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National Animal Production Research Institute
Ahmadu Bello University
P.M.B 1096, Shika-Zaria,
Kaduna State, Nigeria.
Email:japr@napri.gov.ng Url:journals.napri.gov.ng

INFLUENCE OF DRY SEASON ON NUTRIENTS COMPOSITION, SECONDARY METABOLITES COMPOSITION, AND ANTIOXIDANT CAPACITIES OF SOME TROPICAL GRASSES

[*1]Idowu, O. J., [2]Chaudhry, A. S., [3]Dolfing, J. and [1]Ojo, V. O. A.

[1]Department of Pasture and Range Management, Federal University of Agriculture, P.M.B. 2240, Abeokuta, Nigeria

[2]School of Natural and Environmental Sciences, Newcastle University, NE1 7RU, Newcastle upon Tyne, United Kingdom

[3]School of Civil Engineering and Geosciences, Newcastle University, NE1 7RU, Newcastle upon Tyne, United Kingdom

[*]Corresponding Author: idowuoj@funaab.edu.ng or o.j.bolaji@newcastle.ac.uk

ABSTRACT

This study was undertaken to investigate and compare the nutrients composition and secondary metabolites content of four tropical grasses (*Pennisetum purpureum*, PP; *Panicum maximum*, PM; *Brachairia decumbens*, BD; and *Andropogon gayanus*, AG) collected during the dry season when they are fully matured (i.e. 20 weeks) using chemical methods. The aim was to select the best suitable grass among the most available grasses in the dry season for ruminant feeding using chemical composition parameters. A completely randomized design was used for arranging the experiment and significant ($P < 0.05$) differences were observed between the grasses in most of the parameters measured. Most of the values obtained for the parameters measured are not within the acceptable range for good quality forages, thus they can be regarded as grasses with low nutritive value. From the result of this study *P. purpureum* exhibited low fibre i.e. NDF and ADF and lignin contents with values of 729.49 g / kg DM, 525.22 g / kg DM, and 75.88 g / kg DM respectively; and high in most of the mineral contents i.e. Ca, Na, Mg, Cu, and Zn with values of 0.24 g / kg DM, 0.003 g / kg DM, 0.13 g / kg DM, 0.39 mg / kg DM and 2.97 mg / kg DM respectively than other grasses. *A. gayanus* was high in soluble fraction i.e. CP and EE with values of 117.29 g /kg DM and 15.98 g / kg DM respectively; high in secondary metabolites i.e. total phenol (TP), total tannin (TT), condensed tannin (CT), and Hydrolysable tannin (HT) contents with values of 17.20 g / kg DM, 13.80 g / kg DM, 9.06 g / kg DM, and 4.74 g / kg DM respectively; high in some mineral contents i.e. K and Mn; and high in total antioxidant content (7.12 g / kg DM) than other grasses. Among the grasses *P. purpureum* and *A. gayanus* seems suitable and promising for dry season feeding but the suitability varied based on different parameters measured. It is concluded that *P. purpureum* and *A. gayanus* can still be used in ruminant feeding during the dry season, though nutritionist might need to harvest and conserve it at an early stage before maturation set in, supplement with lacking nutrients and or upgrade the forages either chemically, physic-chemically or biologically to optimise the nutritional content in anticipation for ruminant feeding.

Keywords: Antioxidant components, Dry season, Nutrient composition, Ruminants, Tropical grasses

INTRODUCTION

Generally, ruminants depends majorly on grasses as their major source of feed (Brum *et al.*, 2008) due to several immense benefits, especially in the provision of essential minerals, ammonia, peptides/amino acids and vitamin A

and E for ruminant animals. Vitamin A and E (i.e. antioxidants component) are essential in maintaining a balanced immune system and health condition (Daley *et al.*, 2010; Elejalde *et al.*, 2010) improves the lactating capacity of animals. Other benefits of grasses include: prevention of respiratory disorders; prevention of digestive disorders (such as diarrhoea, absorption of nutrients, etc.); prevention of urinary tract disorders (such as stones in kidneys, ureter and bladder); provision of minerals, crude protein, total digestible nutrients, dry matter and carotene etc. (Brum *et al.*, 2008; Elejalde *et al.*, 2010). However, in most tropical countries such as Nigeria, during the prolonged dry season these benefits are limited in the available grasses due to extreme weather conditions that increases their growth rate and early maturation, thus lowering their nutritive value. During this season, the available grasses are usually characterised by high dry matter content, low soluble fraction (i.e. protein and ether extract contents), high insoluble carbohydrates and fibre, low mineral content, and low antioxidant content (Yayneshet *et al.*, 2009; Minson, 2012). However, it has been reported that the rate at which forages attain maturity varies even when cultivated at the same time and it is greatly influenced by prevailing growing conditions (e.g. climate, weather and management practices) and species (Wilson, 1994). In addition, the growing conditions especially weather over the past few years have been greatly affected by global warming, therefore limiting the use of existing information in this regard, and thus requiring the need for updated information which are limited. This work was carried out with the view of comparing some commonly used grass species in Nigeria that are usually available during the peak of dry season; a time when the nutritive quality of the grasses are declining because of maturation, higher temperature, lower rainfall and higher sunlight. The purpose being to select the best suitable grass species that can be used in ruminant feeding during this season using nutrient composition parameters for the comparison.

MATERIALS AND METHODS

Sample Collection and Preparation

The field experiment was carried out at experimental field of the College of Animal and Livestock Production (COLANIM), Federal University of Agriculture, Abeokuta (FUNAAB) 2014. The site lies within the derived savannah zone on latitude 7^0N and longitude 3.5^0E. The climate is tropical with wet season (temperature between 28-30^0C, relative humidity between 63 – 96%) and dry season (temperature between 30 – 34^0C, relative humidity between 55 – 84%). The grasses were grown in September 2014 and harvested in January 2015 that falls in the dry season. Grass species (i.e. *Pennisetum purpureum* (PP), *Panicum maximum* (PM), *Brachiaria decumbens* (BD) and *Andropogon gayanus* (AG)) were selected based on the fact that they are commonly used, available and promising in this location. Each forage sample was cut at 15cm above the ground level, bulked, chopped, and oven-dried at 65^oC. The chemical analysis was carried out at the laboratories located in the School of Agriculture, Food and Rural Development, Newcastle University, United Kingdom. The samples were re-dried at 55^0C in a forced- air oven for 48 h and ground through a 1 mm sieve before analyses.

Chemical Analyses

Proximate and Cell Wall Composition

The grass samples were analysed in triplicate for all chemical components. Dry matter (DM), Ash, and Ether extract (EE) were analysed using Association of Official Analytical Chemist (AOAC, 1990)**.** Nitrogen values were obtained using Leco Elementar vario macro cube (Elementar, model FP-428, Leco corporation St. Joseph, MI, USA) analyser which involved using combustion, post combustion and reduction tube in the furnace of

the analyser (Sweeney and Rexroad, 1987) and the Crude protein (CP) content was then calculated (N x 6.25). Neutral Detergent Fibre (NDF), Acid Detergent Fibre (ADF) and Acid Detergent Lignin were assessed using the methods Van Soest *et al.* (1991) and Goering and Van Soest (1970) without using sodium sulphite and Dekalin. The difference between NDFom and ADFom determined the concentration of hemicellulose, while the difference between ADFom and Lignin established the concentration of cellulose. Ash concentration was determined by complete combustion of the sample in a muffle furnace (Carbolite, CWF 1200 muffle furnace) at 550^0C for 5hrs (AOAC, 1990).

Mineral Composition

The mineral solution in dried and milled forage samples (2g, 1mm in size) were extracted by wet digestion using digestion acid containing perchloric acid and nitric acid at 100^0C. During digestion when all the perchloric acid has been volatised, the digested sample was brought up to 10ml with 2M hydrochloric acid. This was then diluted to 50ml with distilled water in a 50ml beaker. The sample solutions were filtered through Whatman filter paper no 541 and investigated for mineral contents (Calcium, Potassium, Sodium, Magnesium, Copper, Zinc, Manganese, Iron and Copper) through the inductively coupled plasma optical emission spectroscopy (ICP-OES, Unicam 701 ICP-OES). Individual certified standards were purchased from Sigma-Aldrich UK for machine calibration of relevant concentrations of minerals analysed. The extraction of minerals from grasses into solution (i.e. mineralization) and measurements of each mineral element were performed in duplicates. The element content was calculated in dry matter content of plant (mg / kg DM).

Secondary Metabolites Composition

The Total phenolic (TP) and total tannin (TT) contents were measured using modified Folin-Ciocalteu method (Singleton and Rossi, 1965). This involved the use of an insoluble matrix, polyvinyl polypyrrolidone (binds tannic phenolics), that separates non-tannin phenols from tannin phenols, therefore making it easy to obtain tannin measurements. The condensed tannin (CT) was analysed using the butanol-HCl – iron method (Makkar, 2003). Both TP and TT were expressed as tannic acid equivalents, while CT was expressed as (-) - epigallocatechin equivalents. The calculated difference between the TT and CT was shown as the Hydrolysable tannins (Singh *et al.*, 2005). Antioxidant capacities of the samples were determined according to the Ferric Reducing Antioxidant Power assay (Benzie and Strain, 1996) and results were expressed as µmol Fe (II)/g dry weight of the sample. The samples were analysed in triplicate.

Statistical Analysis

All data obtained from this experiment were subjected to one way analysis of variance (ANOVA) procedure on Minitab 16 software to determine the differences in the chemical composition of the grasses. A $P < 0.05$ was considered to indicate statistical significance between grasses. Various means were separated using Tukeys *post-hoc* test and the differences between means were declared significant if $P < 0.05$.

RESULTS AND DISCUSSION

The mean proximate and fibre compositions (g/ kg DM) of the grasses are presented in Table 1. The chemical contents (g / kg DM) of the grasses significantly ($P < 0.05$) varied. In this study, almost all of the grasses were low in CP (i.e. < 80 g/ kg DM), with an exception in AG, and EE (i.e. < 20 g/ kg DM); high in fibre (i.e. NDF > 700g / kg DM and ADF > 500 g/ kg DM) and lignin (i.e. > 80 g/ /kg DM). The CP contents ranged from 58.96 g/ kg DM (*B. decumbens*) to 117.29 g / kg DM (*A. gayanus*). The highest amount of EE (15.98 g/ kg DM) was observed in *A. gayanus*. Based on the CP, EE, NDF, ADF, ADL of most of the grasses, it can be concluded that they all fall in the low quality category. The values obtained in these

study for the various chemical components falls within the CP values of < 80 g / kg (Narmsilee *et al.*, 2002; Titgemeyer *et al.*, 2004), EE values of < 20 g / kg (Harfoot and Hazlewood, 1997), NDF values of > 650 g / kg DM and ADF values of > 450 g / kg DM (Van Saun, 2006) reported in low quality forages that negatively affect forage intake and digestibility. The differences obtained in the proximate and cell wall composition of these grasses might be attributed to species, variations in the rate of attainment of maturity stage, inherent plant factors and plant types used when sampled (Melesse *et al.*, 2017; Almeida *et al.*, 2019). Also the decrease in the soluble fractions (i.e. CP and EE) and increase in the insoluble fractions (i.e. fibre and lignin contents) in all the grasses can be attributed to maturation and harsh weather condition. As plants matures coupled with the harsh weather that helps accelerates the maturation process, the stemmy fraction is increased at the detriment of leafy portion. At this stage a decline in the soluble fractions (i.e. CP and EE) of the forage sets in and a corresponding rise in the insoluble fractions (i.e. fibre and lignin) is reported (Melesse *et al.*, 2017; Suha Uslu *et al.*, 2018).

The variation recorded in the CP content of the grasses can be explained due to the N available in the soil and the rate of N uptake by each forage during growth and stage of maturation (Melesse *et al.*, 2017). The high CP content of *A. gayanus* supports the report of Jones (1978), that it contains higher nitrogen content not regarding its high fibre content. Also it may be due to the reduced number of stem fraction that is usually found in it, as leaves contains higher CP content than stem and inherent qualities (Suha Uslu *et al.*, 2018). The CP content is beyond the 100 g/kg of DM required in forages to facilitate better intake (Ranjhan, 2001) and beyond 80 g/kg of DM needed to meet the requirement of animals on maintenance level (Norton, 1994).

The differences recorded in the EE content in the forages investigated might probably be due to maturity stage of the grass when sampled and environmental conditions. Although EE is not a major source of energy in forages, high EE containing forages can be used as feed material for modifying the profile of fatty acid in milk (Elgersma, 2015). The higher EE content obtained in *A. gayanus* may be due to the fact that it has lesser stem and more leafy tissue than other grasses and since increased leafy proportion has been found to be positively correlated to higher EE content than stem (Harwood, 1980; Khan *et al.*, 2015). The higher CP and EE contents in *A. gayanus* is an indicator that the grass is still capable to an extent of increasing the ruminant feed intake and productivity through better digestibility (France *et al.*, 2000; Fraser *et al.*, 2004) than other grasses despite the effect of harsh weather and maturity, as CP and EE are positively correlated to better fermentation of feed (Newman *et al.*, 2006; Hariadi and Santoso, 2010). However the CP content is still within the range of grasses regarded as low quality forage (National Research Council, 1981; Titgemeyer *et al.*, 2004) and the values can be regarded as limited for rumen microbial proper functioning (Minson, 1990). Also the values of EE obtained in these grasses is still considered inadequate to serve as source of fatty acids in the diets of ruminants (Doreau and Ferlay, 1994; Harfoot and Hazlewood, 1997). Therefore supplementation or nutrient upgrade of the grass will still be needed for better animal production and performance. Based on the CP and EE contents, the grasses can be grouped as follows: *A. gayanus* < *P. purpureum* < *P. maximum* < *B. decumbens*.

The NDF contents ranged from 729.49 g / kg DM (*P. purpureum*) - 774.08 (*B. decumbens*) g / kg DM. The ADF contents followed the same trend as the NDF content ranging from 525.22 – 547.78 g / kg DM. The expectation was that *A. gayanus* would have recorded the lowest fibre content in this study as it records higher soluble fraction, however this was not the case as *P. purpureum* recorded the least fibre contents,

although it was similar to that of *A. gayanus* and *P. maximum*. Based on the fibre content, the grasses can be grouped as follows: Other grasses (*P. purpureum, A. gayanus* and *P. maximum*) < *B. decumbens*. The ADL values obtained in this study ranged 75.88 g / kg DM (*P. purpureum*) – 137.19 (*P. maximum*) g / kg DM. Based on the lignin content, the grasses can be grouped as follows: *P. purpureum* < *B. decumbens* < *A. gayanus* < *P. maximum*. It was observed in these grasses, that the higher the soluble contents (i.e. CP and EE), the lower the fibre content with an exception in *A. gayanus*. The expectation is that the lignin content should follow the same pattern as the fibre content, however this was not the case with most of the grasses as *P. maximum* with the highest ADL content did not record the highest fibre content. The grasses recorded a hemicellulose content ranging from 204.28 g / kg DM (*P. purpureum*) to 226.31 g / kg DM (*B. decumbens*) and cellulose content ranging from 399.93 g / kg DM (*P. maximum*) to 467.47 g / kg DM *(B. decumbens*). It was observed that the hemicellulose content followed similar pattern as the NDF content, however, the cellulose content of most of the grasses followed opposite pattern to that of the ADL content i.e. the lower the lignin, the higher the cellulose content of the grasses. The lower fibre contents of *P. purpureum* is in agreement with the findings that the higher the CP content the lower the fibre composition, as CP is strongly negatively correlated with fibre parameters (Abdulrazak *et al.*, 2000; Idikut *et al.*, 2009). Although AG recorded higher CP content, it also contained fibre and lignin contents that were even higher than some other grasses. However, *A. gayanus* not containing the least fibre despite its high CP content, supports the findings of Jones (1978) that the grass contains higher nitrogen content along with high fibre content, although the fibre content is similar to that of *P. purpureum*. The lower NDF and ADF contents of *P. purpureum* might be able to increase the voluntary feed intake and digestibility than other grasses. This is because the lower the NDF content of a forages, the higher the voluntary feed intake as NDF is used to predict the feed intake (Ahmad *et al.*, 2014) and the lower the ADF content of a forage the higher the digestibility, as ADF can be used to estimate forage digestibility (Rayburn, 1991; Ball *et al.*, 2001). Despite the fact that *P. purpureum* recorded the lowest fibre content, the amount are still detrimental to obtaining an increased amount of feed intake and digestibility that will support better ruminant production and performance. Also they are not in the right amount to provide animals with fibre needed for stimulating rumen microbial function and cud chewing (Suha Uslu *et al.*, 2018).

The lignin content of the forages not following the same pattern of fibre might be due to species diversity with lesser effect of season on as they were all collected during the dry season. The obtained result was in agreement with the findings of Adjorlolo *et al.* (2014) where season had no effect on the lignin but the fibre content. The hemicellulose content following the same pattern as NDF confirms the report that NDF is mostly composed of hemicellulose. Therefore the higher the hemicellulose content in a forage the lower the voluntary feed intake as hemicellulose is a major component of NDF which is used to predict intake (Wilson, 1994; Jung and Allen, 1995). The lower lignin that was attributed to higher cellulose content in the grasses investigated supports the report that lignin contents of most forages are usually of lesser percentage and cellulosic carbohydrates (i.e. cellulose and hemicellulose) with greater portion (Melesse *et al.*, 2017). Among the cellulosic carbohydrates, cellulose occupies more significant portion of the substrate, followed by hemicellulose (Pérez *et al.*, 2002; Baldrian and Valášková, 2008). The higher the cellulose, the greater the amount of energy or carbohydrate source in the forage (Merkel *et al.*, 1999), but in matured forage it is usually found between lignin layers which protects it

and makes it difficult for possible breakdown (Leonowicz *et al.*, 1999). Thus making the cellulose not available for ruminants' usage as source of energy.

Table 1: Mean proximate and fibre compositions (g / kg DM) of grasses alongside standard error of means (SEM)

Composition	*P. purpureum*	*P. maximum*	*B. decumbens*	*A. gayanus*	SEM
Dry matter	950.67[b]	936.96[b]	951.97[a]	950.52[a]	2.1
Ash	134.03[d]	114.34[c]	75.79[d]	84.54[c]	7.0
Crude protein	65.63[b]	61.46[b]	58.96[b]	117.29[a]	7.4
Ether extract	13.65[ab]	9.79[c]	11.49[bc]	15.98[a]	0.8
NDF	729.49[b]	744.84[b]	774.08[a]	743.18[b]	5.2
ADF	518.55[c]	537.12[ab]	547.78[a]	535.68[b]	3.4
ADL	75.88[c]	137.19[a]	80.31[bc]	93.48[b]	7.4
Hemicellulose	204.28[a]	207.71[a]	226.31[a]	207.50[a]	3.0
Cellulose	448.34[b]	399.93[c]	467.47[a]	442.20[b]	7.4

[a, b, c] means with different letters in the same row were significantly different ($P < 0.05$) for each forage group
SEM: Standard error of means; NDF: Neutral detergent fibre, ADF: Acid detergent fibre, ADL: Acid detergent lignin.

The mineral composition of the grasses is given in Table 2. Most of the mineral differed significantly ($P < 0.05$) with an exception in K and Cu. All the grasses are low in Ca (< 0.25 g / kg DM); K (< 0.35 g / kg DM); Na (< 0.005 g / kg DM); Mg (< 0.15 g / kg DM); Cu (< 0.5 mg / kg DM); Zn (< 5 mg / kg DM); Mn (< 15 mg / kg DM); and Fe (< 20 mg / kg DM). Based on the mineral contents, the grasses can be grouped as follows: *P. purpureum* < *A. gayanus* < *B. decumbens* < *P. maximum*. Among the grasses, *A. gayanus* recorded the highest K (0.35 g /kg DM) and Mn (12. 04 mg / kg DM) contents. *P. purpureum* was found with the highest contents for Ca (0.24 g /kg DM), Na (0.003 g /kg DM), Cu (0.39 mg / kg DM) and Zn (2.97 mg /kg DM). *P. maximum* recorded the lowest contents in almost all the mineral contents measured with an exception in Zn were *A. gayanus* recorded the lowest value of 1.43 mg / kg DM respectively. The grasses have shown that they are of low quality in terms of their macro (i.e. Ca, K, Na and Mg) and micro (i.e. Cu, Zn, Mn, and Fe) minerals composition. The values obtained in this study for the macro minerals content are far less than the optimum K value of 6 - 10 g / kg DM required in the diets of dairy animals and 5 -7 g / kg DM required in the diet of sheep (National Research Council, 1981; National Research Council, 2001); the optimum Na value of 0.6 – 1.0 g / kg DM required in the diets of animals (National Research Council, 2000; National Research Council, 2001); the optimum Ca value of 8 - 10 g / kg DM (National Research Council, 2001) required in animal diet. The micro mineral nutrients are also far below the recommended optimum values of 10 mg / kg (Cu), 30 mg / kg (Zn), 40 mg / kg (Mn), 50 mg / kg Fe (National Research Council, 2000; National Research Council, 2001) that is expected to be in the diets of ruminant. The optimum availability of some minerals are capable of increasing the assimilation or degradation of fibres and fats; reduce methane production in ruminant animals (Machmüller

and Kreuzer, 2005); increase the assimilation of other minerals especially micronutrients (National Research Council, 2001); allow normal body function and proper energy utilisation (Khan and Chaudhry, 2010); and helps facilitate good animal health. The variations recorded in the mineral composition of the grasses might probably be due to the effects of species, plant inherent quality, and nutrient removal potential of forage from the soil (Marschner, 1995; Juknevičius and Sabienė, 2007). *P. purpureum* being high in most of the mineral content and *A. gayanus* being high in some of the minerals is an indication that they are capable of supplying animals with some minerals more than other grasses (i.e. *B. decumbens* and *P. maximum*), although not available in the required amount. *P. purpureum* being the grass with higher amount of most of the minerals supports the fact that most of these minerals have a synergistic relationship and are capable of leading to each other's metabolism but in some instances an antagonistic relationship has been found between K and Mg (Juknevičius and Sabienė, 2007). The antagonistic relationship was supported in this study with the grass high in K not being high in Mg. Therefore there is the need to supplement minerals if these grasses are to be used in ruminant feeding during this season.

Table 2: Mean mineral i.e. macro (g / kg DM) and micro (mg / kg DM) compositions of grasses alongside standard error of means (SEM)

Minerals	*P. purpureum*	*B. decumbens*	*A. gayanus*	*P. maximum*	SEM
Calcium	0.24^{a}	0.19^{b}	0.16^{bc}	0.14^{c}	0.01
Potassium	0.24^{a}	0.30^{a}	0.35^{a}	0.17^{a}	0.03
Sodium	0.003^{a}	0.002^{b}	0.003^{a}	0.001^{b}	0.00
Magnesium	0.13^{a}	0.11^{a}	0.08^{b}	0.08^{b}	0.01
Copper	0.39^{a}	0.23^{a}	0.33^{a}	0.22^{a}	0.03
Zinc	2.97^{a}	1.59^{bc}	1.43^{c}	1.71^{b}	0.19
Manganese	8.14^{b}	5.08^{c}	12.04^{a}	2.47^{d}	1.08
Iron	14.41^{ab}	15.92^{a}	13.67^{b}	9.96^{c}	0.69

$^{a, b, c, d}$ means with different letters in the same row were significantly different ($P < 0.05$)
SEM: Standard error of means

The secondary metabolites and total antioxidant capacity compositions of the grasses were presented in Table 3. The metabolites differed significantly ($P < 0.05$). All the grasses recorded very low TP content (< 10 g / kg DM); TT content (< 10 g / kg DM); CT content (< 6 g / kg DM); HT content (< 2 g / kg DM); and TAC (< 5 g / kg DM) with an exception in *A. gayanus*. Based on the secondary metabolites contents, the grasses can be grouped as follows: *A. gayanus* < *P. purpureum* < *B. decumbens* < *P. maximum*. Among the grasses, *A. gayanus* recorded the highest TP (17.20 g / kg DM), TT (13.80 g / kg DM), CT (9.06 g / kg DM), HT (4.74 g / kg DM) and TAC (7.12 g / kg DM) contents. *P. maximum* recorded the lowest contents in all the secondary metabolites

investigated and was almost similar to that of *B. decumbens*.

Secondary metabolites i.e. total phenolic compounds, total tannin, condensed tannin, and hydrolysable tannin are known as anti-nutritive compounds due to the fact that they are detrimental to ruminant nutrition (Bodas *et al.*, 2012; Piluzza *et al.*, 2014). High level of these substances can be toxic to animals, can reduce feed intake and digestibility, and in some instances when available in lower amount they can be advantageous to the production of animals by improving the nutritive content of feeds as they acts as bypass protein sources (Patra and Saxena, 2011; Kumar *et al.*, 2014). The secondary metabolites composition in this study are far below the amount of TT (60 -120 g / kg) and CT (20 -45 g / kg) regarded to be detrimental to ruminant nutrition (Patra, 2007; Khan and Chaudhry, 2010). The study confirms the report that grasses are generally low in metabolites compared to legumes (Getachew *et al.*, 2002; Piluzza *et al.*, 2014). However the variations recorded in the secondary metabolites composition of the grasses can be due to species effect, plant inherent qualities. Among the grasses, more secondary metabolites was accumulated in *A. gayanus*, there is the possibility that the grass could cause a reductive effect on the rumen microbial community when compared to other grasses. The higher total phenolic content accumulated *in A. gayanus* may be due to the presence of some anti- nutritive factors identified in it in some literatures such as saponin (Ogungbesan *et al.*, 2011; Ogungbesan *et al.*, 2014), phytate (Eeckhout and De Paepe, 1994) and tannin, although the tannin observation was unusual (Ogungbesan *et al.*, 2011) and might be due to its high CP content as some metabolites are associated with increased availability of nitrogen (Reed, 1995). The higher total tannin obtained in *A. gayanus* supports their observations, however the TT content was lower than the threshold levels (50 g/kg) reported by Chesson *et al.* (1982) to inhibit the growth and activity of specific microbes, such as bacteria and anaerobic fungi (Patra and Saxena, 2011; Goel and Makkar, 2012), that are involved in the degradability of fibre and which directly or indirectly reduce the feed intake (Patra and Saxena, 2011; Bhatta *et al.*, 2013).The inclusion of *A. gayanus* at this level of TT content in the feed of ruminant might be regarded as safe to help increase feed intake, digestibility and subsequently increase the weight gains and milk production (Patra and Saxena, 2011; Piluzza *et al.*, 2014). Also at the level of the CT content in ruminant diets might show some beneficial effects in the rumen due to the formation of protein – tannin complexes that prevent degradation of protein (Min *et al.*, 2003; Grainger *et al.*, 2009). This complex presumably tends to breakdown at a lower pH in the intestine (Reed, 1995; Mueller-Harvey, 2006).

The antioxidant components of feeds such as Vitamin E, Vitamin C, carotenoid and some trace minerals (Ca, Mg, and K) if supplied in the required amount plays a major role in ensuring that the animal is in good health and the immune functions are excellent (Roeder, 1995). Antioxidant maintains the structural and functional integrity of cells by stabilizing highly reactive free radicals (i.e. reactive oxygen species and reactive nitrogen species) and non-radicals reactive derivatives of oxygen and nitrogen which damages biologically important molecules such as DNA, proteins, lipids and carbohydrate during physiological metabolism of tissues (Chew, 1995; Weiss, 2005). However, complex lignified feed with higher phenolic hydroxyl groups, lower aliphatic hydroxyl groups showing a low molecular weight and slight poly-dispersity are good antioxidant substrates (Pan *et al.*, 2006). This is reflected in *A. gayanus*, although the value is low but it is still far above the other grasses and capable of producing these benefits if incorporated into animal feed at this dry season. Relative to the parameters measured, the expected nutritive value of other grasses is

as follows: P. *purpureum* < *B. decumbens* < *P. maximum*.

Among the grasses based on the soluble fractions, secondary metabolites contents and total antioxidant content, *A. gayanus* seems more favourable while based on the fibre and lignin contents, and mineral compositions, *P. purpureum* seems more favourable than other grasses. Although these two (2) grasses seems to reflect similar nutritive contents.

Table 3: Mean secondary metabolite and total antioxidant capacity compositions (g/kg OM) of grasses alongside standard error of means (SEM)

Composition	*P. purpureum*	*P. maximum*	*B. decumbens*	*A. gayanus*	SEM
Total phenols (TP)	9.93[b]	7.01[c]	8.76[b]	17.20[a]	1.2
Total tannins (TT)	6.30[b]	2.80[c]	3.19[c]	13.80[a]	1.3
Condensed tannins (CT)	4.73[b]	1.88[c]	1.85[c]	9.06[a]	0.9
Hydrolysable tannins (HT)	1.56[b]	0.92[b]	1.34[b]	4.74[a]	0.5
Total antioxidant capacity (TAC)	3.90[c]	4.17[c]	4.95[b]	7.12[a]	0.4

[a, b, c] Means with different letters in the same row were significantly different (P < 0.05) for each forage group
SEM: Standard error of means

CONCLUSION

The grasses are of low nutritive quality and sole feeding of these grasses to ruminant is not capable of achieving and sustaining better ruminant production and performance during the dry season as they cannot meet the nutrients' needs of the animals. Thus supplementation of these grasses with other available tropical feed resource rich in nutrients i.e. carbohydrate, protein, minerals, total antioxidant content is advised. However, despite their low nutritive quality, it appears that *P. purpureum* and *A. gayanus* has a promising and potential usage in ruminant feeding at the dry season than other grasses. The feeding potential of these grasses can be improved if upgraded either chemically, physico-chemically and or biologically and supplemented along with available multipurpose trees and shrubs that can be used as protein supplements for improved ruminant production. *In vitro* nutritional evaluation and or animal based feeding trials is recommended to validate the feeding value of these grasses at dry season.

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