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Nutritive value of *Adenodolichos rhomboideus* leaves compared with *Leucaena leucocephala* and *Stylosanthes guianensis* forages in indigenous goats in Lubumbashi (DR Congo)

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Three forages (*Adenodolichos rhomboideus*, *Leucaena leucocephala*, and *Stylosanthes guianensis*) were evaluated for their chemical composition, and for both voluntary intake and apparent *in vivo* digestibility of dry matter (DM), organic matter (OM), crude protein (CP), neutral detergent fibre (NDF), and acid detergent fibre (ADF) as estimated by six goats (17.1 kg ± 0.7) used in a 3 × 3 double Latin square design. Forage from *S. guianensis* had a lower ($p < 0.001$) CP content than *L. leucocephala* forage and *A. rhomboideus* leaves. Fibre content (ADF and NDF) was lower ($p < 0.001$) in *L. leucocephala* (35%) forage than in *A. rhomboideus* (59.5%) and *S. guianensis* forages (56.5%). *Leucaena leucocephala* forage presented higher CP, ash, and ether extract levels, and higher digestibility and voluntary intake of CP. *Adenodolichos rhomboideus* leaves had lower ($p < 0.05$) apparent digestibility and intake of DM. Digestible CP content was similar for *A. rhomboideus* leaves and *S. guianensis* forage. *Leucaena leucocephala* appears to be the most adequate forage for goat production. Low digestibility and voluntary intake of *A. rhomboideus* leaves may be due to negative effect of an anti-nutritional factor such as tannin.
Keywords. Goats, digestibility, nutrient intake, forage legumes, *Adenodolichos rhomboideus*.

Valeur nutritive des feuilles de *Adenodolichos rhomboideus* en comparaison de fourrages de *Leucaena leucocephala* et de *Stylosanthes guianensis* chez la chèvre locale à Lubumbashi (R.D. Congo). Les fourrages de trois espèces végétales (*Adenodolichos rhomboideus*, *Leucaena leucocephala*, *Stylosanthes guianensis*) ont été évalués des points de vue de leur composition chimique, consommation volontaire et digestibilité apparente de la matière sèche (MS), de la matière organique (MO), de la protéine brute (PB), des fibres insolubles dans le détergent neutre (NDF) et des fibres insolubles dans le détergent acide (ADF) utilisant à cette fin six chèvres mâles (17,1 kg ± 0,7) dans un dispositif en double carré latin 3 × 3. Le fourrage de *S. guianensis* a présenté une faible teneur en PB ($p < 0,001$) par rapport aux feuilles de *A. rhomboideus* et au fourrage de *L. leucocephala*. Les teneurs en fibres (ADF et NDF) ont été plus faibles ($p < 0,001$) dans le fourrage de *L. leucocephala* que dans les feuilles de *A. rhomboideus* et le fourrage de *S. guianensis*. Le fourrage de *L. leucocephala* a montré les teneurs les plus élevées en PB, matières minérales et extraits éthérés. La digestibilité apparente et la consommation volontaire de PB ont été les plus élevées pour *L. leucocephala* et les plus faibles pour les feuilles de *A. rhomboideus* ($p < 0,05$). La teneur en protéines digestibles a été similaire pour les trois fourrages. *Leucaena leucocephala* semble être le mieux adapté pour la production carpine. Les faibles digestibilités et consommations de feuilles de *A. rhomboideus* peuvent être dues aux effets négatifs de certains facteurs anti-nutritionnels comme les tanins.
Mots-clés. Chèvre, digestibilité, ingestibilité des nutriments, légumineuses fourragères, *Adenodolichos rhomboideus*.

1. INTRODUCTION

Ruminant livestock in the southeastern region of DR Congo, especially the indigenous goats that are those productive, suffer from inadequate nutrition during the dry season. This situation is caused by the scarcity of natural vegetation, primary source of forage, owing to lengthiness of the dry season, which lasts for more than six months and during which straw is mainly available. However, during this period, some species retain their green leaves and are available as fodder for ruminants. Among these feed sources are *Adenodolichos rhomboideus*, *Leucaena leucocephala*, and *Stylosanthes guianensis*.

Adenodolichos rhomboideus is a herbaceous legume that is well adapted to local ecosystems and widespread in the region, growing on normal and soil contaminated by trace metal (Meerts, 2008). Its nutritional value for ruminants has never been investigated.

Leucaena leucocephala is a shrub with high nutritional value and leaf availability is limited by tree height during the dry season. Garcia et al. (1996) reported that digestive energy and total apparent digested crude protein (CP) value for *L. leucocephala* ranged from 11.6 to 12.9 MJ·kg^{-1} and 64.7 to 78.0%, respectively. Rumen degradable protein (RDP) was found to be close to 42%, and undegradable protein (UDP) 48%, giving a TADCP value of 70%.

Stylosanthes guianensis is a herbaceous legume having good nutritional value but its use in the dry season is limited by lignification. The metabolisable energy (ME), CP, and DMD values of *S. guianensis* forage have been reported to be close to 5.4 MJ·kg^{-1}, 13.3 to 18%, and 52%, respectively (Ajayi et al., 2008). Several digestibility methods are used to assess the digestible value of forage, but *in vitro* and *in sacco* methods may lead to some erroneous conclusions if not supported by feeding trials (Norton, 1998). The form in which the leaves are offered (fresh, wilted, or dry) is also known to affect both intake and digestibility in some species (Palmer et al., 1992). Since there are no known techniques to predict palatability and intake, the nutritive value of forage species can only be accurately determined by feeding trials that give information on animal health and productivity. The aim of this study was to assess he nutrient content, intake, and digestibility of *A. rhomboideus* forage compared with *L. leucocephala* and *S. guianensis* fed to indigenous goats.

2. MATERIALS AND METHODS

2.1. Diets, animals, and experimental design

Three different forages were tested from 15 June to 18 August 2010. These comprised *A. rhomboideus* leaves (Fabaceae), *L. leucocephala* (Mimosaceae), and *S. guianensis* (Fabaceae) forages. One to two months of regrowth of *A. rhomboideus* leaves were harvested at area golf Meteorology of Lubumbashi (DR Congo), 11°37'58.2" latitude south, 27°24'54.5" longitude east, 1,266 m altitude. *Leucaena leucocephala* was harvested from old trees (over 10 years old) at the University of Lubumbashi in the Faculty of Agriculture (Agronomic Faculty), 11°36'38" latitude south, 27°28'29.6" longitude east, 1,296 m altitude. *Stylosanthes guianensis* forage was obtained from experimental fields, established in December 2009 at the farm of the Faculty of Veterinary Medicine, University of Lubumbashi, 11°42'46.2" latitude south, 27°32'31.2" longitude east, 1,216 m altitude.

These three forages were offered green. Forage from each species was harvested daily and mixed thoroughly before being offered to the goats as the only feed.

Adenodolichos rhomboideus and *L. leucocephala* samples were collected as leaves with petiole, while *S. guianensis* was mown at 15 cm height approximately. To facilitate chewing, *S. guianensis* forage was chopped and *A. rhomboideus* and *L. leucocephala* were sorted to remove hard petioles and dry leaves before distribution.

Six local yearling male goats, mean live weight 17.1 kg ± 0.73, were used. The animals were separated in two Latin squares of three animals each. Diets were offered twice daily over three periods of 21 days each, comprising 15 days of adaptation, followed by 7 days of data collection. Each group of animals was subjected to each forage according to the period.

Voluntary intake and *in vivo* apparent digestibility of the forages were studied. Voluntary intake was determined by the difference between the quantity offered and refusal. *In vivo* apparent digestibility was determined by complete collection (Jetana et al., 2010) in pens measuring 120 cm × 80 cm × 70 cm.

$$\text{Component digestibility (g·kg}^{-1}) = \frac{\text{Component in feed - component in feces}}{\text{Component in feed}} \times 100$$

Water and trace mineral blocks were provided throughout the experimental period. The animals were weighed with a balance for maximum load and 0.1 kg accuracy on the initial day of the experimental period. Individual daily feed intake and total fecal production were also measured. The bulked fecal output from each

animal was immediately weighed, mixed thoroughly, and sub-sampled for analyses. One sample of the offered forages was taken every day, dried in a forced air oven at 60 °C during 72 h, and ground through a 1-mm screen in an IKA WERKE type M20 machine.

Ashes of forage and feces were determined with a muffle furnace at 560 °C for one night. Dry matter (DM) of forage and feces was determined by drying in an oven at 105 °C for 24 h. Protein content of forage and feces was determined with a Hach Digesdahl® Digestion Apparatus (Ref. No 23130-21) using the method described by Brayton (1992). Cell walls of forage and feces constituents (neutral detergent fibre [NDF] and acid detergent fibre [ADF]) were determined based on the Gerhardt FibreBag method established by Van Soest et al. (1991). Ether extract (EE) of forage and feces was determined by the Soxtec system method (Matsler et al., 2005).

2.2. Data analyses

Data were analyzed using the general linear model (GLM) procedure of SAS (Statistical Analysis System Institute, 2010). Significant differences between feeds means were tested by using the ANOVA procedure and the Student's t-test. The model for analysis included the effects of the forage, period, square, and animal. The effects due to periods, square, and animal were not significant.

3. RESULTS

The chemical composition of the forages is presented in **table 1**. *Leucaena leucocephala* was richer in CP, EE, and ashes than *A. rhomboideus* and *S. guianensis*. Forage from *S. guianensis* had a higher value for DM content, while *A. rhomboideus* had higher concentrations of OM, ADF, and NDF than the other forages.

All variables differed ($p < 0.01$) among the three forages in terms of intake (**Table 2**). Voluntary intake of *L. leucocephala* and *S. guianensis* was higher than that of *A. rhomboideus* for organic matter (OM), DM, and EE ($p < 0.01$). *Leucaena leucocephala* had higher voluntary intake than *S. guianensis* and *A. rhomboideus* for CP ($p < 0.001$). NDF and ADF intake were higher for *S. guianensis* than *L. leucocephala* and *A. rhomboideus* ($p < 0.01$).

Apparent digestibility coefficients of the different forages are presented in **table 3**. *Stylosanthes guianensis* and *L. leucocephala* had higher OM, DM, and CP digestibility than *A. rhomboideus* ($p < 0.001$). *Leucaena leucocephala* and *A. rhomboideus* had lower apparent digestibility coefficients of ADF ($p < 0.001$), NDF ($p < 0.001$), and EE ($p < 0.05$) than *S. guianensis*.

Daily digestible intake of *A. rhomboideus*, *L. leucocephala*, and *S. guianensis* forages are given in **table 4**. *Leucaena leucocephala* and *S. guianensis* forages had higher ($p < 0.01$) digestible intake than *A. rhomboideus* forage for OM and DM. Forage from *L. leucocephala* had higher ($p < 0.001$) digestible intake of CP than *A. rhomboideus* and *S. guianensis*. Forage of *S. guianensis* had higher ($p < 0.001$) digestible intake of ADF and NDF than *L. leucocephala* and *A. rhomboideus*. Ether extract digestible intake was highest ($p < 0.001$) for *L. leucocephala*, followed by *S. guianensis* and then *A. rhomboideus*.

Digestible nutrient content ($g \cdot kg^{-1}$ DM) of *A. rhomboideus*, *L. leucocephala*, and *S. guianensis* forages for indigenous goats are given in **table 5**. *Leucaena leucocephala* forage had higher ($p < 0.01$)

Table 1. Chemical composition of *Adenodolichos rhomboideus*, *Leucaena leucocephala*, and *Stylosanthes guianensis* forages fed to indigenous goats at Lubumbashi — *Composition chimique de fourrages de* Adenodolichos rhomboideus, Leucaena leucocephala *et* Stylosanthes guianensis *consommés par la chèvre locale à Lubumbashi*.

Parameter	Forage				
	A. rhomboideus	*L. leucocephala*	*S. guianensis*	SEM	F-test
Dry matter (% FM)	36.7[a]	35[a]	71.4[b]	1.1	***
Organic matter (% DM)	95.3[c]	91[a]	94[b]	0.08	***
Crude protein (% DM)	15.12[b]	28.8[c]	11.9[a]	0.6	***
ADF (% DM)	48.1[c]	20[a]	39.2[b]	1.03	***
NDF (% DM)	59.5[b]	35[a]	56.5[b]	0.9	***
Ether extract (% DM)	1.7[a]	4.4[c]	2.8[b]	0.05	***

FM: fresh matter — *matière fraiche*; DM: dry matter — *matière sèche*; ADF: acid detergent fibre — *fibres insolubles dans les détergents acides*; NDF: neutral detergent fibre — *fibres insolubles dans les détergents neutres*; SEM: standard error of the mean — *erreur standard de la moyenne*; F-test: significance level of the ANOVA F-test — *niveau de signification du test F d'analyse de la variance*; Values followed with different letters in a row are significantly different from each other ($p < 0.05$) — *Les valeurs suivies de différentes lettres dans une ligne sont significativement différentes ($p < 0,05$)*; ***: very highly significant ($p < 0.001$) — *très hautement significatif ($p < 0,001$)*.

Table 2. Daily voluntary intake of *Adenodolichos rhomboideus*, *Leucaena leucocephala*, and *Stylosanthes guianensis* forages by indigenous goats at Lubumbashi — *Ingestion volontaire journalière de* Adenodolichos rhomboideus, Leucaena leucocephala *et* Stylosanthes guianensis *chez la chèvre locale à Lubumbashi*.

Parameter	Forage				
	A. rhomboideus	***L. leucocephala***	***S. guianensis***	**SEM**	**F-test**
Voluntary intake (g DM per head per day)					
Dry matter (DM)	192[a]	337[b]	384[b]	18.5	**
Organic matter	183[a]	306[b]	361[b]	17.2	**
Crude protein	29[a]	97[b]	47[a]	4.7	***
ADF	94[b]	67[a]	151[b]	7.0	**
NDF	114[a]	118[a]	216[b]	9.0	**
Ether extract	3.3[a]	14.8[b]	10.8[b]	0.70	**
Voluntary intake (g DM·kg^{-1} W$^{0.75}$ per day)					
Dry matter	23.0[a]	40.0[b]	45.5[b]	2.05	**
Organic matter	22.0[a]	36.0[b]	43.0[b]	1.90	**
Crude protein	3.5[a]	11.5[b]	5.5[a]	0.53	***
ADF	11.1[a]	8.0[a]	18.0[b]	0.80	***
NDF	13.5[a]	14.0[a]	25.6[b]	0.99	**
Ether extract	0.4[a]	1.8[b]	1.3[b]	0.08	**

ADF: acid detergent fibre — *fibres insolubles dans les détergents acides*; NDF: neutral detergent fibre — *fibres insolubles dans les détergents neutres*; SEM: standard error of the mean — *erreur standard de la moyenne*; F-test: significance level of the ANOVA F-test — *niveau de signification du test F d'analyse de la variance*; Values followed with different letters in a row are significantly different from each other ($p < 0.05$) — *les valeurs suivies de différentes lettres dans une ligne sont significativement différentes des autres ($p < 0,05$)*; **: highly significant ($p < 0.01$) — *hautement significatif ($p < 0,01$)*; ***: very highly significant ($p < 0.001$) — *très hautement significatif ($p < 0,001$)*; The average proportion of refusals during the experiment was 25%, 16%, and 19% for *A. rhomboideus*, *L. leucocephala*, and *S. guianensis*, respectively — *la proportion moyenne de refus durant l'expérimentation fut de 25 %, 16 % et 19 % pour* A. rhomboideus, L. leucocephala, and S. guianensis, *respectivement*.

Table 3. Apparent digestibility coefficient (%) of *Adenodolichos rhomboideus*, *Leucaena leucocephala*, and *Stylosanthes guianensis* forage fed to indigenous goats at Lubumbashi — *Coefficient de digestibilité apparente (%) de* Adenodolichos rhomboideus, Leucaena leucocephala *et* Stylosanthes guianensis *chez la chèvre locale à Lubumbashi*.

Parameter	Forage				
	A. rhomboideus	***L. leucocephala***	***S. guianensis***	**SEM**	**F-test**
Organic matter	61.2[a]	75.0[b]	73.0[b]	1.02	***
Dry matter	58.4[a]	73.0[b]	72.0[b]	0.93	***
Crude protein	42.0[a]	67.5[b]	58.3[b]	2.30	***
ADF	48.0[a]	45.0[a]	66.7[b]	2.60	***
NDF	50.0[a]	58.4[b]	68.5[c]	1.24	***
Ether extract	51.0[a]	52.7[a]	67.7[b]	2.80	*

ADF: acid detergent fibre — *fibres insolubles dans les détergents acides*; NDF: neutral detergent fibre — *fibres insolubles dans les détergents neutres*; SEM: standard error of the mean — *erreur standard de la moyenne*; F-test: significance level of the ANOVA F-test — *niveau de signification du test F d'analyse de la variance*; Values followed with different letters in a row are significantly different from each other ($p < 0.05$) — *les valeurs suivies de différentes lettres dans une ligne sont significativement différentes ($p < 0.05$)*; *: significant ($p < 0.05$) — *significatif ($p < 0,05$)*; ***: very highly significant ($p < 0.001$) — *très hautement significatif ($p < 0,001$)*.

Table 4. Daily digestible nutrient intake of *Adenodolichos rhomboideus*, *Leucaena leucocephala*, and *Stylosanthes guianensis* forages by indigenous goats — *Ingestion journalière de nutriments digestibles de fourrage de* Adenodolichos rhomboideus, Leucaena leucocephala *et* Stylosanthes guianensis *chez la chèvre locale*.

Parameter	Forage				
	A. rhomboideus	***L. leucocephala***	***S. guianensis***	**SEM**	**F-test**
Digestible intake (g per head per day)					
Organic matter	113[a]	229[b]	264[b]	13.4	**
Dry matter	113[a]	246[b]	278[b]	14	**
Crude protein	12[a]	66[b]	28[c]	3.7	***
ADF	47[a]	30[a]	100.8[b]	5.5	***
NDF	57[a]	69[a]	148[b]	6.2	***
Ether extract	1.7[a]	10.0[c]	5.8[b]	0.50	***
Digestible intake ($g \cdot kg^{-1}$ $W^{0.75}$ per day)					
Organic matter	13.4[a]	27.0[b]	31.0[b]	1.50	**
Dry matter	13.4[a]	29.0[b]	33.0[b]	1.56	**
Crude protein	1.4[a]	7.8[b]	3.4[c]	0.42	***
ADF	5.6[a]	3.6[a]	12.0[b]	0.65	***
NDF	6.8[a]	8.2[a]	17.6[b]	0.70	***
Ether extract	0.2[a]	1.2[c]	0.7[b]	0.06	***

ADF: acid detergent fibre — *fibres insolubles dans les détergents acide*s; NDF: neutral detergent fibre — *fibres insolubles dans les détergents neutres*; W: live weight — *poids vif*; SEM: standard error of the mean — *erreur standard de la moyenne*; F-test: significance level of the ANOVA F-test — *niveau de signification du test F d'analyse de la variance*; Values followed with different letters in a row are significantly different from each other ($p < 0.05$) — *les valeurs suivies de différentes lettres dans une ligne sont significativement différentes ($p < 0,05$)*; **: highly significant ($p < 0.01$) — *hautement significatif ($p < 0,01$)*; ***: very highly significant ($p < 0.001$) — *très hautement significatif ($p < 0,001$)*.

Table 5. Digestible nutrient content ($g \cdot kg^{-1}$ dry matter) of *Adenodolichos rhomboideus*, *Leucaena leucocephala*, and *Stylosanthes guianensis* forages for indigenous goats at Lubumbashi — *Teneur en nutriments digestibles ($g \cdot kg^{-1}$ matière sèche) de* Adenodolichos rhomboideus, Leucaena leucocephala *et* Stylosanthes guianensis *pour la chèvre locale à Lubumbashi*.

Parameter	Forage				
	A. rhomboideus	***L. leucocephala***	***S. guianensis***	**SEM**	**F-test**
dOM	583[a]	680[b]	685.5[b]	7	***
dCP	63[a]	195[b]	72[a]	5.9	***
dCF	231[a]	27[b]	191[a]	21.7	***
dADF	237.6[b]	91.4[a]	261.6[c]	13.5	***
dNDF	296[b]	205.5[a]	386.6[c]	10.8	***
dEE	8.7[a]	29.8[c]	14.8[b]	1.01	***
dNFE	683[b]	561[a, b]	493[a]	29.7	**
dAsh	14[a]	187[b]	229[b]	15.8	***

dOM: digestible organic matter — *matière organique digestible*; dCP: digestible crude protein — *protéines brutes digestibles*; dCF: digestible crude fibre — *fibres brutes digestibles*; dADF: digestible neutral detergent fibre — *fibres insolubles dans les détergents acides digestibles*; dNDF: digestible neutral detergent fibre — *fibres insolubles dans les détergents neutres digestibles*; dEE: digestible ether extract — *extraits éthérés digestibles*; dNFE: digestible nitrogen-free extract — *extractifs non azotés digestibles*; dAsh: digestible ashes — *matières minérales digestibles*; SEM: standard error of the mean — *erreur standard de la moyenne*; F-test: significance level of the ANOVA F-test — *niveau de signification du test F d'analyse de la variance*; Values followed with different letters in a row are significantly different from each other ($p < 0.05$) — *les valeurs suivies des différentes lettres, dans une rangée, sont différentes significativement ($P < 0,05$)*; **: highly significant ($p < 0.01$) — *hautement significatif ($p < 0,01$)*; ***: very highly significant ($p < 0.001$) — *très hautement significatif ($p < 0,001$)*.

digestible CP and EE contents than *A. rhomboideus* and S. guianensis. *Leucaena leucocephala* and *A. rhomboideus* forages had higher ($p < 0.01$) digestible OM and ashes contents than *S. guianensis*.

4. DISCUSSION

Dry matter of green forage classically varies between 12 to 50% fresh matter (Martin-Rosset, 1990; Djago et al., 2007). The DM content for all three forages in this experiment was high and linked to the fact that the study was conducted in dry season. The CP for all three forages exceeded the range of 7 to 8% CP suggested as a lower limit below which consumption by ruminants and microbial activity in the rumen would be affected (Van Soest, 1994). It has been reported that the CP concentration of *L. leucocephala* varies between 22 to 30% (Garcia et al., 1996). The values of CP found in this study are in the upper range values and similar to those given by Amjad et al. (2002) because the forages used in this study were leaves (petioles and blades) without stems. Garcia et al. (1996) reported a mean value of CP of 29% for leaves *versus* 22% for stems.

In the studies of Peters (1992) and Mani et al. (1992), the CP concentration of *S. guianensis* forage varied between 6.3 and 10.6% DM in the dry season. Our value falls in the upper range of these values but is lower than those given by Risopoulos (1966) for forage of this species from Yangambi in DR Congo, highlighting important regional differences in soil type, age, and climatic conditions in such comparisons. The CP concentration of *A. rhomboideus* leaves in the present study is in the same order of magnitude as the values found in Nigeria by other authors for *Adenodolichos paniculatus* forage in dry season (Wolfgang, 1990; Omokanye et al., 2001). In this study, the CP concentration of *A. rhomboideus* was lower than for *L. leucocephala* but higher than for *S. guianensis*. This difference may arise from the fact that both *L. leucocephala* and *A. rhomboideus* species are plants that develop well in the dry season, while *S. guianensis* is a seasonal plant. The differences in CP concentrations between these browses are probably due to differences in protein accumulation during growth. In the case of mature herbage, nutrient concentrations are generally highest in young material and then decline with advancing maturity. The decline can be both substantial and very rapid.

According to Garcia et al. (1996), *L. leucocephala* forage is rich in ADF (34.1–36.1%) and NDF (49.3–64.4%). This study found a lower value than those reported by Garcia et al. (1996), Abubeker et al. (2008), and Ngwa et al. (2000), which are similar to those reported by Boukila et al. (2005) and higher than those found by Mtenga et al. (1994) for NDF. The ADF values found in this study are similar to those reported by Boukila et al. (2005) and lower than those of Ngwa et al. (2000). The differences found in this study are probably due to soil types, plant varieties, climate, and parts of the plant used. The leaves, which are lower in fibre than stems, were used. The ADF and NDF concentrations of *S. guianensis* forage vary between 37 to 61% and between 42 to 72%, respectively (Mani et al., 1992; Matizha et al., 1997; Ladeira et al., 2001; Valarini et al., 2006). Our results fall in these intervals. The ADF and NDF concentrations of *A. rhomboideus* forage found in this work are higher than those found by Wolfgang (1990) for *A. paniculatus*. These differences may arise from differences in plant species, soil, and climate conditions.

The results obtained in this study show that ADF and NDF contents of *A. rhomboideus* and, to a lesser extent, *S. guianensis*, reach the recommended amount, in contrast to the values for *L. leucocephala*. The ADF fraction for all forages was about 50% of the NDF, which is indicative of high levels of hemicellulose.

Digestibility values were generally high, and better in *L. leucocephala* and *S. guianensis* forages than *A. rhomboideus* forage. Crude protein digestibility is related to the CP in forage (Lopez et al., 1998). Furthermore, San Martin et al. (1989) observed protein digestibility of 61.9% in sheep for diets with 10.5% CP and the digestibility declined to 36.1% in sheep with a decrease in diet CP to less than 7.5%. These values are not in agreement with the finding in the present study, which revealed higher CP digestibility for *S. guianensis* (58.3%) than *A. rhomboideus* forage (42%), though the CP content of *A. rhomboideus* leaves was significantly higher than that *S. guianensis* forage. The first explanation is that the nitrogen in *A. rhomboideus* may be associated with lignified cell wall to form a bulk of rumen UDP that is unavailable for post-ruminal digestion. A second explanation is that cell wall degradability of the forage may affect the overall CP digestibility. A third explanation is that the tannin component was at a level that could impact some qualities of ruminal UDP by enhancing the utilization of its protein due to a potentially higher amino acid flow to the small intestine (Meissner, 1997). It was shown that the tannin component of *Sanguisorba minor* depressed ruminal CP degradation but increased the passage of non-ammonia nitrogen in the small intestine (Acheampong-Boateng, 1991).

Organic matter and DM digestibility were higher for *L. leucocephala* and *S. guianensis* than *A. rhomboideus*. The results are higher than those reported by Garcia et al. (1996) and Abubeker et al. (2008) but similar to those given by Nguyen (1998) for *L. leucocephala*. In subhumid Nigeria, Peters (1992) found that the DM digestibility of *S. guianensis* and *S. hamata* averaged 50% or less throughout the dry

season. Little et al. (1984) reported *S. guianensis* DM digestibility close to 50% (range 20–71). The DM digestibility found in this study is higher than the value given by others (Little et al., 1984). Wolfgang (1990), in studies on a leguminous forage plant of dry season belonging to the same genus (*A. paniculatus*), found a lower DM digestibility value than that found in this study for *A. rhomboideus*.

Neutral detergent fibre digestibility gives us accurate estimates of total digestible nutrients (TDN), net energy (NE), and feed intake potential (Karen, 2003). Karen (2003) found that increased NDF digestibility resulted in higher digestible energy and forage intake. The results of the present study are in disagreement with this statement; despite *S. guianensis* having significantly higher NDF and ADF digestibility than *L. leucocephala* (**Table 3**), there was no significant difference in DM intake (**Table 2**) and digestible DM (**Table 4**) between these two species.

Thus, increased NDF digestibility will result in higher digestible energy, and the digestibility of plant material in the rumen is related to the proportion and lignification of plant cell walls. Forages with a low NDF content (20–35%) are usually of high digestibility and species with high lignin contents are often of low digestibility. Linn et al. (1993) reported that diets containing 21% NDF from high quality forages allowed more milk production and reduce off-farm feed costs. In this study, ADF and NDF digestibility were higher for *S. guianensis* than for other forages and are similar to those reported by Mani et al. (1992) for *S. guianensis* but higher than those reported by Abubeker et al. (2008) for *L. leucocephala*. The digestibility of cell walls is a function of lignin concentration and composition.

The nutritive value of forage was also considered in terms of nutrient intake. Organic matter and DM intake of *A. rhomboideus* forage were lower than those for *L. leucocephala* and *S. guianensis* forages, which had similar values. Crude protein intake of *A. rhomboideus* was similar to that of *S. guianensis* but lower than that of *L. leucocephala*, because of the lower CP content of *A. rhomboideus* and *S. guianensis*. Van Soest (1994) demonstrated that the intake of DM was negatively correlated with rumen retention time and positively correlated with ruminal volume and feed digestibility. High intake has been associated with a reduction in the extent of ruminal digestion due to decreased ruminal residence time (Staples et al., 1984). Factors other than the rate of digestion in the rumen determine the voluntary intake of foliage by ruminants. Low intakes associated with high feed digestibility may be related to the presence of compounds that are appetite depressants (tannins, alkaloids,.. ; Frutos et al., 2004). High feed intakes and low feed digestibility may be related to rapid rates of passage of feed through the rumen. Feed intake increases with the concentration of CP in the diet (Faverdin, 1999). However, CP intake was similar to *L. leucocephala* forage and high compared with *A. rhomboideus* and *S. guianensis* forage. According to Journet et al. (1983), voluntary intake of ADF and NDF of *Gliricidia sepium* forage was similar to that of *S. guianensis* forage and higher than that of *L. leucocephala* and *A. rhomboideus* forages. Digestible CP intake was higher for *L. leucocephala* and *S. guianensis* than *A. rhomboideus*.

Adenodolichos rhomboideus forage can be used for the maintenance and, to a lesser extent, for growth, whose protein requirements are estimated at between 0.74 to 1.96 $g \cdot kg^{-1}$ $BW^{-0.75}$ per day and between 0.26 to 2.2 $g \cdot g^{-1}$ live weight gain (ILCA, 1979).

5. CONCLUSION

This study shows that, under the conditions of the present study, *A. rhomboideus* has a higher CP content than *S. guianensis*, but *A. rhomboideus* forage is less consumed compared with *L. leucocephala* and *S. guianensis* forages. The intake and apparent digestibility of all nutrients from *A. rhomboideus* are lower than those of *L. leucocephala* and *S. guianensis*. This is probably due to anti-nutritional factors that are present in *A. rhomboideus* forage. A new study should focus on evaluating live weight gain by goats on a diet of grass hay supplemented with *A. rhomboideus* forage and on characterization of the nutritional anti-factors (saponins, tanins, alkaloids,…) in this forage.

List of abbreviations

ADF: acid detergent fibre
CP: crude protein
dADF: digestible acid detergent fibre
dAsh: digestible ashes
dCF: digestible crude fibre
dCP: digestible crude protein
dEE: digestible ether extract
DM: dry matter
DMD: digestible dry matter
dNDF: digestible neutral detergent fibre
dNFE: digestible nitrogen-free extract
dOM: digestible organic matter
EE: ether extract
FM: fresh matter
GLM: general linear model
ME: metabolisable energy
NDF: neutral detergent fibre
NE: net energy
OM: organic matter
RDP: Rumen degradable protein

TADCP: total apparently digested crude protein
TDN: Total digestible nutrient
UDP: undegradable protein
W: live weight

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