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National Animal Production Research Institute
Ahmadu Bello University
P.M.B 1096, Shika-Zaria,
Kaduna State, Nigeria.
Email:japr@napri-ng.orgWebsite:www.naprijapr.org

PHYSICAL AND CHEMICAL CHARACTERISTICS OF *PENNISETUM PURPUREUM* GRASS SILAGE AS AFFECTED BY MANURE TYPE AND ENSILING DURATION

[1]Dele P. A., [*2]Amole T. A., [1]Akinyemi B. T., [1]Sangodele O.T., [1]Okukenu O.A., [1]Oyebanjo E. D., [1]Adepoju R. O., [1]Ewetola I. A., [1]Ojo V.O.A. and [1]Olanite J. A.,

[1]Department of Pasture and Range Management, Federal University of Agriculture, Abeokuta
[2]International Livestock Research Institute (ILRI), Ouagadougou, Burkina Faso
[*]Corresponding author's e-mail: t.amole@cgiar.org

ABSTRACT

An experiment was conducted at the Organic Research Site and Laboratory of the Department of Pasture and Range Management, Federal University of Agriculture, Abeokuta between August, 2011 and April, 2012 to evaluate the effects of ensiling duration on the physical and chemical characteristics of manured –organic *Pennisetum purpureum* silage. The experiment was arranged in a 4 x 2 factorial with three manure treatments namely: cattle, swine, poultry and control (no manure) and two ensiling durations (45 and 90 day). The colour of the silage was slightly ($P < 0.05$) affected by the manure type and ensiling duration. The mouldiness of the silage was slightly higher ($P < 0.05$) in silage produced from manured *Pennisetum*. Effect of manure type and ensiling duration were significant ($P < 0.05$) for all parameters evaluated for the silage. The silage produced from poultry manure (PM) fertilized *P. purpureum* and ensiled for 90 days recorded the highest CP (92.33g/kg). Silage from PM fertilized *P. purpureum* and ensiled for 45 days had the least NDF (572.79g/kg) value and silage produced from unfertilized *P. purpureum* had the highest gas production. It could be concluded that silage produced from PM fertilized *P. purpureum* can be a better feed resource for dry season organic ruminant animal production.

INTRODUCTION

Herbaceous forages, browse species and crop residues are the main components of livestock feed resources in sub-Saharan Africa. The production of these plants biomass is affected by soil nutrient quantity and availability (Demey *et al.*, 2013). In biomass production systems, the ability to supply plants with the required nutrients relies on natural soil fertility and on external inputs such as fertilizers. The high cost of inorganic fertilizers, pattern of land use that allocates grasslands to soils of low fertility, and the increasing pressure on available land associated with crop production for both food and bio-energy as well as its residual effect on the environment and human health (Bamikole *et al.*, 2001; Oad *et al.*, 2004), call for a re-evaluation of how nutrients is supplied for efficient production of biomass (Castillo, 2009) for animal. Animal manures represent an alternative source of nutrients for biomass production, not only due to lower cost compared to inorganic fertilizers (Dele, 2012), but also because the material already exists as a by-product of livestock production (Osuhor *et al.*, 2002; Fasae *et al*., 2009). Manure is a valuable resource in plant nutrition, having the dual positive effects of supplying the soil with both nutrients and organic matter. An effective utilisation of manure reduces the risk of pollution and enables the farmer to make substantial savings on mineral fertiliser (Rammer and Lingvall, 1997). Its capacity to increase soil organic matter and promote carbon storage in climate change mitigation strategy has been discussed (Li *et al.*1994). Therefore, using the manure for increased pasture production may, in fact, be a

means of recycling the waste for environmental sustainability and may, on the long run, revolutionize ruminant livestock production in Nigeria. As forage quality and quantity tends to increase in wet season and as a result of improve soil nutrient by manure application, several authors has advocated for the conservation of excess of herbage yield in the rainy season in south west Nigeria (Dele 2012; Olanite *et al*. 2012) as ruminant livestock feeds for the dry season when there is scarcity and therefore reduced wastage and improve off season herbage availability, hence the reason for evaluating the effects of animal manure type and ensiling duration on the physical and chemical characteristics of Pennisetum silage

MATERIALS AND METHODS

The forage materials used for the silage were harvested from Organic Pasture Research Farm while the laboratory analyses were carried out at the Department of Pasture and Range Management Laboratory both of the Federal University of Agriculture, Abeokuta Nigeria. . Twelve (12) plots of sole *Pennisetum purpureum* forage each measuring 4 m x 3 m were established in June, 2010. The plot treatments consist of three (3) manure types from three animal species namely: cattle, swine and poultry and a control plot without manure. All treatments were replicated three (3) times. The manures were collected from the Livestock Teaching and Research Farm, Federal University of Agriculture, Abeokuta 14 days prior to application and sub-samples taken from each manure type and analysed (Table 1). The rate of application was 300 kg/N and quantities applied were determined based on the nitrogen content of each manure type. Plots were kept weed free throughout the establishment period. In August, 2011, the plots were cut-back to stimulate re-growth of fresh materials which were thereafter used for silage production.

Forage samples of the *Pennisetum purpureum* grass were harvested eight weeks after cutback. Harvested samples were chopped to about 1.5cm size and wilted for 4 hours to reduce moisture contents by spreading the chopped forages on a platform. The wilted forages were carefully packed into silage kilner jar bottles. The grass materials were compressed gently to expel air space and silage bottles covered and sealed with masking tape. The experiment was arranged in a 2 x 4 factorial which consist of 2 ensiling duration (45 and 90 days) and 3 manure types (swine, cattle, poultry and a control), to give a total of 8 treatments and were replicated thrice. The ensiled forage materials were left on the laboratory bench for a period of 45 and 90 days, respectively. Sub-samples of 10 g of the ensiled materials were taken per replicate and soaked in 100 ml of distilled water for 12 hours. The mixtures were filtered and divided into four aliquots samples for pH determination using a pH meter (Wilson and Wilkins, 1972). The silages were also evaluated for physical characteristics: aroma, colour, mouldiness and moistness using the Procedure of Bostami *et al.* (2008). Proximate composition (dry matter content, crude protein, ash, ether extract and non-fibre carbohydrate) of the samples were determined according to A.O.A.C. (2006) and fibre fraction analysis (Neutral detergent fibre (NDF), acid detergent fibre (ADF), acid detergent lignin (ADL) were determined according to the Procedure of Van Soest *et al*. (1991). The *in vitro* gas production was determined following the Procedure of Menke and Steingass (1988). Data collected were subjected to analysis of variance and significant treatment means were separated using Duncan's Multiple Range Test using SAS (2002) Package and presented graphically.

RESULTS

The pH contents of the silages made from *Pennisetum purpureum* grass was significantly ($P<0.05$) affected both by the manure types and ensiling period. Days of ensiling increased significantly with ($P<0.05$) the pH contents of the silages, with the exception of the silage made from plots with poultry manure application. At both 45 and 90 days of ensiling, silage made from the control treatment had the highest ($P<0.05$) pH value. Colour of the all silages changed from greenish to brownish yellow as the days of ensiling were prolonged from 45 to 90days, with the exception of silage made from plots with poultry manure application (Table 2)

Figure 1 showed the results of the proximate composition of *Pennisetum purpureum* silage as affected by manure type and period of ensiling. The dry matter content (295 g/kg) of the silage made from poultry manure for 45days had the highest dry matter as compared to the least dry matter (205 g/kg) obtained in silage made from swine manure at 90days of ensiling (Figure 1a). As indicated in Figure 1, silage made from poultry manure for 90days had the highest crude protein (CP) content of 92.33 g/kg while the least CP content was recorded in silage made from the control treatment at 90days. Only silage made from poultry manure recorded an increase in the CP content with prolonged days of ensiling. Days of ensiling had no significant effect on the non-fibre carbohydrate (NFC) content on the silage made from poultry manure (Figure 1e).

The neutral detergent fibre (NDF) of the silages obtained from this study ranged between (572.79 and 651.13 g/kg) with silage made from control treatment at 45days having the highest NDF content and silage from poultry manure at 45days having the least NDF content (Figure 2). It was also observed that the effect of manure type and days of ensiling on acid detergent fibre (ADF) content of the silage made from swine and cattle manures at 90days of ensiling were similar, but had higher values than other two treatments. Silage made from poultry manure at 45days had the least content of ADF (306.80 g/kg).

The *in vitro* gas production of the silage made from the grass as affected by manure type and ensiling duration is presented in Figure 3 indicated that the volume of gas production increased steadily from 3 to 48 hr for all the silages, however, silage made from the control treatment produced the highest gas volume. Ensiling duration had a significant ($P<0.05$) effect on the gas volume of the silage. It was noticed that silages ensiled for 45days had higher ($P<0.05$) gas volume throughout the incubation period.

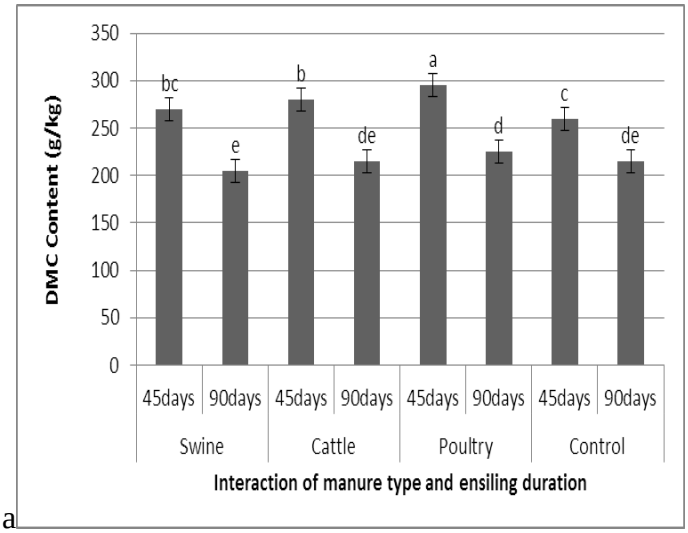
Table 1: Nutrient composition of three animal manures

Parameters	Cattle	Swine	Poultry
N (g/kg)	15.6	16.9	30.2
P (g/kg)	6.9	6.3	10.6
K (g/kg)	7.3	7.6	10.3
Ca (g/kg)	21.2	31.6	37.2
Mg (g/kg)	11.7	19.2	17.3
Na (g/kg)	1.1	1.6	2.1
Fe (mg/kg)	614.6	650.7	630.9
Zn(mg/kg)	54.8	81.2	75.4
Cu(mg/kg)	29.1	27.3	32.7
Mn(mg/kg)	321.9	260.3	217.9

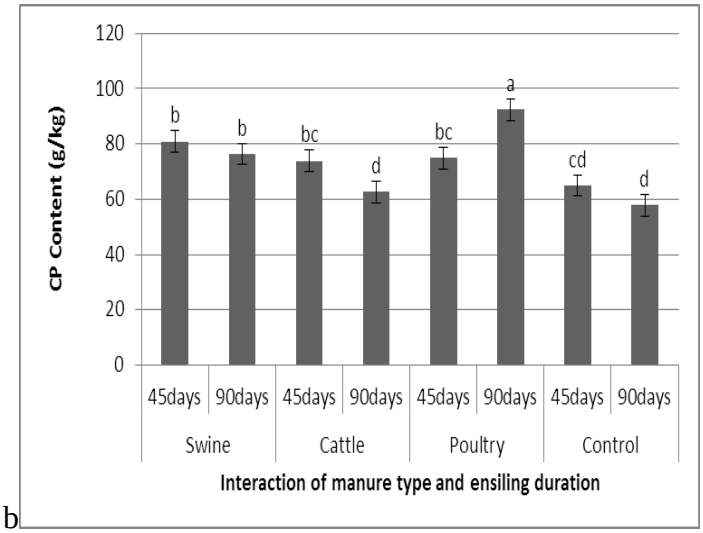
Table 2: Physical characteristics and pH of *Pennisetum purpureum* silage as affected by manure type and ensiling duration

Manure	Ensiling Duration (Days after ensiling)	pH	Colour	*Aroma	Mouldiness
Swine	45	4.37^{a}	Greenish	Moderately good	Absent
	90	4.96^{b}	Brownish yellow	Moderately good	Present
Cattle	45	4.37^{a}	Greenish	Moderately good	Absent
	90	4.86^{b}	Brownish yellow	Moderately good	Present
Poultry	45	4.59^{ab}	Greenish	Moderately good	Present
	90	4.36^{a}	Greenish	Moderately good	Absent
Control	45	5.15^{bc}	Greenish	Moderately good	Absent
	90	5.31^{c}	Brownish yellow	Moderately good	Absent
SEM		0.14			

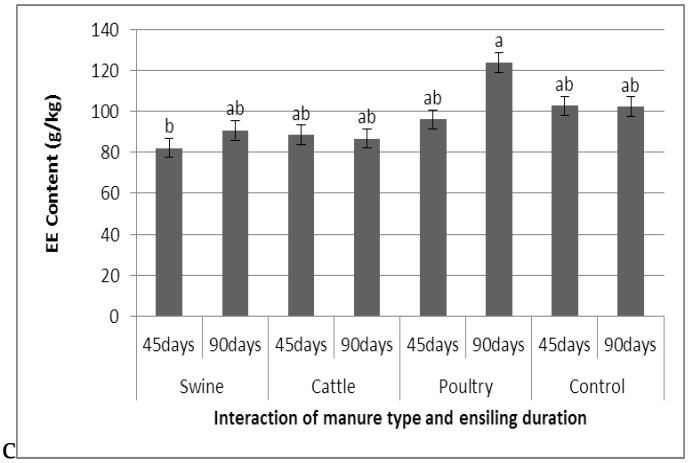
Means followed by different letters within columns differ significantly (P<0.05). * Bostami *et al.* (2008).


DMC Content (g/kg)
350
300
250
200
150
100
50
0
bc
e
b
de
a
d
c
de
45days
90days
45days
90days
45days
90days
45days
90days
Swine
Cattle
Poultry
Control
Interaction of manure type and ensiling duration

a

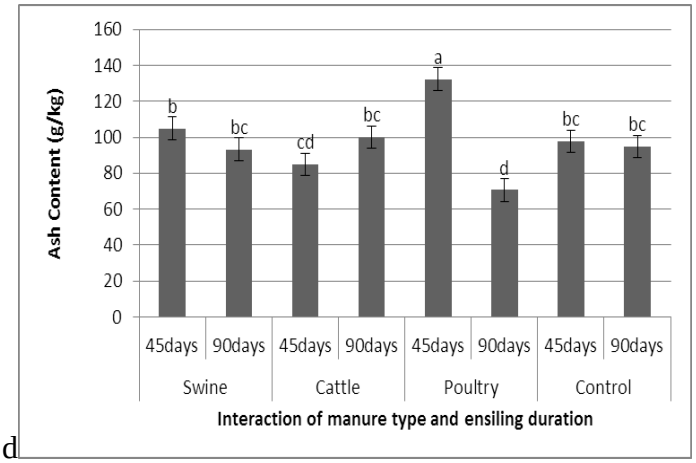

CP Content (g/kg)
120
100
80
60
40
20
0
b
b
bc
d
bc
a
cd
d
45days
90days
45days
90days
45days
90days
45days
90days
Swine
Cattle
Poultry
Control
Interaction of manure type and ensiling duration

b

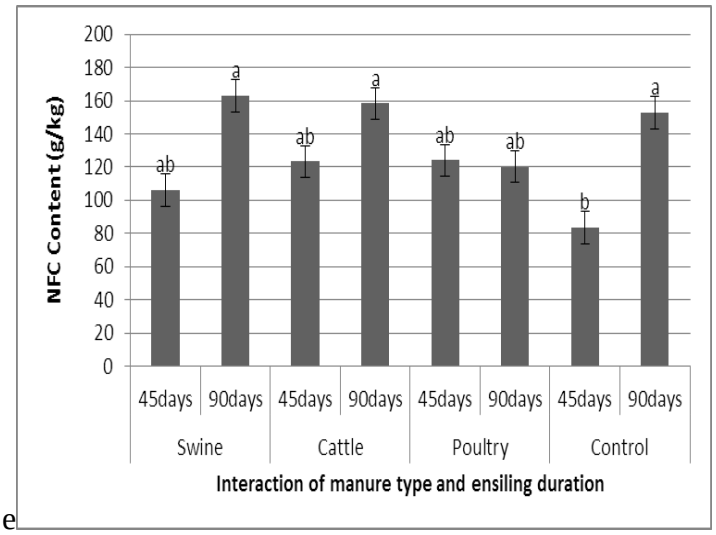

EE Content (g/kg)
140
120
100
80
60
40
20
0
b
ab
ab
ab
ab
a
ab
ab
45days
90days
45days
90days
45days
90days
45days
90days
Swine
Cattle
Poultry
Control
Interaction of manure type and ensiling duration

c

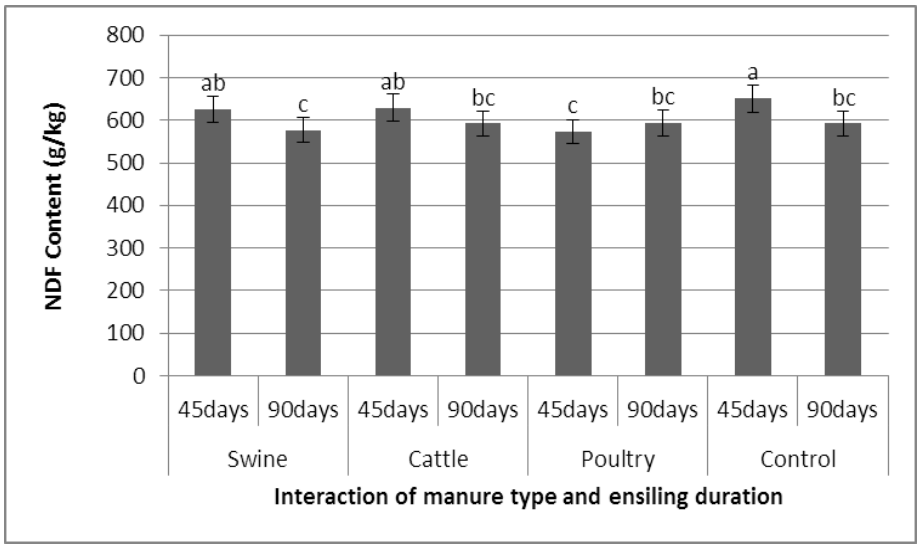
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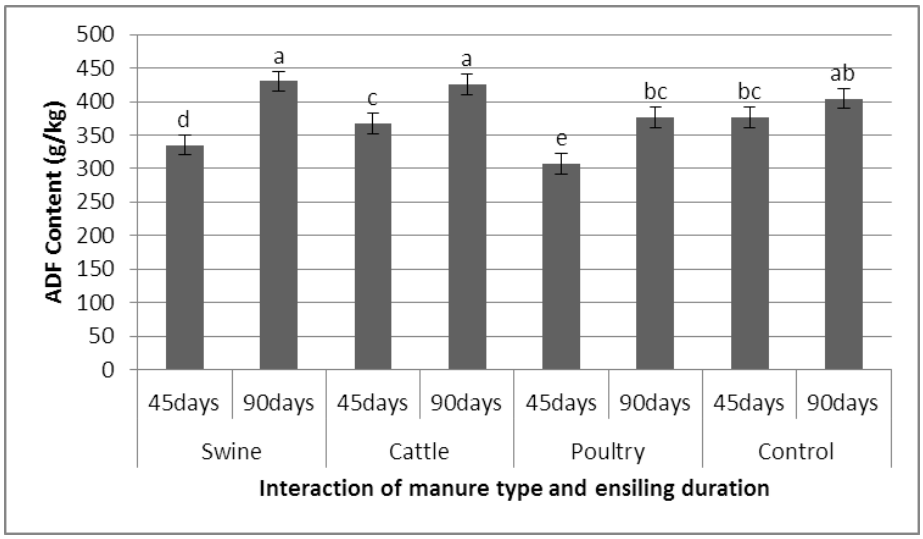
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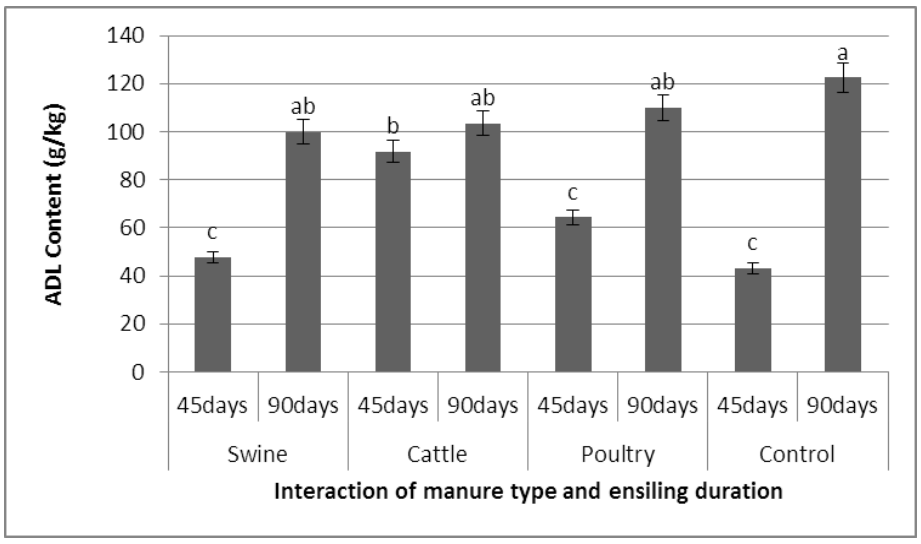
Figures 1: a: Interaction effect of manure type and ensiling duration on the dry matter content (DMC) of *Pennisetum purpureum* silage; b: Interaction effect of manure type and ensiling duration on the crude protein (CP) of *Pennisetum purpureum* silage; c: Interaction effect of manure type and ensiling duration on the ether extract (EE) of *Pennisetum purpureum* silage; d:Interaction effect of manure type and ensiling duration on the Ash content of *Pennisetum purpureum* silage; e:Interaction effect of manure type and ensiling duration on the Non-fibre carbohydrate (NFC) of *Pennisetum purpureum* silage;


NDF Content (g/kg)
800
700
600
500
400
300
200
100
0
ab
c
ab
bc
c
bc
a
bc
45days
90days
45days
90days
45days
90days
45days
90days
Swine
Cattle
Poultry
Control
Interaction of manure type and ensiling duration

a


ADF Content (g/kg)
500
450
400
350
300
250
200
150
100
50
0
d
a
c
a
e
bc
bc
ab
45days
90days
45days
90days
45days
90days
45days
90days
Swine
Cattle
Poultry
Control
Interaction of manure type and ensiling duration

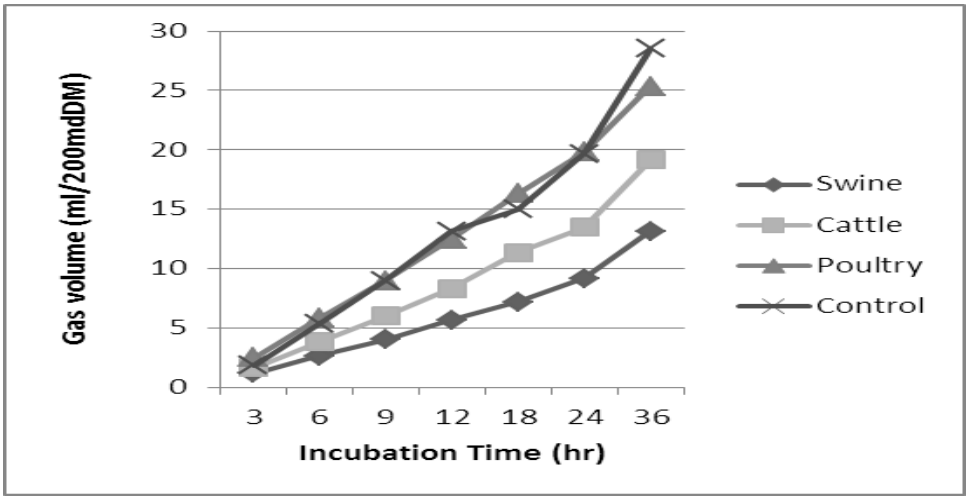
b


ADL Content (g/kg)
140
120
100
80
60
40
20
0
c
ab
b
ab
c
ab
c
a
45days
90days
45days
90days
45days
90days
45days
90days
Swine
Cattle
Poultry
Control
Interaction of manure type and ensiling duration

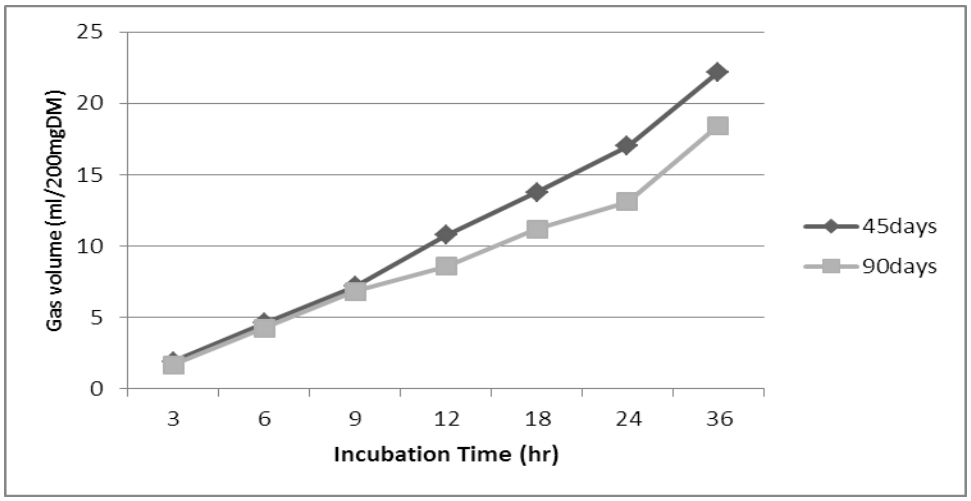
c

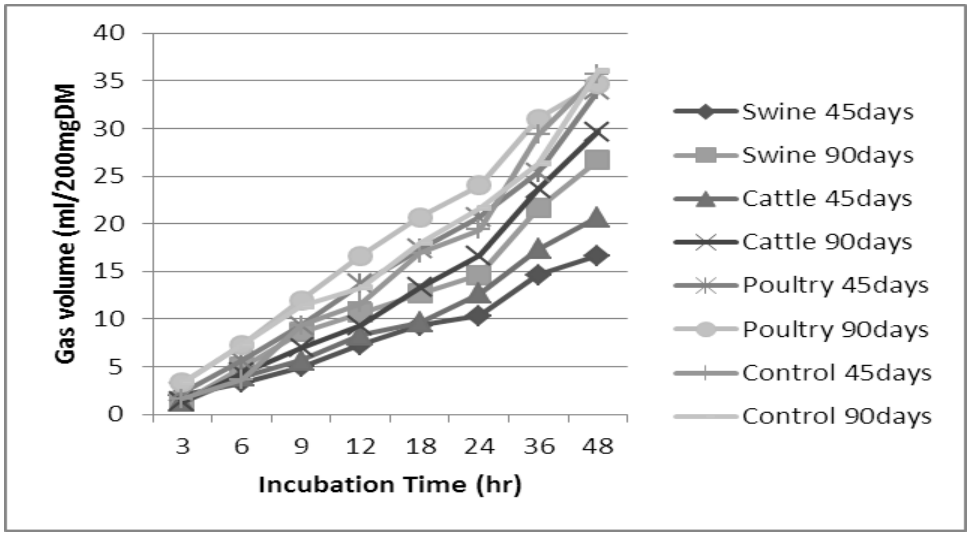
Figures 2: a: Interaction effect of manure type and ensiling duration on the Neutral detergent fibre (NDF) of *Pennisetum purpureum* silage; b: Interaction effect of manure type and ensiling duration on the Acid detergent fibre (ADF) of *Pennisetum purpureum* silage; c: Interaction effect of manure type and ensiling duration on the Acid detergent lignin (ADL) of *Pennisetum purpureum* silage

a



b



c 

Figures 3: a: Effect of manure type on the *in vitro* gas production of *Pennisetum purpureum* silage; b: Effect of ensiling duration on the *in vitro* gas production of *Pennisetum purpureum* silage; c: Interaction effect of manure type and ensiling duration on the *in vitro* gas production of *Pennisetum purpureum* silage.

DISCUSSION

Ensiling is one of the methods used in preserving forage and also a way to salvage the under-utilized pasture for better acceptability and degradability. The pH of silage is one of the simplest and quickest ways of evaluating its quality, as silage properly fermented will have a much lower pH. The pH of the silages in the present study is within the ranged (4.50-5.50) reported as good silage (Meneses *et al*., 2007), but higher than 4.2 recommended for normal grass silage (Kung and Shaver, 2001). Good silage usually preserve well with the original colour of the pasture (t'Mannetje, 1999). This was also observed in this study, but with the increase in ensiling duration, the colour changed slightly from green to yellowish brown which could be as a result of the mould evident along with the length of ensiling. Changes in colour during ensiling has been attributed to browning reaction when useful protein forming complexes with carbohydrate and thereby making them less digestible and loss of nutritional quality (Bolsen *et al.*, 1996). Only silage made from poultry manure application retain its greenish colouration in spite of prolonged days of ensiling which in an indicator that the silages were well-preserved (Oduguwa *et al*., 2007). This colour retention could be an indication that the nutrition composition of the silage could be maintained and could meet the nutrient requirement of ruminants during the 3-4 month of dry season in south west Nigeria.

The CP recorded from all the silages is well above the threshold of 60 g/kg required by rumen microbes to build their body protein except for the unfertilized Pennisetum silage ensiled for 90days, below this threshold, intake of forages by ruminants and rumen microbial activity would be adversely affected (Van Soest, 1994). Consequently, the silages are therefore adequate for meeting the protein requirement of growing calves as well as other small ruminant animals to generate a high level of ammonia in the rumen from degradable protein to ensure an efficient digestion process (Ørskov, 1995). The higher CP values recorded for silage sample from Pennisetum plot with poultry manure was an indication of a more positive effect of that manure on the grass. This could be as a

result of higher nitrogen contents in the poultry manure as observed in the result. Earlier report observed that nitrogen application improved forage quality by increasing crude protein content (Adam, 2004). Gasim (2001) also found that crude protein increased with increased phosphorus application. Schegel (1992) had earlier observed that poultry manure had the highest effect on N and P availability in the soil than the other animal manures. Poultry manure might have produced rapid organic matter decomposition, and quick release of nutrients, in the form of nitrogen and phosphorous for plant uptake because it contains higher concentrations of Uric acid and phosphorus-bearing feed materials that could be readily available for further conversion into plant nutrients soon after application to soil (Olanite, 2014). The reduction in CP content with advancement in duration of ensiling from 45 to 90 days in silage from Pennisetum established with cattle manure, swine manure and the control was attributed to the extensive proteolysis that might have taken place during the ensiling process (Ruiz *et al.*, 1992). Prolonged storage did not reduce the CP contents of the silage made from Pennisetum with poultry manure application.

The ether extract (EE) contents of the silage has higher than the value reported by Babayemi (2009), but slightly lower than what was reported by Anele *et al.* (2011). However the range of EE of silages were slightly above 80 g/kg level as established by NRC (2001) as a limit from which reductions would occur in the DM intake by ruminants. The ash content as affected by the manure types is similar to that reported by Jusoh (2005) for Napier grass fertilized with sheep manure. The NFC value recorded for the silage in this study was similar to what was obtained and fell within the range reported by Anele *et al.* (2009). This indicates that the NFC of the grasses 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 a positive relationship with ammonia nitrogen (NH_3-N) utilization in the rumen (Tylutki *et al*., 2008). The range of values for the fibre fractions of the silages indicated that they were diverse in terms of their cell wall contents. Forage digestibility depends mainly on the cellular content and the nature of the cell wall which is made up mainly of cellulose, hemicellulose and lignin. The range of NDF contents in the silages irrespective of the factor under consideration in the present study is below the 650 g/kg suggested as the limit above which intake of tropical feeds by ruminants would be limited (Van Soest *et al.*, 1991). Although, the results obtained in the present study showed that manure type may not have direct impact on the NDF content of the silage (Olanite *et al.*, 2014; Rogers *et al*., 1996), reduction in the NDF content with advancement in ensiling duration signifies a breakdown of the cell wall during proteolysis (Ruiz *et al*., 1992). This underscores the role of ensiling in increasing digestibility of forage materials in ruminant and promote feed intake. Notwithstanding, silage from Pennisetum plot with poultry manure recorded the least NDF content which may be attributed to the higher nitrogen content of the manure. Johnson, *et al*. (2001) reported that the NDF concentration linearly decreased with increasing N fertilization.

The ADL content of the silages under the present study is slightly higher than that which was reported by Aganga *et al*. (2005) for Napier silage while the increase in ADL with increase in ensiling duration could have been due to utilization of readily digestible cell wall content by fermentative bacteria (Schingoethe, 2004). The *in vitro* gas production technique is a useful tool in determining the nutritional value of forages because the volume of gas produced by forage species reflects the end products of the fermentation of its substrate to volatile fatty acids (VFA), microbial biomass and neutralization of the VFA, thereby demonstrating the nutritional value of such forages (Blummel and Becker, 1997). Lower gas volume produced from silages made from Pennisetum plot

with different manures could be attributed to fermentation of higher protein contents present in the their silages, as this might cause the production of ammonia which inhibits the CO_2 release from the carbonate buffer (Cone and Valk, 1997). The presence of certain amounts of nitrate in silage crops may inhibit clostridial growth (McDonald *et al.,* 1991) and promote good fermentation profile in silage from Pennisetum plot with poultry manure. Lack of nitrate in forages following low level of nitrogen application may cause unsatisfactory fermentation quality. The hazard of manure application to silage crops concerning contamination with microorganisms undesirable for silage fermentation has been discussed (Weissbach *et al.,* 1993). But this may be accentuated by considering the appropriate manure application rate and proper handling.

CONCLUSION

This study has indicated positive effects of organic manures on forage quality. It could be concluded that silage produced from *P. purpureum* with poultry manure application ensiled for 90 days is a good feed resource for ruminant animal production.

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