Nutrient intake, digestibility and nitrogen balance of two temperate and two tropical forage legume hays fed to New Zealand white rabbits

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Abstract

An experiment was carried out to evaluate two temperate forage legumes (Trifolium pratense and Trifolium repens) and two tropical forage legumes (Stylosanthes guianensis and Centrosema molle) for hay intake and digestibility in the cool tropical climate of Vom, Jos, Plateau State of Nigeria. The legumes were planted in the month of June, 2016 and harvested at early-podding stage for hay. Sixteen (16) growing male New Zealand White rabbits were used for the digestibility study. The rabbits were arranged in a Completely Randomised Design and in individual cages measuring 55 cm x 39 cm x 40 cm. Nutrient contents, intake and digestibility in rabbits were determined. Crude protein content was significantly (P<0.01) higher in T. repens (18.38%) compared to T. pratense (16.50 %), whereas S. guianensis produced the least value of 13.83%. The crude fibre content of the hay was significantly higher (P<0.0I) in S. guianensis (37.29 %) compared to the other forage legumes. Dry matter intake was significantly (P<0.01) higher in rabbits fed T. repens (77.88%) compared to T. pratense (76.57%), and the lowest value of 62.97% was obtained in S. guianensis. Crude protein intake was significantly (P<0.01) higher in rabbits fed T. repens (15.05 g d^{-1}) compared to those fed T. pratense (12.71 g d^{-1}), but S. guianensis had the least value of 8.64 g d^{-1}. On the other hand, rabbits fed S. guianensis hay had a higher (P<0.01) crude fibre intake (23.39%). Trifolium repens was significantly (P<0.01) higher in dry matter and crude protein digestibility (64.79 and 85. 88 %), while S. guianensis had lower values of 56.89 and 71.33%, respectively. Trifolium repens also had a significantly (P<0.01) higher total nitrogen intake and retained compared to the other forage legumes. Nitrogen retained in T. repens was 2.40 g d^{-1} compared to 1.87 g d^{-1} in T. pretense, while S. guianensis had the lowest of 1.34 g d^{-1}. The temperate forage legume hays were higher in nutrient content, intake and digestibility compared to the tropical legume hays. Therefore, the forage crops may serve as better supplementary feeds for livestock feeding especially during the dry season.

Keywords: Forage legumes, nutrient intake, digestibility, tropical, temperate

Introduction

Ruminant livestock in most parts of the tropics graze intensively on naturally growing forages which are poor in quality (Awad and Elhadi, 2010). Tolera and Abebe (2007) reported that these naturally growing forages provide 90 – 93 % of animal feed requirement either through grazing or as conserved forages. Tropical forages are generally known to be lower in nutrient composition and digestibility. This may be due to higher lignifications of the plant leaves which is a mechanism they have developed to minimise water loss or transpiration, in order to increase their survival in hot conditions (Boschma *et al*., 2010). Red clover *(Trifolium pratense* L) and White clover (*Trifolium repens* L) are perennial forage legumes widely grown in the temperate regions of the world and as well as in the sub-tropical areas of Australia for extensive livestock feeding. The two legumes provide forages that are high in protein content and digestibility, which facilitate high feed intake by animals (Black *et al*., 2009). Zemenchik *et al.* (2002) observed that the legumes usually have higher crude protein content, lower acid detergent fibre and neutral detergent fiber in grass stands, and especially in grasses mixed with clovers. Another benefit of clovers is that digestibility remains fairly constant throughout maturity period (Schlueter, 2011). Stylo (*Stylosanthes guianensis* Cv. Cook) is one of the forage legumes well suited to the sub-humid tropical and sub-tropical zones with a marked dry season (Heuzé *et al*., 2015). Thang *et al.* (2010) observed that *S. guianensis* is often used as a supplement during dry season to improve the nutritive value of low quality forages, such as crop residues or by-products such as rice straw. The Organic Matter Digestibility (OMD) of *S. guianensis* ranges between 51 to 67% (Magalhaes *et al*., 2003) which is lower than *T. pratense* and *T. repens*. Dry matter and crude protein digestibilities were reported to be between 71.82 and 71.80% (Ogunbode and Akinlade, 2012). Centro (*Centrosema molle* Mart. ex Benth.) formerly called *Centrosema pubescens* is widespread in the wet tropics from the Tropic of Cancer in the North to the Tropic of Capricorn in the Southern hemisphere and up to an altitude of 1,600 m and is one of the most palatable legumes (Teitzel and Chen, 1992). It is considered to be a valuable feedstuff since it provides fresh green matter during the dry season (Heuzé and Tran, 2014). Forage yield of *C. molle* is variable depending on nutrient availability in the soil. The legume is generally described as fairly good quality forage with high protein content but medium digestibility. It has an average OMD of 64.4% (Warly *et al*., 2010). Nutrient content and digestibility are higher in cold climate legumes and C_3 (temperate) grasses when compared to warm climate legumes and C_4 (tropical) grasses, respectively (Archimède *et al*., 2011). Ward and de Ondanze (2008) reported that cooler weather promotes neutral detergent fibre (NDF) digestibility. Tropical legumes and grasses require more physical breakdown for degradation and their N concentration is also lower than in C_3 grasses and cold climate legumes (*Chapman et al., 2014)*. These problems limit the productivity of animals in the tropical regions. *Trifolium pratense* and *T. repens* are perennial forages grown in the temperate regions of the World while *S. guianensis* and *C. molle* are perennial forage legumes grown in tropical countries. There is need to grow and evaluate the performance of animals fed the temperate forages in a cool temperate-like environment of Vom, Jos, Plateau State, Nigrian. The main aim of the study was to evaluate hay from four forage legumes for quality at early podding stage of maturity and their digestibilty in New Zealand White rabbits.

Materials and methods

Location of the study

The experiment was also carried out at the Nigerian Institute for Trypanosomiasis Research (NITR), Vom (Lat 9° 43' 60N, Long 8° 46' 60E and 1,223m above sea level), (Ovimaps, 2014). The area is characterised by two major seasons (rainy and dry seasons). The rainy season starts in late-May and ends in early-October each year, while the dry season starts from late-

October and ends in early- May. Peak of the rain is normally observed in the month of August each year. The soil is classified as sandy-clay loam. It is low in total nitrogen (0.33%), phosphorus (7.53 mg/litre), but fair in potassium (247.2 mg/litre). The climate of the area is cool with tempearature ranging from 15 - 27°C during the rainy season and 7 - 18°C during the hamattam season (NRCRI, 2016).

Plant material and preparation of hay

The temperate forage legume seeds of Red clover (*Trifolium pratense* L.), AberClaret variety and White clover (*Trifolium repens* L.), AberHerald variety were obtained from the Institute of Biological, Environmental and Rural Sciences (IBERS), University of Aberystwyth, United Kingdom. The tropical forage legume seeds of Cook Stylo (*Stylosanthes guianensis*) and Centrosema (*Centrosema molle* Mart. Ex Benth) were obtained from the Feeds and Nutrition Research Programme of the National Animal Production Research Institute (NAPRI), Ahmadu Bello University, Shika, Zaria, Nigeria. The seeds of the lesgumes were planted in June, 2016. Hay making was carried out at early-podding stage (one pod with fully developed seeds). The forage legumes were harvested 5 cm above the ground level with the aid of a sickle. The harvested fresh forages were spread under the shade of a tree in the field and the cut forages were turned twice daily for effective drying and to maintain the desired green colour. Sub-samples of the forage materials were oven-dried to test for dry matter content. Sub-samples of the forage materials were weighed and oven-dried at a temperature of 45^{0}C for 72 hrs to determine the dry matter and moisture contents. The forage materials were removed from the field when the moisture content was less than 15%, therefore, sub-samples were taken for physical and chemical quality evaluation. The hay harvested from the four forage legumes were then packed in seperate sacks and stored until the commncement of the digestibility trial.

Experimental animals and management

Sixteen growing bucks of New Zealand White rabbits obtained from His Grace Agric. Enterprise, Jos, were used for this study. Four (4) rabbits were used as replicates for each legume (*T. pratense, T. repens, S. guianensis* and *C. molle*) hay. The experimental rabbits for the trial had an average weight of 1,700 g (1.7 kg ± 0.1kg) and were placed in individual cages measuring 55cm X 39cm X 40cm. The rabbits were carefully examined for any ill-health and treated against ecto- and endo-parasites using Ivomectine before the commencement of the digestibility trial.

Experimental design and diets

The rabbits were placed in individual cages using the Completely Randomised Design (CRD). The hay made from the four legumes served as experimental diets during the digestibility studies. The diets include sole four forage legume (*T. pratense, T. repens, S. guianensis and C. molle*) hays harvested at early-podding stage.

Chemical quality evaluation of hay

Dried forage samples of the hay materials were ground with a Thomas Willey Laboratory Mill-Model 4 to pass through 1-mm sieve. Proximate analyses of crude protein (CP), ash, crude fibre (CF), ether extract (EE) and nitrogen-free extract (NFE) were carried out using the Method of AOAC (1990), while detergent fibre analysis was carried out according to the Method described by Van Soest *et al.* (1991). Mineral composition (Ca, P, Mg, K and Na) of the samples was carried out using the Atomic Absorption Spectrophotometer of AOAC (1990). Poximate and detergent fibre analyses were carried out at the Biohemisty and Animal Nutrition Laboratories of the Departments of Animal Science and Ahadu Bello University, Zaria and the University of Agriculture, Makurdi, respectively. Mineral analyses were carried out at the General Laboratory, Department of Soil Science, Ahmadu Bello University, Zaria, Nigeria.

Evaluation of nutrient intake and digestibility

The procedure described by Osuji *et al.* (1993) was used for evaluating nutrient-intake and digestibility of the four legume hays. The trial lasted for 14 days. The first seven days was adjustment period for the rabbits and this was followed by another seven days faecal and urine collection. Faecal and urine collection trays were thoroughly washed a day prior to the collection. The rabbits were fed 60 g forage dry matter of each forage legume hay per kg live weight a day. During the trial, water was provided *ad- libitum*. The animals were fed twice at 0800 and 1600 hrs each day. Daily urine output for each rabbits was collected into plastic bottles containing 0.2 mL of 0.1N Sulphuric acid. An aliquot sample of about 10% from each animal's urine output per day was taken and stored in a refrigerator at a temperature of about (-20°C) until required for analysis. Daily faecal output was collected for each animal using a polyethylene bag. Similarly, about 10% of the faecal output was taken and stored in a refrigerator at (-20°C). At the end of the collection period, the samples were bulked together and 10% of the sub-samples taken for proximate and nitrogen analyses.

Statistical model

$$Y_{ij} = \mu + A_i + e_{ij}$$

Where; Y_{ij} = observation in treatment i

μ = population mean

A_i = i^{th} effect of treatment (4 legumes)

e_{ij} = Random error

Statistical analysis

All data generated were subjected to Analysis of Variance (ANOVA). The general linear model of SAS (2001) statistical software was used for the analyses and means were seperated using the Tukey's test (1949).

Results

Chemical Composition of Four Forage Legume hays at early-podding stage

The proximate and detergent fibre compositions of the four legume hays are presented in Table 1. Crude protein (CP) content was significantly higher ($P<0.01$) in *T. repens* (18.38%) than in *T. pratense* (16.50 %), while *S. guianensis* had the least value of 13.83 %. The crude fibre (CF) content was, however, significantly higher ($P<0.01$) in *S. guianensis* (37.29%) than in the other forage legumes, while *T. repens* (22.61%) had the lowest value. Ether extract (EE) content was significantly lower ($P<0.01$) in *S. guianensis* (1.09%) than in the other legumes. The result showed that *T. repens* (10.02 %) was significantly ($P<0.01$) higher in ash content compared to the other legumes. The difference between the forage legumes for nitrogen free extract was not significant ($P>0.05$); however, *S. guianensis* (51.35 %) was significantly higher ($P<0.01$) than the other three forage legumes for NDF content. The result also showed that ADF content was significantly ($P<0.05$) higher for *S. guianensis* than the other forage legumes.

Table 2 shows the mineral composition of the hay from four forage legumes. Calcium concentration was significantly ($P<0.01$) higher in *T. pratense* (14.28 g kg^{-1}) than in *T. repens* (12.44 g kg^{-1}), while *S. guianensis* had the least value of 9.25 g ka^{-1}. However, the P and K values for *T. repens* (2.91 and 19.51 g kg^{-1}) were significantly ($P<0.01$) higher compared to those for *T. pratense* (1.26 and 15.73 g kg^{-1}) while those of *C. molle* (0.84 and 10.57 g kg^{-1}) were lowest.

Table 1: Proximate and detergent fibre composition of four forage legume hays (%)

	Forage legume					
Parameter	*T. pratense*	*T. repens*	*S. guianensis*	*C. molle*	SEM	LOS
Crude protein	16.50[b]	18.38[a]	13.82[d]	14.52[c]	0.08	**
Crude fibre	26.33[c]	22.61[d]	37.29[a]	34.51[b]	0.06	**
Ether extract	2.09[a]	2.23[b]	1.09[d]	1.57[c]	0.02	**
Ash	9.31[b]	10.02[a]	6.64[d]	7.16[c]	0.10	**
NFE	40.40	41.58	40.68	42.09	2.96	NS
NDF	43.24[c]	39.13[d]	51.35[a]	48.21[b]	0.10	*
ADF	31.05[c]	27.08[d]	43.66[a]	38.17[b]	0.59	**

[abcd]Means with different superscripts within the row are significantly different, SEM= standard error of means, LOS=level of significance (* P<0.05, **P<0.01, NS= Not significant)

The Mg content of *T. pratense* (2.85g kg^{-1}) was significantly (P<0.01) higher than that for *T. repens* (1.88 g kg^{-1}), while *C. molle* had the least value of 1.23 g kg^{-1}. Sodium content was significantly (P<0.05) higher in *T. repens* compared to the other three forage legumes.

Nutrient intake and digestibility in New Zealand white rabbits fed four legume hays

Table 3 shows the nutrient intake of the forage legume hays in New Zealand White rabbits fed sole forage legume hays. Dry matter (DM), crude protein (CP), ether extract (EE), ash, nitrogen free extract (NFE) and organic matter (OM) intakes were significantly higher (P<0.01) in rabbits fed *T. repens*, while crude fibre (CF) intake was significantly higher (P<0.01) in those fed *S. guianensis.* The highest value (81.88 g d^{-1}) for DM intake was recorded for rabbits fed *T. repens* compared to 76.57 g d^{-1} for *T. pratense*, while those that consumed *S. guianensis* had the lowest value (65.05 g d^{-1}). Rabbits fed *T. repens* had a significantly (P<0.01) higher crude protein intake of 15.05 g d^{-1}, compared with 9.48 g d^{-1}for for thoses fed *S. guianensis* hay. Similarly, the EE intake was significantly higher (P<0.01) for *T. repens* (1.79 g d^{-1}) compared to *T. pratense* (1.58 g d^{-1}); lowest value (1.06 g d^{-1}) was recorded for *S. guianensis*. The results also indicated that ash intake was significantly higher (P<0.01) in rabbits fed *T. repens* hay (8.30 g d^{-1}) and lowest intake (4.66 g d^{-1}) was recorded in rabbits fed *C. molle* hay. Crude fibre intake was significantly higher P<0.01) in rabbits fed *S. guianensis* (23.46 g d^{-1}) than in *C. molle* (22.70 g d^{-1}); the value for *T. repens* (18.63 g d^{-1}) was the least. The highest value (72.16%) for OM intake was also recorded for *T. repens* which was significantly higher (P<0.01) than the value for *T. pratense* (68.90%) and *S guianensis* (58.23%).

Table 2: Mineral composition of hay four forage legumes (g kg^{-1})

	Forage legume					
Parameter	*T. pratense*	*T. repens*	*S. guianensis*	*C. molle*	SEM	LOS
Calcium	14.25[a]	12.44[b]	8.06[d]	9.25[c]	0.02	**
Phosphorus	1.26[b]	2.91[a]	1.16[c]	0.84[d]	0.04	**
Magnesium	2.85[a]	1.88[b]	1.78[c]	1.23[d]	0.03	**
Potassium	15.73[b]	19.51[a]	14.53[c]	10.57[d]	0.02	**
Sodium	0.23[c]	0.64[a]	0.32[b]	0.23[c]	0.04	*

[abcd]Means with different superscripts within the row are significantly different, SEM= standard error of mean, LOS=level of significance at **1% and *5%

Table 3: Nutrient intake of hay from four forage legumes by New Zealand White rabbits (g d^{-1})

	Forage legume					
Parameter	*T. pratense*	*T. repens*	*S. guianensis*	*C. molle*	SEM	LOS
Dry matter	76.57^b	81.88^a	62.95^d	65.09^c	0.13	**
Crude protein	12.71^b	15.05^a	8.64^d	9.48^c	0.12	**
Ether extract	1.58^b	1.79^a	0.66^d	1.06^c	0.04	**
Ash	7.19^b	8.30^a	4.18^d	4.66^c	0.10	**
Nitrogen free extract	30.89^b	34.08^a	25.55^d	27.35^c	0.11	**
Crude fibre	20.25^b	18.60^d	23.39^a	22.46^b	0.09	**
Organic matter	68.90^b	72.16^a	58.23^d	60.34^c	0.67	**

[abcd]Means with different superscripts along the row are significantly different, SEM= Standard error of mean, LOS= Level of significance at 1%.

Table 4 shows the nutrient digestibilities of the four legume hays by growing male New Zealand White rabbits. Nutrient digestibilities were significantly (P<0.01) higher in rabbits fed *T. repens* than in the other three legume hays. The highest dry matter digestibility of 64.79% was recorded for *T. repens* compared to *T. pratense* (62.23%) and *S. guianensis* (56.89%) which was the lowest value. Crude protein digestibility was also significantly higher in rabbits that consumed *T.repens* (85.88%) than in those that were fed *S. guianensis* (71.33%). A similar trend of results was observed for EE, NFE and CF, where digestibilities were significantly (P<0.01) higher for *T. repens* than for the other three legumes. Organic matter digestibility was also significantly higher (P<0.01) for *T. repens* (67.55%) than for *T. pratense* (65.83%); the value for *S. guianensis* (62.48%) was the lowest. Results of nitrogen intake, urinary nitrogen, faecal nitrogen and nitrogen retained by New Zealand White rabbits are presented in Table 5. Total N intake was significantly (P< 0.01) higher in rabbits fed *T. repens* (3.41 g d^{-1}) than in those fed the other three legumes. There were no significant (P>0.05) differences in urinary N values among the legume hays. The result of the faecal N, indicated that rabbits fed *T. repens* had a significantly (P<0.01) higher value (0.53 g d^{-1}) than those fed *T. pratense* (0.46 g d^{-1}); the values for *S. guianensis* and *C. molle* were not significantly (P>0.05) different. Nitrogen retained was significantly (P<0.01) higher in rabbits fed *T.repens* hay (2.40 g d^{-1}) than in those fed the other three legume hays.

Table 4: Apparent nutrient digestibility of four legume hays by New Zealand White rabbits

	Forage legume					
Parameter (%)	*T. pratense*	*T. repens*	*S. guianensis*	*C. molle*	SEM	LOS
Dry matter	62.23^b	64.79^a	56.89^d	59.92^c	1.07	**
Crude protein	81.39^b	85.88^a	71.33^d	78.88^c	0.87	**
Ether extract	78.09^b	81.32^a	71.77^d	73.66^c	0.32	**
Nitrogen free extract	87.16^b	89.29^a	79.07^d	83.95^c	0.50	**
Crude fibre	65.96^b	68.34^a	59.84^d	61.85^c	0.55	**
Organic matter	65.85^b	67.55^a	60.47^c	62.48^d	0.33	**

[abcd]Means with different superscripts along the row are significantly different, SEM= Standard error of mean, LOS= Level of significance at 1%.

Table 5: Nitrogen intake, urinary nitrogen, feacal nitrogen and nitrogen balance of New Zealand White rabbit fed four forage legume hays

	Forage legume					
Parameter (g kg^{-1})	*T. pratense*	*T. repens*	*S. guianensis*	*C. molle*	SEM	LOS
Total nitrogen intake	2.90^{b}	3.41^{a}	2.38^{c}	2.49^{b}	0.02	**
Urinary nitrogen	0.62	0.61	0.60	0.57	0.02	NS
Faecal nitrogen	0.46^{b}	0.53^{a}	0.42^{b}	0.43^{c}	0.01	**
N- retained	1.87^{b}	2.40^{a}	1.34^{c}	1.48^{c}	0.17	**
N-retained (% intake)	64.24^{b}	70.29^{a}	58.32^{d}	59.17^{c}	0.33	**

[abcd]Means with different superscripts along the row are significantly

Discussion

The CP and ash contents obtained in this study were higher, whereas CF, NDF and NDF were lower than the results (16.5 %, 9.3 %, 26.9 %, 31 % and 43 %, respectively) reported by Preston (2010) for *T. pratense* in the USA. The CP content of 18.38 % was lower that 21.4%, but the CF content 22.61 % was higher than that of 20.9 %, reported by Cheeke (1987) for *T. repens*. The CF content obtained in this study was similar, but the CP (18.4 %) and EE (3.9 %) were lower while the ash (8.4 %) content was higher than the result recorded by McDonald *et al.* (1998). The higher nutrient compositions in hay of the temperate forage legumes agreed with the findings of Archimède *et al.* (2011) that the temperate forages have higher nutrient compositions. Forages growing in the hot climate mature rapidly and have lower nutritive value than their counterparts in cooler environments (Kellems and Church, 2002).*Trifolium repens* hay could meet the CP requirements of 15 – 17 and 18 - 19 % for growth and reproduction, respectively (Lebas, 2004) in rabbits, while *T. pratense* hay harvested at the early podding stage in this environment can only meet the requirement for reproduction. The CP contents in the tropical forage legume hays cannot meet these requirements. Rabbits fed the tropical legume hays should, therefore, be supplemented with higher CP content feeds to meet these requirements. The legume hays can supply more than 16.0 and 30.0 % for ADF and NDF, respectively, required by rabbits (De-Blas and Mateos, 2010). All the forage hays can meet the CP range of 7 – 16 % required by small ruminants for growth and productive/physiological functions (Rashid, 2008). The forage legume hays could also meet the CP of 7 – 14 % generally required by cows and 10.5 - 14 % for heifers and steers in the tropics (Kubkomawa *et al.*, 2015). The temperate legume hays could also meet the 15.1 – 18.5 % CP required for dairy cows (NRC, 2001), while animals fed with the tropical legume hays harvested at the early podding stage need to be supplemented with diets of higher CP content. The values recorded for calcium and phosphorus contents for *T. pratense* hay were similar to those reported by Preston (2010) in the USA. The higher mineral composition in the temperate legumes agreed with Kellems and Church (2002) who observed that nutrient compositions were higher in the temperate forage species compared to their counterparts in the tropics due to the lower fibre contents in the temperate species. The legume hays could meet the Ca (4 -6 %) and K (<18 %) requirements of rabbits (Lebas, 2004), while the other mineral elements need to be supplemented. All the forage hays can meet the Ca (0.3 - 0.8 %) and Mg (0.18 - 0.4 %) (Rashid, 2008) required for growth and all productive/physiological functions of small ruminants. The hays from the legumes harvested at the early podding stage in this environment have the potential to supply

0.53 - 0.67 % Ca, 0.22 - 0.44 % P, 0.18 - 0.21 %Mg, 0.22 - 0.29 % Cl, 11% K. 0.22 %Na and 0.11 % S required for lactating cows (NRC, 2001). The dry matter intake for *C. molle* obtained in this study was lower than the value (69.0 g) reported by Odeyinka *et al*. (2007) in rabbits at Ile-Ife, Nigeria. This might be due to differences in the stage of plant growth and age of the rabbits. The higher nutrient intake for the temperate forage legumes could be attributed to higher the CP content and digestibility, which tend to increase feed intake (Black *et al*., 2009). The DM digestibility obtained in this study for *T.repens* was lower than 85 % reported by John and Lancashire (1981) in New Zealand White rabbits in the New Zealand, whereas that of *T. pratense* was similar. The DM digestibility recorded for *S. guianensis* was, however, higher than 61.4% (Mao *et al*., 2014) and 60% (Cook *et al*., 2005), but fell within the range of 60 - 67% reported by Mannetje and Lones (1992). The DM digestibility for *C. molle* in this study was higher than the average value of 43.8%, but similar to that reported by Evitayani *et al*. (2004) and Geleti *et al.* (2013), respectively. The higher DM digestibility of the temperate forages compared to the tropical forages even when grown in the same environment as reported by Forde *et al*. (1976) was confirmed in this study. The lower nutrient intake and digestibility of the tropical legumes was due to higher cell wall content and lignification. As DM accumulation increases, there is higher lignification of plant tissues, which lowers digestibility (Buxton and Fales, 1994). The higher nutrient-intake and digestibility of the temperate forages indicated that a higher animal productivity could be attained when animals are fed hay made from those crops in this environment. The higher nitrogen retained from the temperate legumes showed that more N could be available for microbial growth and multiplication that could improve digestion of feeds, thereby improving feed intake, and consequently, animal productivity.

Conclusion

The chemical quality of the temperate forages (*T. pratense* and *T. repens*) hays were better than those for the tropical species (*S. guianensis* and *C. molle*). Nutrient intake and digestibility were outstanding for the temperate legume hays compared to their tropical counterparts. The crude protein content of the forage legume hays could satisfy the requirements for rabbits and were well above the minimum threshold of 7% recommended for ruminant animals in the tropics. It is therefore recommendated that the temperate forage legumes (*T. pratense and T. repens*) can be grown and conserved as hay in the Vom, Jos-Plateau environment. The two temperate legume hays can be used as supplementary feeds especially during the dry season to improve animal productivity in the Jos-Plateau environment.

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