Nutritive value of *Adenodolichos rhomboideus* leaves compared to *Leucaena leucocephala* and *Stylosanthes guianensis* forage in indigenous goats at Lubumbashi (D.R. of Congo).

Valeur nutritive du fourrage de *Adenodolichos rhomboideus* en comparaison de fourrages de *Leucaena Leucocephala* et de *Stylosanthes guianensis* chez la chèvre locale à Lubumbashi (R.D. du Congo).

Tshibangu Muamba Innocent[1*], Nsahlai Ignatius Verla[2], Kiatoko Mangeye Honoré[3] and Hornick Jean Luc[4]

[1*] University of Lubumbashi, Faculty of Agriculture, Department of animal production, D.R. of Congo. itmk2001@yahoo.fr

[2]University of KwaZulu-Natal , Animal and Poultry Science, School of Agricultural Sciences & Agribusiness, South Africa. nsahlaii@un.ac.za

[3] University of Kinshasa, Faculty of Agriculture, Department of animal production D.R. of Congo honorekiatoko@gmail.com

[4]University of Liège, Faculty of Veterinary Medicine, Department of animal production, Belgium. jlhornick@ulg.ac.be

Abstract

Forage from three species (*Adenodolichos rhomboideus, Leucaena leucocephala, Stylosanthes guianensis*) were evaluated by determining chemical composition, 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). Six goats (17.1±0.7 kg) were used in 3 x 3 double latin square design to determine the digestibility and intake of the three forages. Forage from *S. guianensis* had lower ($p<0.001$) CP content than *L. leucocephala* forage and *A. rhomboideus* leaves. Fibres content (ADF and NDF) were lower ($p<0.001$) in *L. leucocephala* (35%) forage than *A. rhomboideus* (59.5%) leaves and *S. guianensis* forages (56.5%). *L. leucocephala* forage was superior in CP, Ash, EE concentrations, digestibility and voluntary intake of CP. *A. rhomboideus* leaves had lower ($p<0.05$) apparent digestibility and intake of DM. Digestible CP intake were similar between *A. rhomboideus* leaves and *S. guianensis* forages. Low digestibility and voluntary intake of *A. rhomboideus* leaves may be due to negative effect of anti-nutritional factor such as tannin. Digestible CP was similar for *A. rhomboideus* leaves and *S. guianensis* forage.

Keys words: *Adenodolichos rhomboideus, Leucaena leucocephala, Stylosanthes guianensis,* Goats, digestibility, intake.

Valeur nutritive de feuilles de *Adenodolichos rhomboideus* en comparaison de fourrages de *Leucaena Leucocephala* et de *Stylosanthes guianensis* chez la chèvre locale à Lubumbashi (R.D. du Congo).

Les fourrages de trois espèces végétales (*Adenodolichos rhomboideus, Leucaena leucocephala, Stylosanthes guianensis*) ont été étudiés pour la détermination de la composition chimique, de la consommation volontaire et de la digestibilité apparente de la matière sèche(MS), la matière organique(MO), protéines brutes (PB), fibres insolubles dans le détergent neutre (NDF) et fibres insolubles dans le détergent acide (ADF). A cette fin, six chèvres mâles (17,1±0,7) ont été utilisées dans un dispositif en double carré latin 3x3.

Le fourrage de *S. guianensis* a présenté une faible teneur en PB ($p<0.001$) par rapport aux feuilles de *A. rhomboideus* et de fourrages de *L. leucocephala*. Les teneurs en fibres (ADF and 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 de teneurs élevées en PB, MM et EE. 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 quantité des protéines brutes digestibles ingérée a été semblable entre les feuilles de *A. rhomboideus* et de *S. guianensis*. Les faibles digestibilités et consommations de feuilles de *A. rhomboideus* peuvent être dues aux effets négatifs de certains facteurs anti-nutritionels comme les tanins. La teneur en protéines digestibles a été similaire pour les trois fourrages.

Mots-clés: *Adenodolichos rhomboideus, Leucaena leucocephala, Stylosanthes guianensis*, chèvres, ingestion

1. Introduction

Ruminants' livestock in the southeastern region of Congo (DR), especially the indigenous goats which are the most productive in the Democratic Republic of Congo, 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 that lasts for more than six months and during which the straw is more available. However, during this period, some species retain their green leaves and are available as fodder for ruminants. Among these feed sources are *A. rhomboideus*, *L. leucocephala* and *S. guianensis*.

A. rhomboideus is an herbaceous legume, which is well adapted to local ecosystems and widespread in the region, growing on normal and trace metal contaminated soil (Meert, 2008). Its nutritional value for ruminants has never been investigated. *L. leucocephala* is a shrub with high nutritional value and its availability is limited by its tree height during the dry season. The digestible energy (DE) value of

Leucaena forage varies from 11.6 to 12.9 MJ kg^{-1} DM, the total apparent digested crude protein (TADCP) reported ranged from 64.7 to 78.0%. A model developed in one source suggested 42% rumen degradable protein (RDP), with 48% of the undegradable protein (UDP) being digested post ruminally, giving a TADCP value of 70% (Garcia et al, 1996).

S. guianensis is a herbaceous legume having good nutritional value but its use in the dry season is limited by lignification. The metabolizable energy (ME), OMD, CP and DMD values of *S. guianensis* forage varies around 5.34MJ/kg, 42.06%, 13.3 to18% and 51.7% (Ajayi and Babayemi 2008).

Several digestibility methods are known to assess the nutritional value of forage, but qualitative methods, such as *in vitro* and *in sacco* methods, may lead to some erroneous conclusions if not supported by feeding trials (Norton, 1998). Forage legumes with low digestibility and high palatability could thus be rejected by animals. The form in which the leaves are fed (fresh, wilted or dry) is also known to affect both intake and digestibility in some species (Palmer and Schlink, 1992). Since there are no known techniques which predict palatability and intake, the nutritive value of forage species can only be accurately determined by feeding trials; in as such method gives information on animal health and productivity. The objective of this study was the assessment of the nutrient contain, intake and digestibility of *A. rhomboideus* forage compared to *L. leucocephala* and *S. guianensis* fed to indigenous goat.

2. Material and Methods

2.1. Diets, animals and experimental design

Three different forages were tested from 15 June to 18 August 2010 and comprised *A. rhomboideus* leaves, *L. leucocephala* and *S. guianensis* forage. One to two months re-growth of *A. rhomboideus* leaves was harvested at area golf Meteorology of Lubumbashi (D. R. of Congo), 11°37’58.2” latitude south, 27°24’54.5’’ longitude east, 1266m of altitude.

L. 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, 1296m of altitude.

S. guianensis forage was obtained from experimental fields, established in December 2009, of the farm of the Faculty of Veterinary Medicine of the University of Lubumbashi, 11°42’46.2” latitude south, 27°32’31.2’’ longitude east, 1216m of altitude.

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

A. rhomboideus and *L. leucocephala* samples were collected as leaves alone with petiole, while *S. guianensis* was mown at the height of 15 cm approximately.

To facilitate the good chewing, *S. guianensis* forage was chopped and *A. rhomboïdes* and *L. leucocephala* were sorted to remove hard petiole and dry leaves before distributing it to the animals.

Six local yearling male goats with live weight 17.1kg± 0.73 were used. These animals were separated into two Latin squares of three animals each. Diets were offered twice in three periods of 21 days each (63 days), comprising 15 days of adaptation, followed by seven days of data collection. Each group of animal was subjected to each forage according to the period.

Voluntary intake and *in vivo* apparent digestibility of the three forages were studied. Voluntary intake was determined by the difference between the quantity of consumed and excreted dry matter. Apparent digestibility was determined by complete collection *in vivo* digestibility trials (Jetana et 2010) in pens 120cmx80cmx70cm.

$$\text{Digestibility (g/kg)} = \frac{\text{Nutrient in feed - Nutrient in feces}}{\text{Nutrient in feed}} \times 1000$$

Water and trace mineral blocks were provided throughout the experimental period.

The animals were weighed to 0.1 kg on the initial day of the experimental period. Daily feed intake and total fecal production was also measured for each animal. Total daily fecal production for each animal was stored frozen until completion of the collection period. 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 hours and ground through a 1-mm screen in IKA WERKE type M20 machine.

Organic matter of forage and feces was determined by placing the samples in a muffle furnace at 560°C for one night. Dry matter of forage and feces was determined by placing samples in an oven at 105°c for 24h. Protein content of forage and feces was determined in the Hach digesdahl digestion apparatus (Réf. n° 23130-21) using the method described by Scott (1992) and 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 of forage and feces (lipid content) was determined by soxtec system method (Matsler and Siebenmorgen, 2005).

2.2. Data analyses

The design was a 3 x 3 double Latin Square, where each of the three feeds was tested six goats in three groups of two animals per group in three periods. Data were analyzed by analysis of variance, using the general linear model (GLM) procedure of SAS (Statistical Analysis System Institute, 2010). Comparisons between feeds were made using Student's *t*-test. The model for analysis included the effects of the different forage, period, square and animal. The effects due to periods, square and animal were not significant.

3. Results

The chemical composition of the three forages is presented in Table 1. The chemical composition for all nutrients of these three forages were very different (p<0.001). *L. leucocephala* was richer in crude protein, ether extract and ash than *A. rhomboideus* and *S. guianensis* forages. Forage from *S. guianenis* had higher value for dry matter content, while *A. rhomboideus* had higher concentrations of OM, ADF and NDF content than any other forage.

All variables differed (p<0.01) among the three forage in term of forage intake (Table 2). The voluntary intake of *L. leucocephala* and *S. guianensis* forages were higher than forage from *A. rhomboideus* for organic matter, dry matter and ether extract (p<0.01). *L. leucocephala* had higher voluntary intake than *S. guianensis* and *A. rhomboideus* for CP (p<0.001). NDF an ADF intake was higher for *S. guianensis* forage than *L. leucocephala* and *A. rhomboideus* forages (p<0.01).

Apparent digestibility coefficients of different forages fed to indigenous goats are presented in Table 3. Forage from *S. guianensis* and *L. leucocephala* had higher organic matter, dry matter and crude protein digestibility than *A. rhomboideus* forage (p<0.001). Forage from *L. leucocephala* and *A. rhomboideus* had lower apparent digestibility coefficients of ADF (p<0.001), NDF (p<0.001) and ether extract (p<0.05) than forage from *S. guianensis*.

Table 1. Chemical composition of *A. rhomboideus, L. leucocephala* and *S. guianensis* forage feed by indigenous goat at Lubumbashi.

Tableau 1. Composition chimique de fourrage de *A. rhomboideus, L. leucocephala and S. guianensis* consommé par la chèvre locale à Lubumbashi.

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

Values followed with different letters in a line are significantly different from each other (P <0.05).
**significant (p<0.05)*

*** Highly significant ($p<0.01$)*

**** Very highly significant (p0.001)*

Daily digestible intake for indigenous goats feed *A. rhomboideus. L. leucocephala* and *S. guianensis* forage are given in Table 4. All variables differed significantly among the forages. *L. leucocephala* and *S. guianensis* forage had higher ($p<0.01$) digestible intake than *A. rhomboideus* forage for organic matter and dry matter. Forage from *L. leucocephala* had higher ($p<0.001$) digestible intake of crude protein 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 were higher ($p<0.001$) for *L. leucocephala* followed in order by *S. guianensis* and *A. rhomboideus*.

Table 2. Daily Voluntary Intake of *A. rhomboideus. L. leucocephala* and *S. guianensis* forage by indigenous goats at Lubumbashi.

Tableau 2. Ingestion volontaire journalière de *A. rhomboideus. L. leucocephala* and *S. guianensis* chez la chèvre locale à Lubumbashi.

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

Values followed with different letters in a row and an effect are significantly different from each other ($P<0.05$).

Les valeurs suivies de différentes lettres, dans une ligne, sont différentes ($P<0,05$)

**significant (p<0.05)*

*** Highly significant (p<0.01)*

**** Very highly significant (p0.001)*

Table 3. Apparent digestibility coefficient (%) of *A. rhomboideus. L. leucocephala* and *S. guianensis* forage consumed by indigenous goat at Lubumbashi.

Tableau 3. Coefficient de digestibilité apparente (%) de *A. rhomboideus. L. leucocephala and S. guianensis c*hez la chèvre locale à Lubumbashi.

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

Values followed with different letters in a line and an effect are significantly different from each other (P <0.05).

Les valeurs suivies de différentes lettres, dans une ligne, sont différentes (P<0,05)

**significant (p<0.05)*

*** Highly significant (p<0.01)*

**** Very highly significant (p0.001)*

Table 4. Daily Digestible Nutrient Intake of *A. rhomboideus. L. leucocephala and S. guianensis* forage by indigenous goat.

Tableau 4. Ingestion journalière de nutriments digestibles de fourrage de *A. rhomboideus. L. leucocephala and S. guianensis* chez la chèvre locale

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

Values featuring different letters in a row and an effect are significantly different from each other ($P<0.05$). Les valeurs suivies des différentes lettres, dans une ligne, sont différentes ($P<0,05$)

significant ($p<0.05$), ** Highly significant ($p<0.01$), * Very highly significant (p0.001)*

Table 5. Digestible nutrients contents (g/kg DM) in *A. rhomboideus, L. leucocephala* and *S. guianensis* forage for indigenous goats at Lubumbashi.

Tableau 5. Teneur en nutriments digestibles (g/kgMS) de *A. rhomboideus, L. leucocephala and S. guianensis* pour la chèvre locale à Lubumbashi.

	A. rhomboideus	***L. leucocephala***	***S. guianensis***	**SEM**	**Effect**
dDM	214a	256a	516b	***10.7***	***
dOM	583a	680b	685.5b	***7***	***
dCP	63a	195b	72a	***5.9***	***
dCF	231a	27b	191a	***21.7***	***
dADF	237.6b	91.4a	261.6c	***13.5***	***
dNDF	296b	205.5a	386.6c	***10.8***	***
dEE	8.7a	29.8c	14.8b	***1.01***	***
dFNE	683b	561ab	493a	***29.7***	**
dAsh	14a	187b	229b	***15.8***	***

Digestible dry matter (dDM), Digestible organic matter (dOM), Digestible crude protein (dCP), Digestible neutral detergent fibre (dNDF), Digestible acid detergent fibre (dADF), Digestible ether extract (dEE), Digestible nitrogen-free extract (dNFE)

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 (P<0,05).

**** Highly significant (p0.001)*

4. Discussion

Dry matter of green forage classically varies between 12 to 50 % fresh matter (Lebas, 2007; Martin-Rosset, 1990). The dry matter 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 exceeds 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 shown that the crude protein concentration of *L. leucocephala* can vary between 22.03 to 30% (Garcia et al., 1996). The values of CP found in this study are in the upper range of previous values and similar to those given by Amjad et al. (2002) because forages used in this study were leaves (petiole and blade) without stems. Garcia et al. (1996) reported a mean value of CP for leaves of 29.2 % versus 22.03% for stem.

In studies of Peters, 1992 and Mani et al., 1992, the crude protein 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 previous values but is lower than those given by Risopoulos (1966) for forage of this species from Yangambi in Congo (DR), highlighting the important regional differences in soil type, age and climatic conditions in such comparisons. These values are in the same order of magnitude as the values found in Nigeria by other authors for *A. paniculatus* forage in dry season (Wolfgang, 1990; Omokanye et al, 2001). In this study the crude protein concentration of *A. rhomboideus* was lower than that of *L. leucocephala* but higher than that of *S. guianensis*. This difference may arise from the fact that both *L. leucocephala* and *A. rhomboideus* species are plants that well develops in the dry season while *S. guianensis* is a seasonal plant, and 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 but then decline with advancing maturity can be both substantial and very rapid.

According to Garcia et al. (1996), L. *leucocephala* forage is rich in acid detergent fibre (34.1 - 36.1%) and neutral detergent fibre (49.3 - 64.4 %). This study found lower value than those reported by Garcia et al. (1996), Abubaker et al. (2008) and Ngwa et al. (2000), that are similar to those reported by Boukila et al. (2005) and higher than those found by Mtenga and Laswai (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, varieties, climate and parts of plant used. The leaves which are lower in fiber than stems were used. The ADF and NDF concentrations of S. *guianensis* forage vary between 37 to 61% and between 42-72%, respectively (Ladeira et al., 2001; Matizha et al., 1997; Mani et al., 1992; Valarini and Possenti, 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 the difference between species, soil and climate conditions.

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

Digestibility values were generally high, best in *L. leucocephala* and *S. guianensis* forage. Crude protein digestibility is related to the crude protein in forage (Lopez et al., 1998). Furthermore Martin and Bryant (1989) observed a 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 present study which revealed higher CP digestibility in *S. guianensis* (58.3%) than CP digestibility of *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 undegradable protein which is unavailable for post-ruminal digestion. A second explanation is that cell wall degradability of the forage may also affect the overall CP digestibility. Third explanation is that tannin component was at a level that could impact some qualities of ruminal undegradable protein by enhancing the utilization of its protein due to a potentially higher amino acid flow to the small intestine (Meissner, 1997). This was demonstrated in the tannin component of *Sanguisorba minor* which depressed ruminal CP degradation but increased the passage of non-ammonia N in the small intestine (Acheampong-Boateng, 1991).

Organic matter and dry matter digestibility were higher for *L. leucocephala* and *S. guianensis* than *A. rhomboideus*. This results were 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 dry matter digestibilities of *S. guianensis* and *S. hamata* averaged 50% or less throughout the dry season. Little et al. (1984) reported *S. guianensis* dry-matter digestibility of approximately 50% (range 20–71). Dry matter digestibility found in this study is higher than the value given by others (Little et al., 1984). Wolgang (1990) in its studies on a leguminous forage plant of dry season, belonging to the same genus *Adenodolichos paniculatus*, found a value lower than that found in this study for *A. rhomboideus*.

NDF 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 will result in higher digestible energy and forage intake, but the results, in present study, is in disagreement with this statement; despite *S. guianensis* had a 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 (NDF). 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 and Kuehn (1993) reported that diets containing 21% NDF from high quality forages will return 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 nutrients intake. Organic matter and dry matter intake of *A. rhomboideus* forage was low for *L. leucocephala* and *S. guianensis* forage which were similar. Crude protein intake on *A. rhomboideus* was similar to *S. guianensis* but low for *L. leucocephala* because of the lower crude protein content of *A. rhomboideus* and *S. guianensis*. Van Soest (1994) demonstrated that the intake of DM is negatively correlated with rumen retention time and positively correlated 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 which are appetite depressants (tannins, alkaloids, etc) (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 crude protein in the diet (Faverdin, 1999). However, crude protein intake was similar to *L. leucocephala* forage and high compared to *A. rhomboideus* and *S. guianensis* forage. According to Journet et al. (1983) voluntary intake of ADF and NDF *Gliricidia sepium* forage was similar to *S. guianensis* forage and high for *L. leucocephala* and *A. rhomboideus* forage. Digestible crude protein intake was higher for *L. leucocephala* and *S. guianensis* to those on *A. rhomboideus. A. rhomboideus* forage can be used for the maintenance and to a lesser extent for growth whose requirement are estimated between 0.74 to1.96 g.kg $BW^{-0.75}$ day^{-1} and between 0.26 to 2.2 g. g^{-1} live weight gain (ILCA. 1979).

5. Conclusion

This study shows that *A. rhomboideus* has a crude protein content higher than that of *S. guianensis*, but forage is slightly consumed compared to *L. leucocephala* and *S. guianensis* forage.

The intake and apparent digestibility of all nutrients from *A. rhomboideus* are lower than those of two other fodder, *L. leucocephala* and *S. guianensis*. This is probably due to anti-nutritional factors that would be contained in *A. rhomboideus* forage.

New study can be focalized in supplementation of grass hay by this forage to evaluate live weight gain by goats and the characterization of the nutritional anti factors (saponins, tanins, alkaloids, etc).

References

Abubeker H., Rethman N.F.G., Apostolides Z. & Van Niekerk W.A., 2008. Forage production and potential nutritive value evaluation of twenty-four shrub type indigofera accessions grown under field conditions. Trop Grasslands. 42, 96–103.

Acheampong-Boateng O., 1991. The nutritive value of sainfoin (Onobrychiis vicifolia) and sheep's burnet (Sanguisorba minor) in relation to Lucerne (Medicago sativa). M.Sc (Agriculture) treatise, University of Pretoria, South Africa.

Ajayi F T and Babayemi O J 2008: Comparative *in vitro* evaluation of mixtures of *Panicum maximum* cv Ntchisi with stylo (*Stylosanthes guianensis*), Lablab (*Lablab purpureus*), Centro (*Centrosema pubescens*) and Histrix (*Aeschynomene histrix*). *Volume 20, Article #83.* Retrieved Mars 4, 2011, from http://www.lrrd.org/lrrd20/6/ajay20083.htm

Amjad A. C., Iqbal Z., Afzal M. & Mushtaque M., 2002. Seasonal variation in chemical composition of Ipil-Ipil(L. leucocephala). Pakistan J Forest. 52(2),109-114.

Boukila B., Pamo T. E., Fonteh F. A., Kana J. R., Tendonkeng F. & Betfiang M. E., 2005. Effet de la supplémentation de quelques légumineuses tropicales sur la valeur alimentaire et la digestibilité *in-vitro* des chaumes de maïs. Livest Res Rural Dev. Volume 17, Article #146. Retrieved October 22, 2013, http://www.lrrd.org/lrrd17/12/bouk17146.htm

Faverdin, 1999. The effect of nutrients on feed intake in ruminants. Proceedings of the Nutrition Society, 58, 523–531

Frutos P., Hervas G., Giraldez F. J., & Mantecon A. R., 2004. Review, Tannins and ruminant nutrition. Span. J. Agric. Res. 2 (2), 191-202.

Garcia G. W., Ferguson T.U., Neckles F.A. & Archibald K.A.E., 1996. The nutritive value and forage productivity of *L. leucocephala*. Anim Feed Sci Technol 60, 29-41.

ILCA (INTERNATIONAL LIVESTOCK CENTRE FOR AFRICA), 1979. Small ruminant production in the humid tropics. Systems Study, Addis Abeba. Ethiopia.

Jetana T., Vongpipatana C., Thongruay S., Usawang S. & Sophon S., 2010. Apparent digestibility, nitrogen balance, ruminal microbial nitrogen production and blood metabolites in Thai Brahman cattle fed a basal diet of rice straw and supplemented with some tropical protein-rich trees. Asian-Aust. J. of Anim. Sci., 23, 465-474

Journet M., Champredon C., Pion R. & Vérité R., 1983. Physiological basis of the protein nutrition of high producing cows. Critical analysis of the allowances. Protein Metabolism and Nutrition. 4th International Symposium. European Association for Animal Production Publication no. 31, 433–448. Paris: INRA.

Karen Dupchak, 2003. NDF Digestibilities: a New Analysis to Evaluate Forage Quality. Agr. Food and Rur. Init. Volume 14 n°1.

Ladeira M.M., Rodriguez N.M., Gonçalves L.C., Borges I.,Benedetti E., Teixeira E.A., Lara L.B., 2001. Consumo e digestibilidades aparentes total e parciais do feno de S. guianensis. Arq. Bras. Med. Vet. Zootec. 53, 2 Belo Horizonte. http://www.scielo.br/scielo.php?script=sci_arttext&pid=S0102-09352001000200018

Lebas F., 2007. Plantes tropicales utilisables pour le lapin. in DJAGO A.Y., KPODEKON M., LEBAS F., 2007. Méthodes et Techniques d'élevage du Lapin. Elevage du lapin en milieu tropical. Doc mis en ligne le 18 août 2007

Linn J. and Kuehn C., 1993. The effects of forage quality on performance and cost of feeding lactating dairy cows. University of Minnesota, Department of Animal Science, 1364 Eckles Avenue, St – Paul, Minnesota 5508-6120, USA http://www.wcds.afns.ualberta.ca/Proceedings/1997/ch04-97.htm

Little D. A., McIvor J.G. and McLean R.W., 1984. The chemical composition and nutritive value of Stylosanthes. In: Stace H. M. and Edye L. A. (eds), The biology and agronomy of Stylosanthes species. Academic Press, Sydney, Australia. pp. 381–403.

Lopez A., Maiztegui, J. and Cabrera, R., 1998. Voluntary intake and digestibility of forages with different nutritional quality in alpacas (Lama pacos). Small Ruminant Res, 29, 295-301.

Mani R.I., Kaufmann R. V., Egan A.R., Dixon R. M. & Holmes J.H.G., 1992. Development of grazing and utilization strategies for stylo-based pasture supplies adapted to cattle production systems. In Stylosanthes as forage and fallow crop. Proceedings of the Regional Workshop on the Use of S. in West Africa held in Kaduna, Nigeria, 26–31 October 1992.

Martín-Rosset W., 1990. L'alimentation des chevaux, collection techniques et pratiques, éd. Quae, INRA, France pp. 232.

Martin S. F. and Bryant, 1989. Nutrition of domesticated South American Ilamas and alpacas. Small Ruminant Res, 2, 191-216.

Matizha W., Ngongoni N.T., Topps J.H., 1997. Effect of supplementing veld hay with tropical legumes Desmodium uncinatum, S. guianensis and Macroptilium atropurpureum on intake, digestibility, outflow rates, nitrogen retention and live weight gain in lambs. Animal Feed Sci Tech 69,187-193.

Matsler A.L. and Siebenmorgen T.J., 2005. Evaluation of Operating Conditions for Surface Lipid Extraction from Rice Using a Soxtec System. Cereal Chem 82(3):282-286.

Meerts P., 2008. Flore du cuivre SCI. Iconothèque numérique. Université Libre de Bruxelles. http://bib18.ulb.ac.be/cdm4/item_viewer.php?CISOROOT=/bst003&CISOPTR=4&CISOBOX=1&REC=2.

Meissner H.H., 1997. Recent research on forage utilization by ruminant livestock in South

Africa. Anim Feed Sci Technol 69, 103–119.

Mtenga L.A. and Laswai G.D., 1994. L. Leucocephala as feed for rabbit and pig: detailed chemical composition and effect of level of inclusion on performance. For Ecol and Manage. 64 (2-3), 249- 257.

Nguyen Thi Hong Nhan., 1998. Effect of Sesbania grandiflora, L. leucocephala, Hibiscus rosa-sinensis and Ceiba pentadra on intake, digestion and rumen environment of growing goats. Livest Res Rural Dev. Volume 10, Number 3,

Ngwa A.T., Nsahlai I.V. and Bonsi M.L.K., 2000. The potential of legume pods as supplements to low quality roughages. S Afr J Anim Sci, 30 (Supplement 1)

Norton B.W., 1998. Anti-nutritive and Toxic Factors in Forage Tree Legumes. Ch. 4.3 in Gutteridge, R.C. and Shelton, H.M. (eds). Forage Tree Legumes in Tropical Agriculture. The Trop Grassland Society of Australia Inc.

Omokanye A.T., Balogun R.O., Onifade O.S., Afolayan R.A. and Olayeni M.E., 2001. Assessment of preference and intake of browse species by Yankasa sheep at Shika, Nigeria. Small Ruminant Res 42, 203-210.

Palmer B. and Schlink, A.C., 1992. The effect of drying on the intake and rate of digestion of the shrub legume Calliandra calothyrsus. Trop Grasslands 26, 89-93.

Peters M., 1992. Evaluation of tropical pasture legumes for fodder banks in subhumid Nigeria. PhD thesis, Justus Liebig University, Giessen, Germany.

Risopoulos S.A., 1966. Amenagement et utilisation des pâturages : Pâturages et cultures fourragères.Etude n°1 ; FAO, RD Congo.

Scott V.B., 1992. Acid Digestion using the Hach Digesdahl Digestion Apparatus. Sample preparation for protein and element analysis. Technical Information. Series-Booklet n°14.

Staples C. R., Fernando, R.L., Fahey, G. C., Berger, L.L. and Jaster, E. H., 1984. Effect of intake of mixed diet by steers on digestion events. J Dairy Sci. 67, 995-1006.

Valarini M. J. and Possenti R. A., 2006. Research note: Nutritive value of a range of tropical forage legumes. Trop Grasslands. Volume 40, 183 –187.

Van Soest P.J., 1994. Nutritional Ecology of the Ruminant. Cornell University Press, Ithaca, NY, 476pp.

Van Soest, P.J., Robertson, J.B. and Lewis, B.A., 1991. Methods for dietary fibre, neutral detergent fibre and non-starch polysaccharides in relation to animal nutrition. J Dairy Sci. 74, 3583–3597.

Wolfgang B., 1990. Use of native browse by Fulani cattle in central Nigeria. Agroforest Syst 12, 217-228.