	25.00^{f}
	0 % Moringa + 100 % Panicum	0.00^{e}	2.00^{de}	4.00^{de}	7.00^{e}	10.00^{e}	19.00^{d}	28.00^{cd}	30.00^{d}
	Moringa 50 %: Panicum 50 %	1.00^{d}	4.00^{bc}	5.00^{d}	9.00^{d}	11.00^{de}	15.00^{f}	20.00^{g}	23.00^{g}
	Moringa 30 %: Panicum70 %	1.00^{d}	5.00^{b}	10.00^{b}	15.00^{b}	19.00^{b}	24.00^{b}	29.00^{cb}	33.00^{cb}
	Moringa70 % : Panicum 30 %	0.00^{e}	3.00^{dc}	5.00^{d}	10.00^{d}	15.00^{c}	18.00^{de}	28.00^{cd}	32.00^{c}
Dry	100 % Moringa + 0 % Panicum	4.00^{a}	7.00^{a}	10.00^{b}	15.00^{b}	19.00^{b}	21.00^{c}	26.00^{e}	28.00^{e}
	0 % Moringa + 100 % Panicum	0.00^{e}	1.00^{e}	3.00^{e}	7.00^{e}	12.00^{d}	18.00^{de}	27.00^{ed}	34.00^{ab}
	Moringa 50 % : Panicum 50 %	3.00^{b}	5.00^{b}	10.00^{b}	15.00^{b}	19.00^{b}	24.00^{b}	30.00^{ab}	34.00^{ab}
	Moringa 30 % : Panicum 70 %	2.00^{c}	5.00^{b}	10.00^{b}	13.00^{c}	19.00^{b}	25.00^{b}	30.00^{ab}	35.00^{a}
	Moringa 70 % : Panicum 30 %	4.00^{a}	8.00^{a}	15.00^{a}	19.00^{a}	21.00^{a}	27.00^{a}	31.00^{a}	34.00^{ab}
	SEM	0.28	0.41	0.67	0.72	0.74	0.72	0.62	0.75

^{abcdefg} Means along the same column with different subscripts are significantly different ($P < 0.05$)

than 9.17 % reported by Fadiyimu *et al.* (2000). Meanwhile, 100 % Moringa + 0 % Panicum silage CP contents for both seasons in this study were lower than 29.68 % reported by Fadiyimu *et al.* (2000). The differences between this study and the other authors could be because they used fresh forage sample in contrast to silage used in this study. Other factors could also be responsible for CP variation in samples. Wattiaux (1999) reported that proteolytic activities that takes place during the ensilage could bring about reductions in CP content, while other variability could be attributed to plant parts, climatic condition, harvesting regime, location, soil type and age (Norton, 1994) and leaf to petiole ratio (Bamikole *et al.*, 2004). The lower CP content of 0 % Moringa + 100% Panicum silage compared to 100 % Moringa + 0 % Panicum silage in this study support the report of Mhere *et al.* (1999) that the major shortcoming of grasses is it low CP content. Hence the need for

Table 5: Effect of season and plant type on the fermentation kinetics of the silage

Season	Forage mixture	b (ml.200 mg DM^{-1})	c (ml.hr^{-1})	Lag time (hr)	SCFA (µmol.g^{-1})	ME (MJ.kg^{-1})	OMD (%)	DMD (%)
Rainy	100 % Moringa + 0 % Panicum	33.14	0.03	1.60^{dc}	0.35^{e}	4.59^{d}	42.67^{ed}	70.00^{ab}
	0 % Moringa + 100 % Panicum	53.18	0.02	4.39^{a}	0.39^{d}	4.81^{d}	40.89^{ef}	50.00^{e}
	Moringa 50 %: Panicum 50 %	29.79	0.03	2.10d^{cb}	0.30^{f}	4.30^{e}	39.61^{f}	60.00^{cd}
	Moringa 30 %: Panicum70 %	36.86	0.05	2.53^{cb}	0.51^{b}	5.52^{b}	48.77^{a}	65.00^{cb}
	Moringa70 % : Panicum 30 %	48.33	0.32	2.55^{cb}	0.37^{de}	4.68^{d}	41.76^{ef}	65.00^{cb}
Dry	100 % Moringa + 0 % Panicum	30.31	0.06	0.83^{d}	0.44^{c}	5.11^{c}	45.13^{cd}	65.00^{cb}
	0 % Moringa + 100 % Panicum	57.20	0.30	3.16^{ab}	0.37^{de}	4.67^{d}	41.06^{ef}	50.00^{e}
	Moringa 50 % : Panicum 50 %	39.20	0.04	1.65^{dc}	0.51^{b}	5.49^{b}	45.97^{cb}	55.00^{ed}
	Moringa 30 % : Panicum 70 %	41.09	0.04	2.19^{dcb}	0.54^{b}	5.63^{b}	48.15^{ab}	75.00^{a}
	Moringa 70 % : Panicum 30 %	35.22	0.06	1.12^{dc}	0.59^{a}	5.89^{a}	47.86^{ab}	60.00^{cdo}
	SEM	2.77	0.04	0.22	0.02	0.10	0.64	1.59

^{abcdef}Means along the same column with different subscripts are significantly different (P < 0.05)
b: Insoluble but degradable fraction, c: Fractional rate of gas production, SCFA: Short chain fatty acid
ME: Metabolizable energy, OMD: Organic matter digestibility, DMD: Dry matter digestibility

mixture of grasses with browse plant that are high in CP, essential vitamin, minerals and amino acids is supported (Makkar and Becker, 1997, Gidamis *et al*., 2003).

The range of non-fibre carbohydrates (NFC) content of the plant types silages in this study indicated that they can be easily degraded or fermented, as NFC is a crude estimate of the carbohydrate pool that differ in digestibility from NDF. The pH of silage is one of the simplest and quickest ways of evaluating its quality. The pH values of different ensiled forage mixtures at different season fell within 4.2 (Kung and Shaver, 2001) and 4.5 and 5.5 (Meneses *et al*., 2007) that was recommended as the normal good silage for ruminants.

A higher CP content for 100 % Moringa + 0 % Panicum silage during the rainy season compared with dry season could be due to higher moisture content and nitrogen uptake being more rapid than dry matter accumulation during the rainy season. This agrees with Bamualim *et al*. (1980) and Larbi *et al*. (1997) who reported that seasonal variations occur between plant species and between seasons with higher crude protein values reported for seasons with higher moisture levels. The higher CP content of 100 % Moringa + 0 % Panicum silage in the rainy season could be due to the continuous flush (regrowth) of leaves during this period (Anele *et al*., 2009).

0 % Moringa + 100 % Panicum silage recorded higher NDF, ADF and ADL above other plant types which was consistent with the observation of Okoli *et al.* (2003) that the fibre contents of tropical grasses is usually higher than that for browse, shrubs and trees. The range of NDF contents in this study for 100 % Moringa + 0 % Panicum silage and all the forage mixtures for both seasons were below the range of 600-650 g.kg DM^{-1} suggested as the limit above which intake of tropical feeds by ruminant animals would be limited (Van Soest *et al*., 1991).

Silages produced from the legumes had higher Ca and P contents than those from the grasses. This is in accordance to the report of Nasrullah *et al*. (2004) and Marschner (1993) that there is a marked difference between the level of Ca and P in legumes and grasses. Since grasses have a tendency to be lower in Ca and P, hence the mixture of grasses and legumes in order to improve the nutrients available to animals. Ca is above the critical level of 3 g.kg DM^{-1} as recommended for ruminants in the warm wet climates (McDowell *et al*., 1993). This result indicates that Ca content of forage satisfied the animal requirements specified by the ARC (1980).

The P level in this study was above the critical level of 2.5 g.kg DM^{-1} for ruminant animals as reported by Muhammad *et al*. (2005). The K contents in all plant type silages at different seasons of the year were higher than 8 g.kg DM^{-1} as recorded for grazing animals (Underwood, 1981).

In vitro digestibility

The value of net gas produced in this study for 100 % Moringa + 0 % Panicum silage is similar to those reported for leaves from tropical trees and shrubs (*Adansonia digitata* and *Bombax glabra*) in south western Nigeria (Ogunbosoye and Babayemi, 2010). The low digestibility observed in this study for 100 %

Moringa + 0 % Panicum silage may be due to the presence of condensed tannins which is an anti-nutritional content found in most of the plant species (Barry and McNabb, 1999). Moringa (30 %) : Panicum (70 %) silage at dry season recorded the highest gas produced which suggests that it is of higher nutritional value than the other plant types and it connotes high digestibility of the forages at that mixtures.

The highest short-chain fatty acids (SCFA) and organic matter digestibility (OMD) contents in 70 % Moringa : 30 % Panicum silage in dry season and other forage mixtures, possibly because the mixtures contain more fermentable carbohydrate which is a vital substrate for growth of ruminal microorganisms (Van Soest, 1994). The estimation of the ME values is valuable for purposes of ration formulation and to set economic value of feed for other purposes (Getachew *et al*., 2002). Gas production is a reflection of the generation of SCFA and microbial mass (Getachew *et al*., 1998).

CONCLUSION

The pH values were within the range of pH for good quality silage. 100 % Moringa + 0 % Panicum silage recorded the highest CP content and lower fibre fractions than the 0 % Moringa + 100 % Panicum silage. Mixtures of the grass and browse plants produced quality silages for both the rainy and dry seasons. This will go a long way to provide quality feed for ruminants during the dry season when forages are scarce with low quality in the natural pastureland.

REFERENCES

AGANGA, A. A. – TSHWENYANE, S. O. 2004. Potentials of guinea grass (*Panicum maximum*) as forage crop in livestock production. *Pakistan Journal of Nutrition*, vol. 3 (1), 2004, p. 1–4.

AJAYI, F. T. – BABAYEMI, O. J. 2008. Comparative *in vitro* evaluation of mixtures of *Panicum maximum* cv Ntchisi with stylo (*Stylosanthes guianensis*), Lablab (*Lablab purpureus*), Centro (*Centrosema pubescens*) and histrix (*Aeschynomene histrix*). *Livestock Research for Rural Development*, vol. 20 (6), 2008, p. 1–15.

ANELE, U. Y. – ARIGBEDE, O. M. – SÜDEKUM, K. -H. – ONI, A. O. – JOLAOSHO, A. O. – OLANITE, J. A. – ADEOSUN, A. I. – DELE, P. A. – IKE, K. A – AKINOLA, O. B. 2009. Seasonal chemical composition, *in vitro* fermentation and *in sacco* dry matter degradation of four indigenous multipurpose tree species in Nigeria. *Animal Feed Science and Technology*, vol. 154 (1), 2009, p. 47–57.

ANELE, U. Y. – JOLAOSHO, A. O. – ARIGBEDE, O. M. – OLANITE, J. A. – ONIFADE O. S. 2011. Effects of air drying and plant types on quality of grass/legume silage. In: Animal Feed: Types, Nutrition and Safety. (Sarah R. Borgearo, ed). pp. 207–218. Nova Science Publishers, Inc. New York, USA.

A.O.A.C. 2000: Association of Official Analytical Chemists. Official Methods of Analysis. 16th edition, Washington DC.

ARC 1980. The nutrient requirements of ruminant livestock. pp. 309-314. Agricultural Research Council. (Commonwealth Agricultural Bureaux: Farnham Royal, Slough, G.B.).

ASSEFA, G. – LEDIN, I. 2001. Effect of variety, soil type and fertiliser on the establishment, growth, forage yield, quality and voluntary intake by cattle of oats and vetches cultivated in pure stands and mixtures. *Animal Feed Science and Technology*, vol. 92, 2001, p. 95–111.

AWAD, O. A – ELHADI, O. A. 2010: Seasonal variability in nutritive value of ruminant diets under open grazing system in the semi-arid rangeland of Sudan (South Darfur State). *Agriculture and Biology Journal of North America. ScienceHuβ*, vol. 1 (3), 2010, p. 243–249. http://www.scihub.org/ABJNA.

BABAYEMI, O. J. – BAMIKOLE, M. A. 2006: Effects of Tephrosia candida DC leaf and its Mixtures with Guinea Grass on *in vitro* Fermentation Changes as Feed for Ruminants in Nigeria. *Pakistan Journal of Nutrition*, vol. 5, 2006, p. 14–18.

BAMIKOLE, M. A. – IKHATUA, O. M. – ARIGBEDE, O. M. – BABAYEMI, O. J. – ETELA, I. 2004. An Evaluation of the Acceptability as forage of some Nutritive and Antinutritive Components and of the Dry Matter Degradation Profiles of Five Species of Ficus. *Tropical Animal Health and Production*, vol. 36, 2004, p. 157–167.

BAMUALIM, A. – JONES, R. J. – MURRAY, R. M. 1980. Nutritive value of tropical browse legumes in the dry season. Proceedings of the Australian Society of Animal Prododuction, 13, 1980, p. 229–232.

BARRY, T. N. – MCNABB, W. C. 1999. The implication of condensed Tannins in the nutritive value of temperature forages fed to ruminants. *British Journal of Nutrition*, vol. 81, 1999, p. 263–272.

FADIYIMU, A. A. 2000. Chemical composition, dry matter degradability and preference by WAD goats of some multipurpose trees in Nigeria. In: Proceeding of 25th Annual Conference of Nigeria Society for Animal Production, March 19–23, Umudike, Imo State, Nigeria. pp. 76–77.

GETACHEW, G. – MAKKAR, H. P. S. – BECKER, K. 1998. The *in vitro* gas measuring techniques for assessment of nutritional quality of feeds: a review. *Animal Feed Science and Technology*, vol. 72, 1998, p. 261–281.

GETACHEW, G. – CROVETTO, G. M. – FONDEVILA, M. – KRISHNAMOORTHY, U. – SINGH, B. – SPANGHERO, M. – STEINGASS, H. – ROBINSON, P. H. – KAILAS, M. M. 2002. Laboratory variation of 24 h *in vitro* production and estimated metabolizable energy values of ruminant feeds. *Animal Feed Science and Technology*, vol. 102, 2002, p. 169–180.

GETACHEW, G. – MAKKAR, H. P. S. – BECKER, K. 2000. Stoichiometric relationship between short chain fatty acid and *in vitro* gas production in presence and absence of polyethylene glycol for tannin containing browses. In: EAAP Satellite Symposium, Gas Production: Fermentation Kinetics for Feed Evaluation and to Assess Microbial Activity, Wageningen, August 18-19, pp. 46–47.

GIDAMIS, A. B. – PANGA, J. T. – SARWATT, S. V. – CHOVE, B. E. – SHAYO, N. B. 2003. Nutrients and antinutrient contents in raw and cooked leaves and mature pods of Moringa oleifera, Lam. *Ecology of Food and Nutrition*, vol. 42, 2003, p. 399–411.

KOLJAJIC, V. – DORDEVIC, N. – GRUBIC, G. 1998. Effects of inoculants on ensiling of maize plant and alfalfa at different ratios. *Review of Research Work at the Faculty of Agriculture, Belgrade*, vol. 43 (2), 1998, p. 95–101.

KUNG, L. – SHAVER, R. 2001: Interpretation and use of silage fermentation analysis reports. Forage Research Centre, Madison, Wisconsin, USA.

LARBI, A. – SMITH, J. W. – ADEKUNLE, I. O. – KURDI, I. O. 1996. Studies on multipurpose fodder trees and shrubs in West Africa: Variation in determinants of forage quality in Albizia and Paraserianthes species. *Agroforestry Systems*, vol. 33, 1996, p. 1–11.

LARBI, A. – SMITH, J. W. – RAJI, A. M. – KURDI, I. O. – ADEKUNLE, I. O. – LADIPO, D. O. 1997. Seasonal dynamics in dry matter degradation of browse in cattle, sheep and goats. *Small Ruminant Research*, vol. 25, 1997, p. 129–140.

MAKKAR, H. P. S. – BECKER, K. 1997. Nutrients and antiquality factor in different morphological parts of the Moringa oleifera Tree. *Journal of Agricultural Science*, vol. 128, 1997, p. 311–322.

MAN, N. V. – WIKTORSSON, H. 2002. Effect of molasses on nutritional quality of cassava and gliricidia tops silage. Asian-Australasian Journal of Animal Science, vol. 15, 2002, p. 1294–1299.

MARSCHNER, H. 1993. Mineral Nutrition of Higher plant Second Edition. Academic press Ltd. London, Great Britain.

MCDOWELL, L. R. – CONRAD, J. H. – HUMBRY, F. G. 1993. Minerals for grazing ruminants in tropical regions. Bulletin: The US Agency for Literature Development and Caribbean Basin Adversary Group (CBAG) USA.

MCMENIMAN, N. P. – LITTLE, D. A. 1974. Studies on the supplementary feeding of sheep consuming mulga (*Acacia anura*). The provision of phosphorus and molasses supplement under grazing condition. *Australia Journal of Experimental Agriculture and Animal Husbandry*, vol. 14, 1974, p. 316–321.

MENESES, M. D. – MEGIAS, J. – MADRID, A. – MARTINEZ-TERUEL, F. – HERNANDEZ, J. – OLIVA, J. 2007. Evaluation of the phytosanitary, fermentaive and nutritive characteristics of the silage made from crude artichoke (*Cynara scolymus* L.) by- product feeding for ruminants. *Small Ruminant Research*, vol. 70, 2007, p. 292–296.

MENKE, K. H. – STEINGASS, H. 1988. Estimation of the energetic feed value obtained from chemical analysis and gas production using rumen fluid. *Animal Research Development*, vol. 28, 1988, p. 7–55.

MHERE, O. – MAASDORP, B. V. – TITTERTON, M. 1999. The effect of intercropping on production and ensilage of sweet forage sorghum and pennisetum with cowpea and dolichos bean. In: (Eds. T. Smith and W. Richards) Proceedings of Livestock Production Programme Workshop on Livestock Research in Zimbabwe. Department for International Development. Matopos, Zimbabwe.

MUHAMMAD, I. R. – ABDULLAHI, B. – MOHAMMED, A. K. – TANKO, R. J. – KALLAH, M. S. – ALAWA, J. P. 2005. Influence of irrigation intervals on dry matter yield, concentration of crude protein, calcium and phosphorus in Lablab purpureus and Sorghum almum fodder in the Sudan savannah zone of Nigeria. *Nigerian Journal of Animal Production*, vol. 32, 2005, p. 280–286.

NASRULLAH, R – NIIMI, M. – AKASHI, R. – KAWAMURA, O. 2004. Nutritive evaluation of forage plants grown in South Sulawesi, Indonesia. II. Mineral composition. *Asian-Australasian Journal of Animal Science*, vol. 17 (1), 2004, p. 63–67.

NAYIGUHUGU, V. – KELLOG, D. W. – LONGER, D. E. – JOHNSON, Z. B. 2002. Case study; performance and ensiling characteristics of tall-growing soybean lines used for silage. *American Registry of Professional Animal Scientist*, vol. 18 (1), 2002, p. 85–91.

NORTON, B. W. 1994. Tree legumes as dietary supplements for ruminants. In: Gutteridge R C and Shelton H M (ed.). Forage tree legumes in tropical agriculture. CABI International, p. 192–201.

OGUNBOSOYE, D. O. – BABAYEMI, O. J. 2010. Potential values of some non-leguminous browse plants as dry season feed for ruminants in Nigeria. *African Journal of Biotechnology*, vol. 9 (18), 2010, p. 2720–2726. Available online at http://www.academicjournals.org/AJB.

OKOLI, I. C. – ANUNOBI, M. O. – OBUA, B. E. – ENEMUO, V. 2003 Studies on selected browses of southeastern Nigeria with particular reference to their proximate and some endogenous anti-nutritional constituents. *Livestock Research for Rural Development*, vol. 15 (9), 2003, http://www.lrrd.org/lrrd15/9/okol159.htm.

PHIRI, M. S. – NGONGONI, N. T. – MAASDORP, B. V. – TITTERTON, M. – MUPANGWA, J. F. – SEBATA, A. 2007. Ensiling characteristics and feeding value of silage made from browse tree legume-maize mixtures. *Tropical and Subtropical Agroecosystems*, vol. 7, 2007, p. 149–156.

ROGERS, P. – MURPHY, W. 2000. Levels of Dry Matter, Major Elements (calcium, magnesium, nitrogen, phosphorus, potassium, sodium and sulphur) and Trace Elements (cobalt, copper, iodine, manganese, molybdenum, selenium and zinc) in Irish Grass, Silage and Hay.

SAS 2002. Statistical Analysis Systems user's guide (Statistics, Version. 8). SAS Institute Inc, Cary.

UNDERWOOD, E. J. 1981. The mineral nutrition of livestock. 2nd edition. Commonwealth Agricultural Bureau, London.

VAN SOEST, P. J. 1994: Nutritional Ecology of the Ruminant, 2nd edition. Comstock Publishing Associates/Cornell University Press, Ithaca, NY, USA.

VAN SOEST, P. J. – ROBERTSON, J. B. – LEWIS, B. A. 1991. Methods for dietary fiber, neutral detergent fiber, and non-starch polysaccharides in relation to animal nutrition. *Journal of Dairy Science*, vol. 74, 1991, p. 3583–3597.

WATTIAUX, M. 1999. Introduction to silage-making. Dairy update. The Babcock Institute. University of Wisconsin. Feeding 502, 1999, p. 1–12, http://babcock.cals.wisc.edu.

YOKOTA, H. – OHSHIMA, M. – HUANG, K. J. – OKAJIMA, T. 1995. Lactic acid production in Napier grass (*Pennisetum purpureum Schum.*) silage. *Grassland Science*, vol. 41, 1995, p. 207–211

ZANINE, A. – SANTOS, E. – FERREIRA, D. – OLIVEIRA, J. – ALMEIDA, J. – PEREIRA, O. 2006. Evaluation of Silage of Elephant-grass with addition of wheat meal. *Archives de Zootechnie*, vol. 55, 2006, p. 75–84.