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EVALUATION OF IN VITRO DRY MATTER DIGESTIBILITY OF SELECTED INDIGENOUS TREE BROWSES AS FEED FOR RUMINANT LIVESTOCK IN CENTRAL EQUATORIA STATE OF THE REPUBLIC OF SOUTH SUDAN

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ABSTRACT

Browse tree leaves from *Acacia nilotica, Balanites aegyptiaca, Combretum adenogonium, Sclerocrya birrea* and *Ziziphus spina-christi* were evaluated for *in vitro* gas production andpotential degradability. Browse species were selected from a field survey. All the parameters studied varied significantly (P < 0.05). Means for *in vitro* gas production incubation time intervals ranged from 30.6 to 45 ml/kg DM for 3 and 96 hrs, respectively. *Balanites aegyptiaca, C. adenogonium* and *Z. spina-christi* at 48hr had high gas production potential compared to *A. nilotica* and *S. birrea*. *In vitro* OM degradability is significantly (P < 0.05) different between the browse species. In the study, *C. adenogonium* and *Z. spina-christi* had the highest (P < 0.05) degradability while, *A. nilotica* and *S. birrea* had (P < 0.05) lower degradability values. Browse species ranked in order of degradability: *Z. spina-christi*>*C. adenogonium*> B. *aegyptiaca* > *S. birrea* > *A. nilotica*. The estimated metabolizable energy (EME) values were relatively similar but *B. aegyptiaca, C. adenogonium* and *Z. spina-christi* had higher (P < 0.05) values compared to *A. nilotica and S. birrea*. Browse ranked on the basis of estimated metabolization energy (EME): *C. adenogonium* > *Z. spina-christi*> *B. aegyptiaca* > *A. nilotica* > *S. birrea*. These browse species have the potential to supplement ruminants feeding on low quality forages with highly degradable feed resources that could provide microbial degradable protein. Further studies are required to evaluate browse species on intake and growth performance in ruminant livestock.

INTRODUCTION

Leaves of tree browses play a critical role in supplementing low qualify feed with nitrogen especially during dry season. Browse leaves are an important component of grazing goats and sheep (Papachristou and Nasis, 1996) and play an important role in the nutrition of grazing livestock in areas with poor quality forage (Meuret, 1990). However, sufficient utilization of tree leaves depend on the tannins content. Although tree leaves are important source of forage for ruminant livestock, there is limited information on the nutritive value of the selected indigenous tree browses in Central Equatoria State of the Republic of South Sudan. Therefore, the aim of the current study was to evaluate the nutritive value of the selected indigenous tree browses based on *in vitro* dry matter digestibility.

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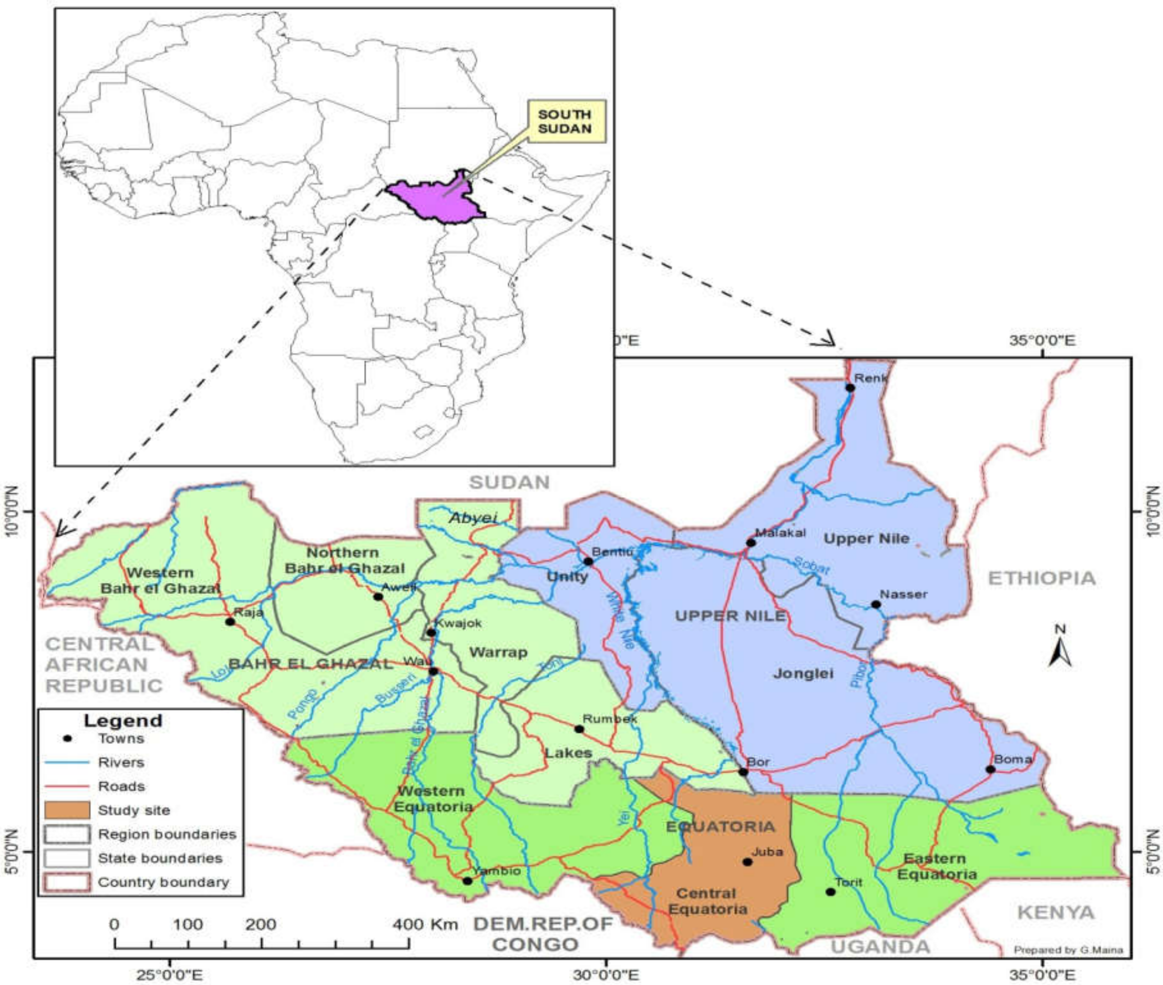
MATERIALS AND METHODS

Study area

The study was conducted in Central Equatoria State of South Sudan. The State lies between latitudes 30° 30and 60° North and 30° 30and 32° East at the extreme Southern parts of the Republic of South Sudan (Figure 1). The State has a hilly topography with a humid climate. It receives a unimodal rainfall with an average of 1000 mm per year between April and November. The period between December and March is normally a dry season. The CES is inhabited mainly by agro-pastoral communities undertaking subsistence crop farming and livestock keeping. Livestock kept include cattle, sheep, goats, pigs and poultry.

Selection of Samples

Samples for investigation were collected from 5 indigenous tree species commonly browsed by ruminant livestock in Central Equatoria State of South Sudan.



Source: Republic of South Sudan Towns and States Map.

Figure 1. Map indicating the study area (Central Equatoria State) of the Republic of South Sudan

The samples were selected for *in vitro* gas production, organic matter degradability and determination of metabolizable energy. Selection of the 5 browses was based on the recommendations of a field survey involving livestock owners in the State which identified the most common and preferred browses by the livestock. Sampling was done during the dry season (December – March), because this is the time of the year when browse species are more important for livestock feeding. The selected species are; *Acacia nilotica, Balanites aegyptiaca, Combretum adenogonium, Sclerocarya birrea* and *Ziziphus spina-christi.*

Collection and preparation of the samples

Leaves of the identified browses were obtained by hand plucking/clipping between December to March in the three study counties of Juba, Yei and Kajo-keji in CES. Samples of the same tree species were collected in different parts of the study locations. The leaf samples collected were dried for seven days under a shade. Thereafter, the leaves were ground through a 1mm screen and packaged in 1kg plastic bags and transported to Animal Nutrition laboratory of the Department of Animal Sciences, Egerton University (Kenya) for the determination of *in vitro* dry matter digestibility, gas production and Metabolizable energy.

Rumen fluid sampling and incubation

The milled dried leaves of browses was evaluated for the *in vitro* digestibility.

Rumen fluid was obtained from two Friesian fistulated steers in Tatton Agriculture Park of Egerton University. The animals were fed on a basal diet of Rhodes grass hay *ad libitum* and given free access to clean drinking water and mineral/vitamin block. A suction bottle (500 ml) was used to collect rumen fluid from various parts of the rumen of each steer. Samples of rumen fluid was withdrawn before morning feeding, transferred into thermos flasks to keep the temperature (warm) and taken immediately to the laboratory and strained through three layers of cheesecloth to remove fibrous food particles and then kept at 39°C under a constant flow of carbon dioxide (CO_2) to maintain anaerobic conditions. Buffer and minerals solution were prepared as described by Menke and Steingass (1988) and used by Guliye *et al.* (2005). Then, one ml of ruminal fluid was added to two ml of buffer and minerals solution to make diluted ruminal fluid. Thirty ml of the diluted ruminal fluid were injected into syringes with 200 mg of each of milled browse leaf samples. The syringes were incubated in a water bath at 39^{o}C for 96 h. Syringes with 30 ml of diluted ruminal fluid only were incubated to correct for endogenous gas production. The syringes were incubated and the volume of gas produced over 96 h period was recorded.

*In vitro*digestibility

The *in vitro* digestibility was determined using the technique of Menke *et al.,* (1979) as described by Abdulrazak and Fujihara (1999) and used by Ondiek (2012).

The obtained gas values were fitted in the equation: $P = b(1-e^{-ct})$ of Ørskov and McDonald (1979). Where,

P = the volume of gas produced/ml at time t
b = the potential gas production (ml)
c = the gas production rate constant
t = incubation time (h)

In vitro organic matter digestibility was determined from the equation of Menke *et al.,* (1979), and the Metabolizable energy (ME; Mj/kg DM) calculated using equation of Menke *et al.,* (1979) as follows: ME (MJ/kg DM) = 2.20 + 0.136GP + 0.057CP where, GP is 24 h net gas production (ml/200mg) and CP is Crude protein (%).

Statistical analysis

Results of*in vitro* gas production and OM degradability characteristics were subjected to analysis of variance (ANOVA) using General Linear Model Procedures (procglm) of statistical package of SAS (2002, version 9.0). All analyses were based on the general statistical model: $Y_{ij} = \mu + S_i + S_e$ where, $Y_{ij}$is the general observation on the tested variables, μ is the overall mean due to all observations, S_i is the effect of i^{th} browse species and S_e is the standard error of means. Significant means were separated using least significant difference (LSD) test.

RESULTS

In vitro gas production characteristics

The *in vitro* gas production characteristics of the browse species are presented in Table 1. Gas production potential was significantly ($P < 0.05$) different among browse species. Potential gas production was lower in *A. nilotica* and *S. birrea*; intermediate in *C. adenogonium* and higher in *B. aegyptiaca* and *Z. spina-christi*. Means for *in vitro* gas production characteristics in different incubation time interval/h range from 30.6 to 45.0 ml/200 mg DM. Gas production and degradability characteristics between the browse trees are presented in Table 2.

Values for a, b, (a+b) and c are significantly ($P < 0.05$) different between the browse trees in the study. The percentage degradability characteristics of the browse leaves range from 0.07 to 1.77, 0.50 to 3.80, 0.79 to 4.56 and 0.06 to 9.45% in *A. nilotica* and *B. aegyptiaca*, *S. birrea* and *Z. spina-christi*, *A. nilotica* and *Z. spina-christi*; and *Z. spina-christi* and *B. aegyptiaca* for a, b, (a+b) and c values, respectively (Table 2). Degradabilityfor*A. nilotica* and *S. birrea* had lower; *B. aegyptiaca* and *C. adenogonium* intermediate degradability while *Z. spina-christi* the highest (Table 2) although not significantly ($P > 0.05$) different from *B. aegyptiaca* and *C. adenogonium,* and*B. aegyptiaca* had significantly ($P < 0.05$) higher rate constant (c) compared to other browse species in this study (Table 2). Individual browse degradability trend is indicated in Figures 1-5 and combine in Figure 6. The browse trees under investigation can be categorized into three groups of low degradable (*A. nilotica* and *S. birrea*), moderate to high degradable (*B. aegyptiaca* and *C.adenogonium*) and highly degradable (*Z. spina-christi*). The estimated metabolizable energy (ME, Mj/kg DM) values of the browse species were relatively similar. However, *A. nilotica* and *S. birrea* had significantly ($P < 0.05$) lower ME compared to *B. aegyptiaca, C. adenogonium* and *Z. spina-christi* which are not significantly ($P > 0.05$) different from one another (Table 2).

DISCUSSION

The differences in diet degradability observed in the current study could be due to effects of anti-nutritive (phenolic and tannin) substances as well as fibre content in the feed, Mangara *et at*.,(2017). Effect of phenolic and tannins in decreasing feed digestibility by binding nutrients and then making them unavailable for digestion has been reported by several researchers (Makkar *et al*., 1995; Makkar and Becker 1996; Abdulrazak *et al.,* 2000; Getachew*et al*., 2000; Rubanza*et al*. 2003; Osuga*et al.,* 2006, 2007 and 2008; and Ondiek *et al*., 2010). Variability of tannins between plant species is related to phenolic type, conformity and reaction mechanisms that result to differential action of anti-nutritive factors (tannins) on degradability (Makkar and Becker, 1993; and Rubanza*et al*., 2003).

Table 1. Cumulative in vitro gas production (ml) for tree browse leaves in Central Equatoria State of the Republic of South Sudan Incubation time (h)

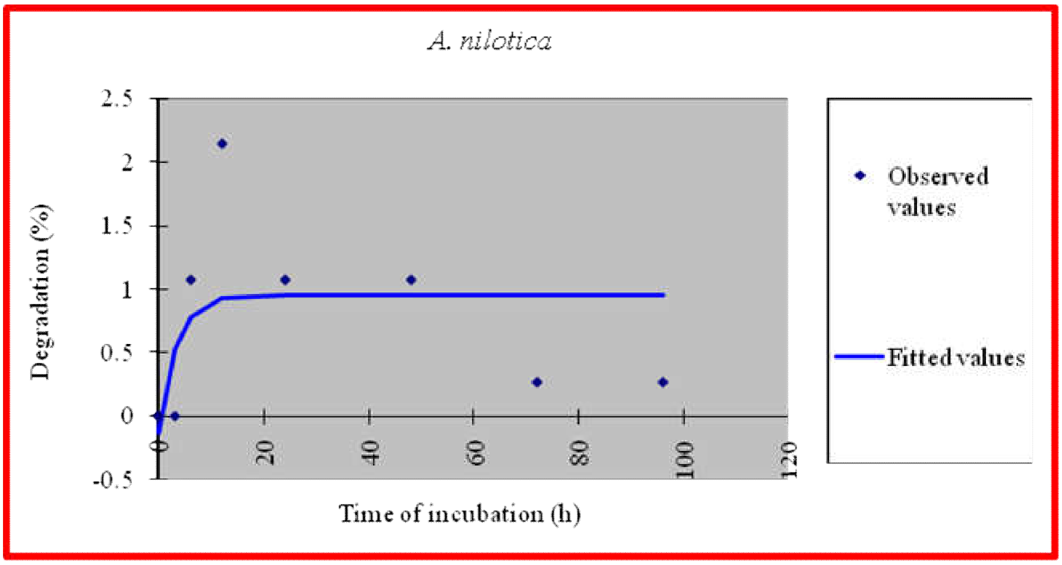
Browse species	3	6	12	24	48	72	96
A. Nilotica	29.0^{d}	30.0^{b}	30.0^{b}	30.5^{b}	31.6^{b}	33.1^{b}	33.3^{b}
B. aegyptiaca	30.0^{c}	32.0^{a}	35.1^{a}	39.6^{a}	47.1^{a}	51.6^{a}	53.6^{a}
C. adenogonium	31.0^{b}	32.0^{a}	34.3^{a}	38.1^{a}	44.0^{a}	47.1^{a}	49.1^{a}
S. birrea	31.0^{b}	31.0^{ab}	33.5^{a}	34.6^{ab}	35.6^{b}	36.1^{b}	36.6^{b}
Z. spina-christi	32.0^{a}	32.0^{a}	34.3^{a}	38.3^{a}	45.3^{a}	50.0^{a}	52.1^{a}
Means	30.6	31.6	33.4	36.2	40.7	43.6	45.0
SEM	0.44	0.93	1.71	3.08	3.97	4.69	4.76

a, b, c, d Means with different superscripts in the same column are significantly ($P < 0.05$) different

Table 2. Organic matter degradability characteristics (%) and ME, Mj/kg DM. OM degradability characteristics

Browse species	a	b	(a+b)	c	RSD	ME
A. nilotica	0.07^{c}	1.21^{b}	0.79^{b}	0.30^{b}	0.70^{cd}	3.32^{b}
B. aegyptiaca	1.77^{a}	3.70^{a}	3.53^{a}	9.45^{a}	2.49^{a}	3.94^{a}
C. adenogonium	0.55^{b}	3.47^{a}	3.85^{a}	0.08^{b}	1.54^{bc}	3.97^{a}
S. birrea	0.95^{b}	0.50^{b}	1.58^{b}	0.08^{b}	0.48^{d}	3.13^{b}
Z. spina-christi	0.73^{b}	3.80^{a}	4.56^{a}	0.06^{b}	1.87^{ab}	3.95^{a}
Means	0.81	2.54	2.86	1.99	1.42	3.66
SEM	0.23	0.58	0.81	0.52	0.52	0.22

a, b, c, d Means with different superscripts in the same column are significantly ($P < 0.05$) different.



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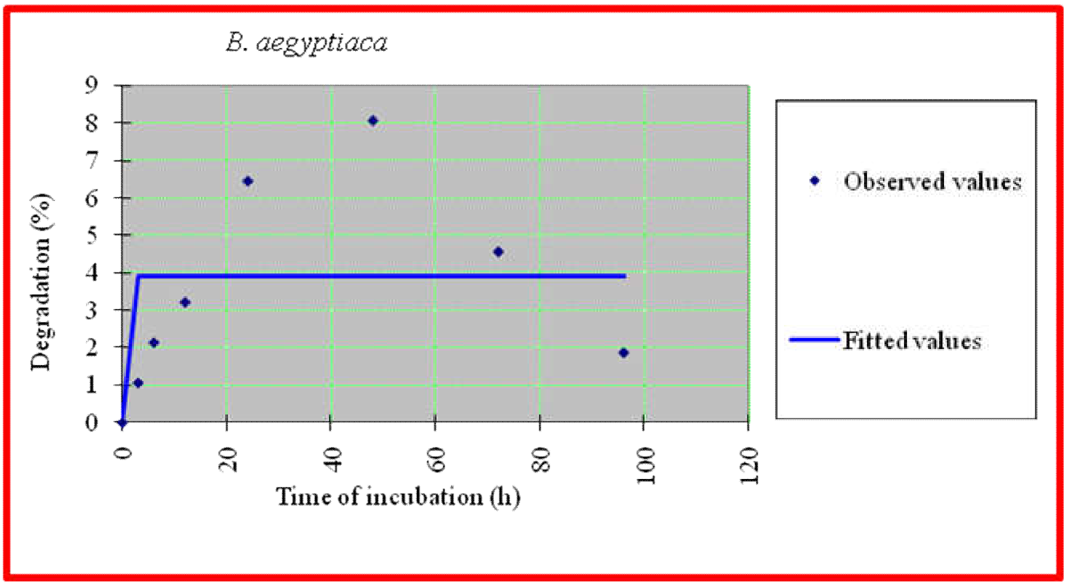

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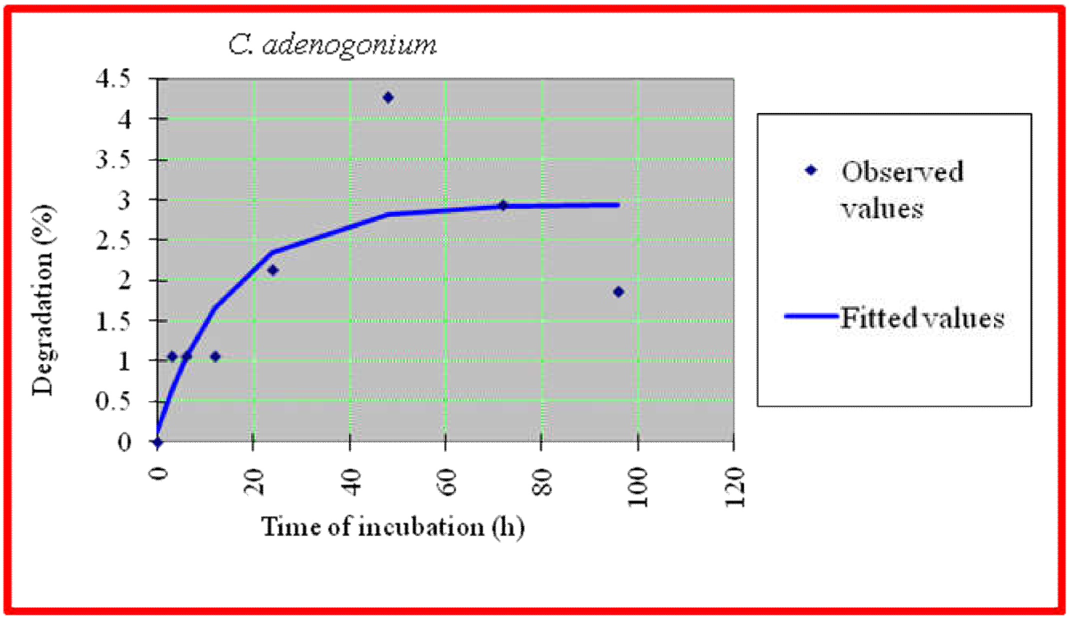

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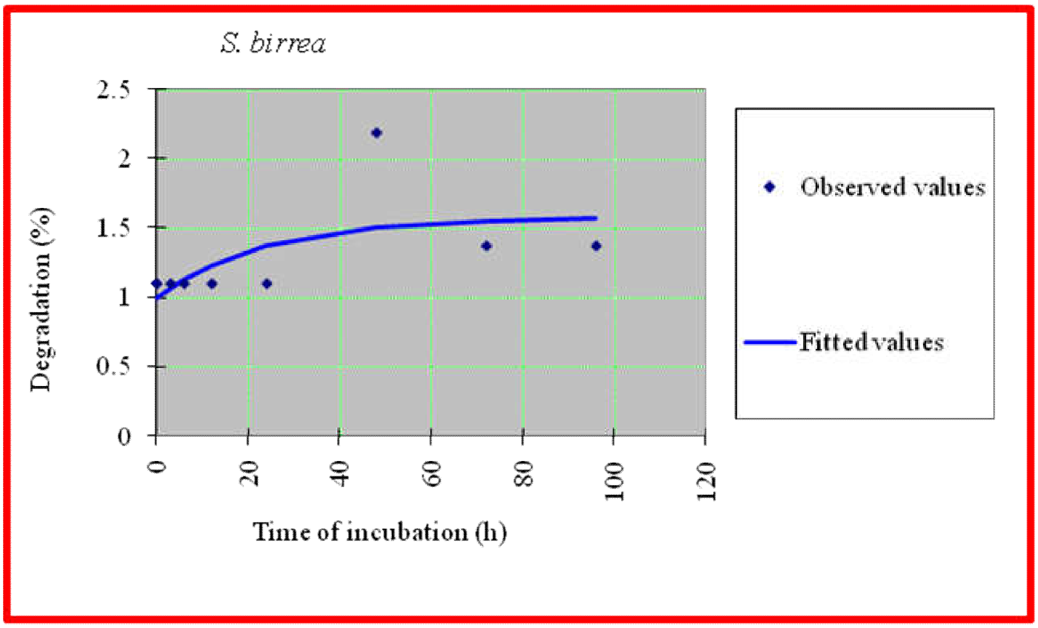

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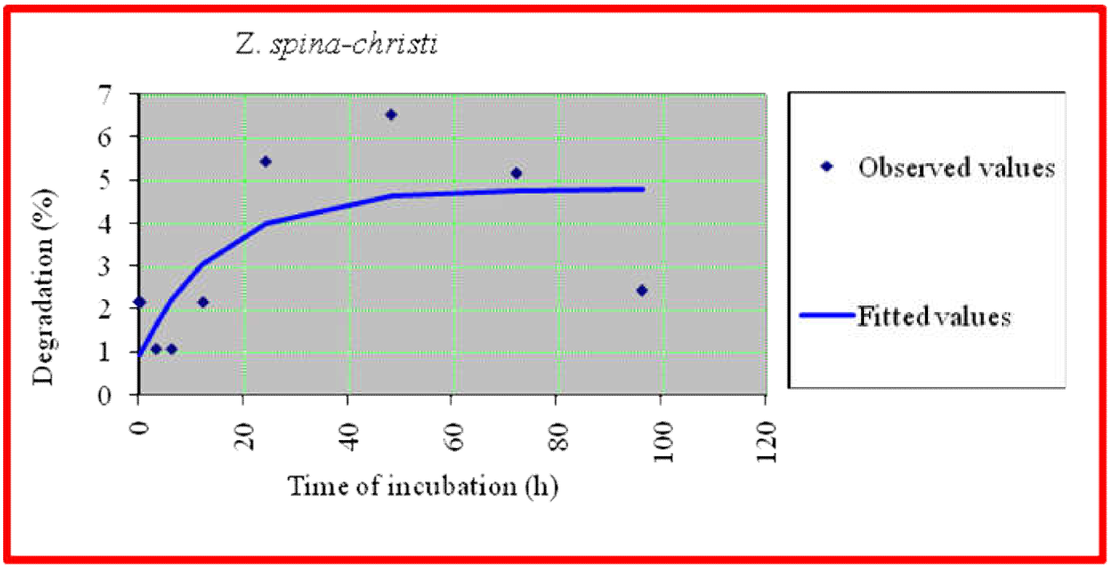

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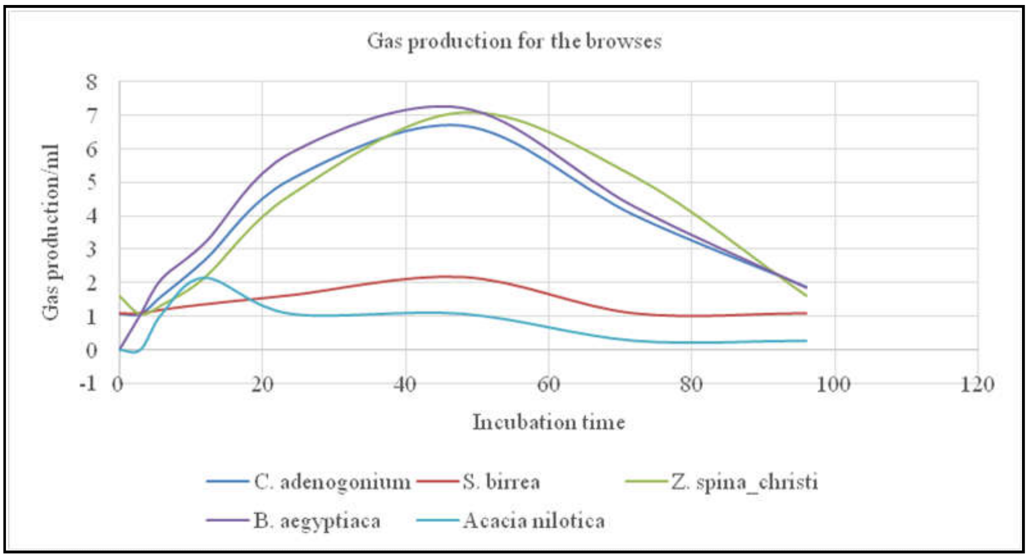

Figure 6. Combine browses degradation curve

Fibre composition, Fonseca *et al.,* (1998) and Rubanza*et al.,* (2003); and lignin content (Van soest, 1994) in the feed determine the extent and rate of feed degradability. In the current study, some browse species had high levels of NDF, ADF and ADL that could have resulted in their variations in degradability. *In vitro* gas production potential in this study indicate significant ($P < 0.05$) difference between the browses. These results are well collaborated with those reported in previous studies (Abdulrazak *et al*., 2000; Rubanza*et al*., 2003; Osuga*et al*., 2008 and Ondiek *et al*., 2010). Blummel and Fennandez-Rivera (2002) reported that gas production is due to fermentation of organic matter in the feed. Therefore, variations in gas production between different browse species could be due to the amount of substrate fermented *invitro*.

In the present study, *B. aegyptiaca*, *C. adenogonium* and *Z. spina-christi* had high gas production potential than the rest of the browse. This could be due to high organic matter in these browses. Osuga*et al*., (2008) also reported similar findings in different browse forages. The calculated metabolizable energy (ME) values are lower than those reported by Elis, (1982) on some browse species native to South Sudan rangelands. Results of this study indicate that *B. aegyptiaca*, *C. adenogonium* and *Z. spina-christi* are highly degradable and fermentable. However, the most highly degradable browses are *C. adenogonium* and *Z. spina-christi* because they have higher OM degradability characteristics. Therefore, these could serve as good supplements for ruminant livestock feeding especially during dry season when other quality forages are in short supply but crop residues and other fibrous based roughage are available.

Conclusion

Tree browse species in Central Equatoria State have the potential as feed for ruminant animals as shown by high organic matter degradability. High degradability of these browses could increase nitrogen content in the rumen and increase microbial load in the rumen that could digest more of poor quality roughages. These results recommend further work on feeding trials to guarantee the nutritive value of these browses on animal performance.

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