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Comparative evaluation of proximate and fibre composition of three tropical grasses hay at different period of harvesting

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Abstract

Managing forages for year-round feeding is crucial to ensuring sustainable ruminant production and mitigating farmers-herders' clashes in Nigeria. This experiment was carried out to evaluate the proximate and fibre composition of three tropical grasses hay harvested at varying ages and their hay. The grasses (Brachiaria ruziziensis BR, Brachiaria decumbens BD and Megathyrsus maximus MM) and three harvest ages (6, 8 and 10 weeks after sowing WAS) were studied in a split-plot experiment. Forages of the grasses were chopped and cured as hay followed by determination of the proximate composition, fibre fractions. Data collected were subjected to two-way analysis of variance (ANOVA) using SAS (2014) package, and effective means were separated using HSD test of R package at a 5% level significance. Results showed that Hay evaluation indicated that BR recorded higher values (92.13%, 4.74% and 54.63%) for DM, EE and NFE, respectively. Hay from grasses harvested at 8 WAS had higher CP contents than other harvest ages while those harvested at 10 WAS recorded 92.55% and 4.89% for DM and EE respectively which were higher than other harvest ages. Fibre fractions of hays were generally not influenced (P<0.05) by species and harvest ages. In conclusion, hays from the three tropical grass species harvested at 8 WAS, irrespective of species, recorded better nutritive qualities and could promote ruminant production than other harvest ages.

Keywords: Evaluation, *Brachiaria,* harvest age, Hay, tropical grass

Évaluation comparative de la composition proximale et en fibres de foin de trois graminées tropicales à différentes périodes de récolt

Résumé

La gestion des fourrages pour un approvisionnement annuel est essentielle pour assurer une production durable de ruminants et atténuer les conflits entre agriculteurs et éleveurs au Nigeria. Cette étude a été menée pour évaluer la composition proximale et en fibres de foin de trois graminées tropicales récoltées à différents stades de croissance. Les graminées (Brachiaria ruziziensis BR, Brachiaria decumbens BD et Megathyrsus maximus MM) ont été étudiées selon trois âges de récolte (6, 8 et 10 semaines après semis, SAS) dans un dispositif expérimental en split-plot. Les fourrages ont été hachés, séchés en foin, puis analysés pour leur composition proximale et leurs fractions fibreuses. Les données ont été soumises à une analyse de variance (ANOVA) à deux facteurs avec le logiciel SAS (2014), et les moyennes significatives ont été comparées par le test HSD du package R au seuil de 5 %. Les résultats ont *montré que le foin de BR présentait des valeurs plus élevées (92,13 %, 4,74 % et 54,63 %) pour la matière sèche (MS), l'extrait éthéré (EE) et les glucides non fibreux (NFE), respectivement. Les foins récoltés à 8 SAS avaient une teneur en protéines brutes (PB) supérieure à celle des autres stades, tandis que ceux récoltés à 10 SAS présentaient des taux plus élevés de MS (92,55 %) et d'EE (4,89 %). Les fractions fibreuses des foins n'ont généralement pas été influencées (P > 0,05) par l'espèce ou l'âge de récolte. En conclusion, les foins des trois graminées tropicales récoltés à 8 SAS, indépendamment de l'espèce, présentaient de meilleures qualités nutritives et pourraient favoriser la production de ruminants par rapport aux autres stades de récolte.*

Mots-clés : Évaluation, *Brachiaria*, âge de récolte, Foin, graminée tropicale.

٤. التقييم المقارن للمكونات الغذائية الأولية ومحتوى الألياف في ثلاثة أنواع من أعشاب المناطق الاستوائية المجففة في فترات حصاد مختلفة.

يُعد إدارة الأعلاف لتوفير التغذية على مدار العام أمرًا بالغ الأهمية لضمان إنتاج مستدام للمجترات، وللتقليل من النزاعات بين المزارعين والرعاة في نيجيريا. وقد أُجري هذا البحث لتقييم التركيب الغذائي الأولي ومحتوى الألياف في التبن المحصود من ثلاثة أنواع من أعشاب المناطق الاستوائية في أعمار حصاد مختلفة. تمت دراسة الأعشاب الثلاثة) براكياريا روزيزينسيسBR ، براكياريا ديكومبنسBD ، وميغاثيرسوس ماكسيموس (MM وأعمار الحصاد الثلاثة (6، 8، و10 أسابيع بعد الزراعة) في تجربة من نوع القطع المنشطر. تم تقطيع الأعلاف وتجفيفها على هيئة تبن، تلا ذلك تحليل مكوناتها الغذائية الأولية وكسور الألياف. وقد خضعت البيانات المجمعة لتحليل التباين الثنائي (ANOVA) باستخدام برنامج(2014) SAS ، وتمت مقارنة المتوسطات الفعالة باستخدام اختبار HSD عبر حزمةR عند مستوى دلالة 5.% أظهرت النتائج أن تقييم التبن أوضح أن عشبة BR سجلت قيمًا أعلى لكل من المادة الجافة (DM) بنسبة 92.13%، والإيثر المستخرج (EE) بنسبة 4.74%، ومستخلص النيتروجين الخالي (NFE) بنسبة 54.63%. وكان تبن الأعشاب المحصودة في الأسبوع الثامن بعد الزراعة يحتوي على نسبة بروتين خام (CP) أعلى من غيره، بينما سجل التبن المحصود في الأسبوع العاشر نسبتي 92.55% للمادة الجافة و4.89% للإيثر المستخرج، وهي أعلى من الأعمار الأخرى. ولم تتأثر كسور الألياف في التبن بشكل عام (P>0.05)بنوع العشب أو عمر الحصاد.الخلاصة: تبن الأعشاب الثلاثة المدروسة والمحصود في الأسبوع الثامن بعد الزراعة، بغض النظر عن النوع، أظهر خصائص غذائية أفضل ويمكن أن يعزز إنتاج المجترات مقارنةً ببقية أعمار الحصاد.

الكلمات المفتاحية: **التقييم، براكياريا، عمر الحصاد، التبن، الأعشاب الاستوائية.**

Introduction

Ruminant animals in Nigeria depend, almost entirely, on the natural vegetation, commonly referred to as 'natural pasture' for their food. The natural pasture cannot satisfy the minimum nutrient requirements of the animals for most of the year due, partly, to their being harvested or grazed at advanced stages of maturity (Abubakar and Ibrahim, 1998). Generally, pasture production capacity is intrinsically related to prevailing environmental conditions and management practices. Factors, such as temperature, sunlight, moisture and nutrients determine the growth, yield and nutritive quality of the pasture during the growing period.

The natural pasture as a feed resource is only adequate for the nutrient requirements of ruminants during the early wet season. This underlies the limitation posed by non-availability of year-round good quality ruminant feed supply in the country as for most of the tropics mainly due to the annual prolonged dry season (Odeyinka and Okunade, 2005). The inadequacy of the nutritive quality of forages during the dry season is mainly due to environmental stresses such as high temperatures (Van Soest, 1988), infertile soils (Roberts, 1987) and poor management (Dev, 2001). In recent decades, there has been increased efforts to improve the nutritive quality of forage resources through propagation of improved species (Dzowela, 1988) in the tropics. This requires establishment of improved species as sown and purposely managed pastures, and feed lots in attempts to meet the higher nutritional needs of more productive animals (Bamikole and Babayemi, 2004).

According to Aregheore (1996), marked seasonal variation in climatic and edaphic factors affect the nutritive quality and dry productivity of forages. Forages tend to be more succulent, more nutritious and more abundant in the rainy season (May - November) as opposed to the dry season (November - April) when they become fibrous, scarce and heavily declined in all indices of quality including acceptability to livestock, digestibility and intake. At this time, the crude protein (CP) content, which is a major nutrient required for optimal animal performance, would have decreased to as low as two to three percent of dry matter (Teka *et al*., 2005). This is far below the minimum requirement of seven to eight percent for the body maintenance of animals (Coleman *et al*., 2003). Therefore, efficient utilization of pasture requires the adoption of a more holistic production model capable of circumventing overgrowing of pastures species, and excessive interplay of the various factors that negatively impact their nutrient content while still on the field. To achieve this objective, harvesting and conservation at the stages of growth when they still have optimal nutrient level may be the major option, or an integral part of the options to improve nutrient intake of animals in the prevailing production system.

The nutritive value of forages is determined by numerous factors, including species, soil type, growth stage, climate, and fertilization (Allen *et al*., 2013). This implies that a forage species may have high nutritive value under certain soil and climatic conditions but have considerably much less under other prevailing conditions due mainly to the veracity of these factors. The challenges of dry season feeding have been widely recognized as a major factor that determines the success or failure of a ruminant production enterprise due to the inadequate nourishment it imposes on the animals. This invariably results in a general decline in productivity of the animals including survivability, growth, body maintenance, production and reproduction (Darrag, 1995).

Forage conservation is an avenue to ensuring sustainability of feed supply to animals irrespective of the season of the year, and by extension, ensuring that animal productivity is not jeopardized by the seasonal fluctuations. Conservation of forages also ensures continuity of animal production during the period of feed scarcity (Balehegn *et al*., 2021), which consequently ensures uninterrupted supply of animal products to the citizenry. Conservation of forage as hay or silage is a major technique used in developed countries to address shortages in feed supply to ruminants during periods of insufficient pasture growth (Vicente-Chandler, 2001). Even though the nutritive qualities of hay could be lower than that of fresh forage, adequate levels of nutrients are retained in it to merit its profitable use as a dry season feed resource (McCullough, 1988). Conserving fresh forage as hay basically aims at producing a stable low-cost product capable of being fed to animals over time with minimal loss of nutritional value. Additionally, to, more effectively, mitigate the problem of poor nutrition of ruminants especially during off-seasons, there is need for utilization of forage species with high dry matter (DM) production and nutritive quality to enhance livestock productivity under the grazing or cut-and-carry systems

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Materials and methods

Experimental location

The experiment was conducted at the Directorate of University Farms and the laboratory of Department of Pasture and Range Management, Federal University of Agriculture, Abeokuta, Ogun State, Nigeria (7°58'N; 3°2'E) in the humid savannah agro-ecological zone. The area receives a mean annual rainfall of 1230 mm in a bimodal distribution pattern that attains peak in June/July and September/October with major dry season between November and March.

Land preparation

The land was ploughed and allowed to rest for a period of two weeks after which the second ploughing was done for the purpose of turning over the uppermost soil to bring fresh nutrient to the surface while burying weed and remains of plants to decay followed by harrowing to break the soil lumps to ensure good soil structure suitable for plant growth. A total experimental land area measuring 1798m^2 (62 m x 29 m) was mapped out and pegged into three blocks of 18m x 25m each. Each block was further divided into 9 plots of 4m x 5m each. Each block was separated by a 2 m pathway while the plots were separated by 1m pathway within the blocks.

Harvesting of forage materials

Grasses were harvested at 6, 8 and 10 weeks after regrowth. The grass was cut at 5 cm above ground level within three 1m^2 quadrants randomly thrown per plot with the aid of a sharp sickle. The total forage material harvested from each plot was weighed towards obtaining the fresh weight (FW) and for hay production.

Hay production

The harvested forage materials were chopped to 4-5 cm length and were cured into hay by spreading them out on the open slated floor, turning them at regular intervals to allow uniform drying, and allowed to dry for two weeks. The drying materials were packed and kept under the shed at the end of each day of drying to prevent moisture reabsorption overnight. The samples were thereafter packed and wrapped up with mosquito nets (to allow free movement of air), labelled accordingly and stored in a well ventilated, cool and dry room, after which sub-sample weighing 500g was taken from each treatment and oven-dried at 65^{0}C to constant weight for chemical analysis. The dried samples were taken, weighed, milled, and sieved through a 1mm sieve. Sub-samples were taken from the milled samples for analyses to determine the proximate and fibre composition of the grasses.

Determination of Proximate and fibre Composition

The dry matter (DM), crude proteins (CP), ether extract (EE), and ash of the grass samples were determined according to AOAC (2000) while Neutral detergent fiber (NDF), Acid detergent fiber (ADF) and Acid detergent lignin (ADL) contents were determined according to Van Soest *et al.* (1991). Cellulose was taken as the difference between ADF and ADL while hemicellulose was calculated as the difference between NDF and ADF.

Experimental design

The study was a 3 x 3 factorial in a split-plot design making a total of nine (9) treatments with three (3) replicates (Figure 2). Grass (*Megathyrsus maximus, Brachiaria decumbens*, *Brachiaria ruziziensis*) was allotted to the main plot while age at harvest (6, 8, 10 weeks) was allotted to the sub-plots. The plots were adequately labelled with their respective treatment numbers while inter and intra-plot spaces were weeded as at when due throughout the experimental period.

Statistical analysis

Data collected were subjected to two-way analysis of variance (ANOVA) using SAS (2014) package, and effective means were separated using HSD test of R package at a 5% level significance.

Results

Tables

Table 1: Main effects of species and age at harvest on the proximate composition of hay produced from three tropical grasses harvested at varying ages

	Species				Age at harvest (Weeks)			
Parameters	***B. ruziziensis***	***B. decumbens***	***M. maximus***	**SEM**	**6**	**8**	**10**	**SEM**
Dry matter	92.13[a]	91.14[b]	91.10[b]	0.41	91.13[b]	90.70[b]	92.55[a]	0.38
Crude protein	17.99	17.80	17.39	0.39	17.99[a]	18.11[a]	17.08[b]	0.36
Ether extract	4.74[a]	4.31[b]	4.81[a]	0.12	4.63[a]	4.34[b]	4.89[a]	0.12
Ash	8.49[b]	8.48[b]	12.77[a]	0.56	10.46	9.11	10.17	0.89
Crude fibre	14.16	13.24	13.73	0.40	13.70	13.93	13.50	0.41
Nitrogen Free Extract	54.63[a]	56.17[a]	51.29[b]	1.02	53.23	54.52	54.35	1.21

[a, b, c:] means on the same row with different superscripts are significantly varied ($P < 0.05$). SEM: standard error of mean.

Table 2: Interaction effects of species and age at harvest on the proximate composition of hay produced from three tropical grasses harvested at varying ages

	B. ruziziensis			***B. decumbens***			***M. maximus***			
Parameters	**6 Weeks**	**8 Weeks**	**10 Weeks**	**6 Weeks**	**8 Weeks**	**10 Weeks**	**6 Weeks**	**8 Weeks**	**10 Weeks**	**SEM**
Dry matter	90.71^{b}	90.83^{b}	94.85^{a}	91.80^{b}	90.49^{b}	91.15^{b}	90.87^{b}	90.78^{b}	91.64^{b}	0.43
CP	17.93^{abc}	18.90^{a}	17.13^{bc}	17.74^{abc}	19.10^{a}	16.56^{c}	18.29^{ab}	16.33^{c}	17.57^{abc}	0.47
EE	4.86^{ab}	4.28^{c}	5.08^{a}	4.21^{c}	4.36^{bc}	4.36^{bc}	5.81^{ab}	4.39^{bc}	5.25^{a}	0.13
Ash	7.46^{d}	7.50^{d}	10.50^{bc}	9.17^{cd}	8.77^{cd}	7.51^{d}	14.75^{a}	11.55^{bc}	12.51^{ab}	0.55
CF	13.57^{ab}	14.72^{ab}	14.19^{ab}	12.66^{b}	14.20^{ab}	12.87^{ab}	14.88^{a}	12.87^{ab}	13.44^{ab}	0.60
NFE	56.19^{ab}	54.61^{abc}	53.10^{bc}	56.23^{ab}	53.58^{bc}	58.72^{a}	47.28^{d}	55.36^{abc}	51.24^{c}	1.16

$^{a, b, c}$: means on the same row with different superscripts are significantly varied ($P < 0.05$). SEM: standard error of mean

Table 3: Main effects of grass species on fibre fraction of hay produced from three tropical grasses harvested at varying age

	Grass species				**Age at harvest (Weeks)**			
Parameters	***B. ruziziensis***	***B. decumbens***	***M. maximus***	**SEM**	**6**	**8**	**10**	**SEM**
Neutral detergent fibre	62.05	60.46	62.36	0.78	61.34	61.78	61.76	0.82
Acid detergent fibre	49.32	47.78	49.54	1.14	40.11^{a}	37.47^{b}	49.07^{ab}	1.07
Acid detergent lignin	16.96	15.88	16.36	0.55	16.18	16.65	16.37	0.56
Hemicellulose	12.74	12.68	12.82	0.80	11.22^{c}	14.32^{a}	12.69^{b}	0.74
Cellulose	32.36	31.90	33.18	0.91	33.93^{a}	30.81^{b}	32.70^{a}	0.86

$^{a, b, c}$: means on the same row with different superscripts are significantly varied ($P < 0.05$). SEM: standard error of mean

Table 4: Interaction effects of species on fibre fractions of hay produced from three tropical grasses harvested at varying age

	B. ruziziensis			*B. decumbens*			*M. maximus*		
Parameters	**6 Weeks**	**8 Weeks**	**10 Weeks**	**6 Weeks**	**8 Weeks**	**10 Weeks**	**6 Weeks**	**8 Weeks**	**10 Weeks**
Neutral detergent fibre	60.79	63.83	61.55	59.72	61.55	61.55	63.51	61.39	62.19
Acid detergent fibre	36.90^{c}	42.40^{a}	38.66a^{bc}	40.96^{ab}	32.65^{d}	39.74^{abc}	42.48^{a}	37.34^{bc}	38.82^{abc}
Acid detergent lignin	16.01^{ab}	18.43^{a}	16.45^{ab}	15.37^{ab}	15.17^{b}	17.09^{ab}	17.17^{ab}	16.34^{ab}	15.58^{ab}
Hemicellulose	13.89^{b}	11.43^{bc}	12.89^{bc}	8.77^{d}	17.47^{a}	11.82^{bc}	11.03^{dc}	14.06^{b}	13.38^{bc}
Cellulose	30.89^{b}	33.97^{ab}	32.22^{ab}	35.59^{a}	27.48^{c}	32.65^{ab}	35.31^{a}	30.99^{b}	33.24^{ab}

$^{a, b, c}$: means on the same row with different superscripts are significantly varied (P < 0.05).

Effects of species and age at harvest on the proximate composition of hay produced from three tropical grasses

Table 1 shows the main effects of species and age at harvest on proximate composition of hay produced from three tropical grasses harvested at varying age. Dry matter, ether extract, ash and nitrogen free extract were significantly influenced by grasses against crude protein and crude fibre that were not significantly affected. *Brachiaria ruziziensis* recorded the highest value (92.13%) for dry matter compared with BD and MM which are statistically at par with lower value (91.14% and 91.10%) respectively. The ash content of *M. maximus* recorded the highest value (12.77%) while BR and BD were statistically at par. The values (4.74% and 4.85%) record for either extract for BR and MM were statistically similar however, MM recorded highest value (4.85%) when compared with BD which has the least value (4.31%). Nitrogen free extract (NFE) was observed to record the highest value (54.63% and 56.17%) statistically for BR and BD. However, BD is significantly higher when compared with the lowest value (51.29%) for MM.

Age at harvest significantly influenced dry matter, crude protein and ether extract against ash, crude fibre and nitrogen free extract which were not affected significantly. The dry matter content was observed to increase with age. Highest value (92.55%) was recorded for grasses harvested at 10week while grass species harvested at 8 weeks and 10week significantly par with lowest value (90.70% and 91.13%) respectively. Grass species harvested at 6week and 8week recorded highest crude protein content statistically, however, grass harvested at 8week has highest value (18.11%) significantly while lowest value (17.08%) was observed in grass harvested at 10week. Nonetheless, Ether extract was observed for grass species harvested at 6week and 10week were statistically similar, however, grass species harvested at 10 weeks recorded the highest value (4.89%) while lowest value (4.34%) was recorded for grass species harvested at 8 weeks.

Interaction effects of species and age at harvest on the proximate composition of hay produced from three tropical grasses

Table 2 shows interaction effects of species and age at harvest on proximate composition of hay produced from three tropical grasses harvested at varying ages. All the parameters observed in this study were significantly influenced by grass and age at harvest. Dry matter recorded the highest value (94.85%) for BR harvested at 10week while BR harvested at 6week and 8week, BD harvested at 6week, 8week, 10week and MM harvested at 6week, 8week and 10week were statistically at par. Nevertheless, the value recorded for crude protein was significantly higher for BR harvested at 8week and BD harvested at 8week (18.90% and 19.10%) however, BD harvested at 8week had highest value (19.10%) when compared with MM harvested at 8week recorded with lowest value (16.56%). Similarly, the value recorded for ether extract was significantly higher for BR and MM harvested at 10weeks (5.08% and 5.25%) however, MM harvested at 10week had highest value when compared with BD harvested at 6 weeks recorded with lowest value (4.21%). Ash and crude fibre of MM harvested at 6 weeks were observed to have highest value (14.75% and 14.88%) respectively while BR harvested 6week, 8week and BD harvested 10week were statistically at par for ash content and BD harvested at 6week recorded lowest value (12.66%) for fibre content. The highest nitrogen free extract (NFE) was observed in BD harvested at 10week (58.72%) than MM harvested at 6 weeks with lowest value (47.28%) for NFE content.

Main effects of species and age at harvest on fibre fractions of hay produced from three tropical grasses

Table 3 shows the effects of species and age at harvest on fibre fraction of hay produced from three tropical grasses harvested at varying age. All the fibre fraction parameters in this study were not significantly influenced by grass species Age at harvest significantly influence acid detergent fibre (ADF), hemicellulose and cellulose against neutral detergent fibre (NDF) and acid detergent lignin (ADL) that were not significantly affected. Species harvested at 6 weeks recorded the highest value (40.11%) for Acid detergent fibre content while grass harvested at 8 week recorded lowest value (37.47%). Hemicellulose was observed to have the highest value (14.32%) for grass harvested at 8 weeks while lowest value (11.22%) for those harvested at 6week of growth. The values (33.93% and 32.70%) recorded for cellulose for grasses harvested at 6 weeks and

10 weeks were significantly higher than those harvested at 8weeks.

Interaction effects of species and age at harvest on fibre fraction of hay produced from three grass species

Table 4 Shows interaction effects of species and age at harvest on fibre fraction of hay produced from three tropical grasses harvested at varying age. All the parameters evaluated were significantly influenced except Neutral detergent fibre (NDF) was not significantly affected. The value recorded for ADF was significantly higher for BR and MM harvested at 6week (42.40% and 42.48%). However, MM harvested at 6 weeks recorded highest value (42.48%) and least (32.65%) was observed for BD harvested at 8week of age. *Brachiaria ruziziensis* harvested at 8 weeks recorded highest (18.43%) Acid detergent lignin (ADL) content while BD harvested at 8 weeks was observed to have lowest value (15.17%). Moreover, BD harvested at 8 weeks was observed to have the highest value (17.47%) for hemicellulose while lowest value (8.77%) was recorded for BD harvested at 8 weeks of growth. The value recorded for cellulose content was significantly higher for BD and MM harvested at 6 weeks (35.59% and 35.31%) respectively and least (27.48%) was observed for BD harvested at 8 weeks of growth.

Discussion

The dry matter (DM) production potential of *B. ruziziensis* in the present study was similar to those reported by Nemera (2016) for natural pasture in Ethiopia (92.02%). This might indicate tropical grass had similar dry matter percentage. Similarly, an increase in DM content with increasing maturity in the current study was in conformity with Tolcha (2017) who suggested that dry matter content increased with delayed harvesting which could be attributed to decreased moisture content in leaves as plants age and become lignified. Moreover, the range of DM values in this study for interaction between hay grass species and age at harvest of hay grass species were similar to those suggested for hay by Rotz *et al*. (1991), who also noted that moisture less than 10% could indicate brittleness or excessive leaf loss, while high moisture greater than 14 to 18% indicates a risk for mould growth and other micro biotic activity of which the moisture content in this study is not up to this value. Crude protein is one of the major criteria for determining the nutritional quality of a feed because as the level of CP increases, the DM intake by livestock and rumen microbial growth would also increase (Chanthakhoun *et al*., 2012). In this study, CP content was of hay grass species observed to be numerically higher than fresh forage. This fact might be due to metabolization of carbohydrate fractions (i.e., respiration in hay) during hay wilting (Van Soest 1994; Bernardes *et al*., 2005), which indirectly increased 10% CP concentration in hay compared with fresh forage. However, the increase in harvest age of grass species reduces the CP content in this study. This observation is in conformity with those reported by Olanite *et al*., (2006); Zinash *et a*l. (1995); Adane (2003); Adane and Berhan (2005) and Yihalem (2004), who indicated that the decline in CP content of the pasture along with increasing stage of harvesting. Similarly, decrease in CP content in this study with advancement in age is also in

line with the findings of Dele (2012) and Tilahun *et al*. (2017) for *Pennisetum purpureum* and *Pennisetum pedicilatum*, respectively. Also, Bayble *et al*. (2007) and Ansah *et al*. (2010) reported for Napier grass a decreasing trend in CP content with increased in harvesting age. This might be attributed to the dilution of the crude protein content by an increasing amount of structural carbohydrates in the late harvested forage materials (Hassan *et al*., 1990). However, the interaction between grass hay species and age at harvest is above 7.5% which is the minimum level of CP for optimal rumen function (Van Soest, 1994; Jusoh *et al*., 2014). Ether extract (EE) represents the lipid content of a feed. It is an important source of energy in the diet with over 2% more energy than carbohydrates. The relatively higher EE content of BR and MM hay in this study when compared with BD implies that it provides higher energy to livestock than normal carbohydrates if consumed in large enough quantities. According to Palmquist (1988) EE has been considered as both beneficial and detrimental feed ingredients for ruminants, depending on the level of inclusion in the feed. The value of EE recorded for hay grass species in this study for age at harvest is within the range of 4-5% level reported by VanHoutert and Leng, (1993) as nutritionally beneficial. However, Forages with more than 5% EE depress digestibility of feed in the rumen. Hence, forages with higher than 5% EE will require calcium supplementation to increase digestibility and energy supply (Leng, *et al*., 1992). Similarly, the value recorded for interaction between grass species and harvesting age also below 7% Linn *et al*. (2021) reported that total fat must not exceed the diet DM. In addition, overfed fat may cause diarrhea to occur in the animal (Marcondes *et al*., 2013). Ash content recorded for MM hay in this study is higher to value 7.1% reported Enoh *et al*. (1999) for BR hay and 9.46% reported by Ewetola *et al*., (2021) for MM hay This could be attributed to environment and management system, age at harvest difference or maturity stage, and plant species competition of the study area. Similarly, the value of ash recorded for interaction between grass species and age at harvest is above the range of 3 -12% reported by Linn and Martin (1999) for most forages. Crude fibres are important for livestock feed because they require a special amount of
fibre in their diet to allow the rumen to function optimally. The interaction between hay grass species and age at harvest of hay grass species for crude fibre is below the minimum value 17% reported by Moran and Brouwer (2014) required for cow diet. Thus, the crude fibre content in this study shows an adequate percentage of crude fibre to fulfil the needed of the cow's diet. It is also below the range (30 to 40%) earlier reported by Muraina *et al*. (2013) and Mckell (1980) on *Stylosanthes species*. Nitrogen free extract (NFE) addresses the extent of a feed that is comprised of non-fiber carbs chiefly sugars and starches (Hall, 2003). Forages with high levels of NFE are desirable and significant since they provide highly digestible carbohydrates. In this case, BD and BR hay recorded the highest NFE when compared with MM. However, for ruminants, the proportion of NFE may not be very significant as ruminants are able to digest fiber

carbohydrates. It has also been reported that different forages with the same fiber content may differ substantially in terms of rate of degradation in the rumen (Grant *et al*., 1995; Dado and Allen, 1996). High growth rates of cattle and high milk production have been reported from feeds that were considered poor (low levels of digestible carbohydrates) (Dolberg and Finlayson, 1995). Acid detergent fibre (ADF) is the value that refers to the cell wall portions of the forage that are made up of cellulose and lignin. However, ADF is the percentage of highly indigestible plant material present in forage. Low ADF values means higher digestibility Eskandari *et al*. (2009) and the higher the value of ADF the lower digestibility (Costa *et al*, 2005). The ADF content of forage in this study at age at harvest is in consonance with the report of Nussio *et al*. (1998) who observed that forage with ADF content around 40%, or more, shows low intake and digestibility. Grass hay species maintained higher values for ADF during all the harvest intervals. Similarly, the value recorded for interaction between grass hay species and age at harvest is above the minimum recommended value (17–21 %) for NRC (2001). However, low ADF content can be seen as positive for forage quality because the lower ADF level means higher digestion according to Dasci, and Comakli (2010) of which ADF content in this study is high. Hemicellulose is a structural carbohydrate that is only slightly digestible in the rumen of animals, though slowly. Therefore, the high hemicellulose content recorded for age at harvest of hay grass species reduces, if not preventing animals from deriving energy from it. However, the value of hemicellulose recorded in this study is lower to 37.70% reported by Archimede *et al*. (2010) for *Gliricidia sepium* hay. This could be attributed to grass species. Similarly, the interaction between hay grass species and age at harvest is within 14% - 26% reported by Okunade *et al.* (2014) who quoted Humphreys (1991) who opined that the higher the hemicellulose fraction, the higher is the feed value. Cellulose is the most important constituent of cell wall. The value recorded for age at harvest of hay grass species in this study were within this range and below the range of 34.25 – 34.73% reported by Ewetola *et al*., (2021) hay grass and is above the 11% to 26% reported by Okunade *et al*. (2014) who opined that fodders of this range have the potentials to support intestinal movement, proper rumen function and promote dietary efficiency. Similarly, the interaction between hay grass species and age at harvest is within the cellulose contents ranged from 20% to 40% DM as reported by Van Soest, (1994) for tropical forage grasses. Tropical forages are well known for their higher lignin contents, a factor which alters voluntary intake and digestibility of the forage Frei (2013), causing higher energy loss. It is a non-digestible cell wall component that prevents microbial enzymes from breaking down hemicellulose and cellulose in the rumen (Hancock, 2014). However, acid detergent lignin (ADL) represents an undigested portion of the forage and is associated with fibre. Therefore, the greater the concentration of lignin in a plant, the lower the digestibly of the forage and the less dry matter an animal can consume (Moore and Jung, 2001). This constituent of cell wall negatively influences degradation of tissues

(Lacerda *et al*., 2006). Moreover, the ADL content for the interaction between hay grass species and age at harvest of this study is not in conformity with the finding of Holubek *et al*. (1999) who reported that non-fertilized semi-natural grassland contained on average 5.50 to 6.08% lignin. This has a limiting effect on feed utilization since an increase in ADL content from 5-6% may reduce cellulose digestibility by 20% (McDonald *et al* 2002). The high ADL content is attributed to differences in plant species, plant ages, and environmental factors including seasons (rain or dry season), tidal seasons, and fertility levels of the soil where the vegetation grow.

Conclusion

In conclusion, *Brachiaria ruziziensis* hay produced the highest dry matter and ether extract. Additionally, harvesting hay grass species at 10 weeks of age produced the highest dry matter. There is no specific trend in crude protein and fibre content of hay grass species at harvest age.

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