# Nutritive Evaluation of Some Fodder Tree Species during the Dry Season in Central Sudan

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**ABSTRACT :** The potential nutritive value was studied on leaves of seven fodder trees in Central Sudan during dry season at two distinct periods, the early dry and the late. The chemical composition, mineral concentration, *in vitro* organic matter digestibility (IVOMD), *in situ* OM or nitrogen degradability and estimated metabolizable energy showed a wide variation among fodder tree species and between different periods of the dry season. Crude protein (CP) ranged from 285 to 197 g/kg DM at early dry season, with a significant reduction in late dry season. *Ziziphus spina-christi* and *Balanites aegyptiaca* showed the least reduction in CP content. The NDF, ADF and lignin were about 200, 160 and 19 g/kg DM, respectively at the early period, and significantly increased at the late period of the dry season, except for lignin of *Z. spina-christi*. For mineral concentration, all fodder tree leaves were rich in calcium but poor in phosphorus. *In situ* OM degradability significantly decreased at the late period of dry season, but values remained as high as over 600 g/kg OM. At both periods, *Z. spina-christi* showed the highest value, while the lowest was recorded in *Acacia seyal*. The IVOMD showed a similar trend to those of *in situ* OM degradability, except for *A. seyal*. The nitrogen degradability was highest in *B. aegyptiaca* and lowest in *Z. spina-christi* at both periods. A significant and positive correlation had existed between CP and IVOMD or *in situ* OM degradability ($r=0.68$, $p<0.05$; $r=0.77$, $p<0.05$, respectively). Also, a significant but negative correlation was found between condensed tannins and nitrogen degradability ($r=-0.87$, $p<0.01$). Results demonstrated that *Z. spina-christi* potentially has a good nutritive value as dry season feed or supplement, while *A. seyal* tends to be less promising. *A. nubica* and *B. aegyptiaca* may be a useful source for degradable protein, even though it may have a limited supply of energy to animals. *A. tortilis*, *A. mellifera* and *A. ehrenbergiana* may have potential value for a supplementation of energy or protein, if they were harvested in the early dry season or in wet season as preserved feed. It is highly recommended to supplement with an appropriate amount of phosphorus when these fodder trees were used. ***(Asian-Aust. J. Anim. Sci. 2002. Vol 15, No. 6 : 844-850)***

**Key Words :** Dry Season, Fodder Tree, Nutritive Value, Ruminants

## INTRODUCTION

There are many areas in Sudan which are characterized by their dense population of livestock and one of these areas is the Butana. Animal keeping in the Butana is a major and most important source of income for the majority of the population. Over 70% of the total population are directly or indirectly engaged in livestock raising (Abu Sin, 1990).

Natural pasture and crop residues contribute about 93% of the nutrient requirements for ruminants in Sudan, which are estimated to be over 120 million heads of cattle, sheep, goats and camels (FAO, 1998). The nutritive value of pasture and range in Sudan is greatly affected by seasonal changes. Elginaid (1997) mentioned that as long as the grasses provide sufficient feed supplies during the rainy season and the beginning of dry season, utilization of the browse species is only intermittent. At the time when grazing offers animals only dry grasses at its least palatable and poor feeding value in dry season, the browse species constitute the real feed resources that are intensively utilized by livestock. This role of the browse species become more important as the dry season grows longer, lasting 5 to 11 months annually, or even longer in case of a drought.

In dry season, therefore, fodder tree leaves become an important source of nutrients for livestock in Sudan. El-Hag (1985) reported that grasses increased their levels of fibrous fractions with a high ash concentration, while decreased their levels of crude protein and total soluble sugars as the dry season progressed, which resulted in poor nutritive value for animals. Grazing sheep in a woodland Savannah pasture in Sudan has been required to provide an energy-protein supplement which sustains its productivity as the dry season progressed from the end of rainy season onward (Mohammed and Salih, 1991). Leaves of fodder trees of some species may have a potential for providing supplemental nitrogen and energy to animals in the dry season. The current knowledge, however, is still limited on the changes in nutritive value of those leaves in the dry season.

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The objective of this study was to assess the nutritive value of leaves of some fodder tree species in Sudan and to determine the effects the progress of the dry season had on their nutritive values.

## MATERIALS AND METHODS

**Study area**

The study was conducted in the Butana area of Sudan, which is located between the Blue Nile, the River Nile, the River Atbara and the border of the extensive rainfed agricultural area. The area lies on fairly flat clay soils. The annual precipitation is 400 mm and occurs only in wet season from July to October.

**Samples collection**

Mature leaves from 7 trees and shrubs species, *Acacia tortilis, A. mellifera, A. seyal, A. ehernbergina*, *A. nubica*, *Ziziphus spina-chrisiti* and *Balanites aegyptiaca* were collected during the dry season (October to June) at two distinct periods, that is, early dry (late October, 1997) and late dry (early June, 1998). Fodder tree species were selected under consideration of the feeding behavior and the preference of animals and species that were dominant and most frequently browsing.

Samples were collected by hand picking from, randomly selected, 10 individual trees of each species. The samples were taken at three heights (top, middle and bottom of the tree), polled, air dried in shaded places and stored in cloth bags for further chemical analysis.

**Sample preparation**

Samples were thoroughly mixed and ground in a hammer mill (Glen Creston, Stanmore, D.F.H. 48) to pass a 1 mm screen for chemical analysis and *in vitro* gas production, and a 2.5 mm screen for *in situ* degradation.

**Chemical analysis**

A proximate composition of leaves was determined according to the AOAC (1984); Neutral detergent fiber (NDF), acid detergent fiber (ADF), and permanganate lignin were analyzed according to Goering and Van Soest (1970). The mineral composition was determined on ash using an atomic absorption spectrophotometer (2380 Perkin Elmer) after hydrochloric acid digestion. The flame photometer (Goring, EEL 100) was used for potassium and sodium. Condensed tannins were analyzed by the method of Price et al. (1978)

***In situ* degradability**

The organic matter (OM) and nitrogen (N) degradation were determined using the nylon bag technique (Orskov et al., 1980). Nylon bags (bag size, 80 mm×140 mm; pore size, 45 μm) containing 4 g of air dried sample were incubated for 48 h in the rumen of three cannulated goats. The animals were fed sudangrass hay plus 150 g of concentrate. The concentrate was offered twice daily, half at 08:00 and the other half at 16:00. Animals had free access to water and mineral licks.

***In vitro* digestibility**

*In vitro* digestibility (Menke and Steingass, 1988) was determined according to the modified method (The Hohenheim gas test) of Aiple et al. (1992). *In vitro* gas production was also measured to estimate the metabolizable energy (ME) content in leaves of each fodder tree species.

**Statistical analysis**

Results of the chemical composition, *in situ* OM and N degradation, and *in vitro* organic matter digestibility (IVOMD) were subjected to the analysis of variance (ANOVA) as complete randomized design with periods of the dry season as the main factor using a general linear model (GLM) of SAS (1993). A simple correlation was used to establish the relationship between CP content, NDF, ADF, lignin, condensed tannins and OM, N degradation and IVOMD.

## RESULTS

The contents of OM, crude protein (CP), and condensed tannins were presented in table 1 for seven species of fodder tree leaves. The OM showed a fairly constant level of around 900 g/kg of DM among fodder tree species and between the periods of harvest, with some variation. The concentration of CP and condensed tannins showed a significant variation among fodder tree species between periods. Three species of acacia, that is, *A. tortilis*, *A. ehrenbergiana* and *A. nubica*, and *Ziziphus spina-christi* contained more than 250 g/kg DM of CP, while *A. seyal* showed the least level of 197 g/kg DM of CP at an early period of the dry season. The CP contents of other species were intermediate between them. When the dry season progressed, the CP content decreased to the level of 156 g/kg for *A. tortilis*, 165 g/kg DM for *A. seyal*, and 193 g/kg DM for *A. nubica* at the late period of the dry season. *Z. spina-christi*, however, showed the least reduction in CP content to the level of 251 g/kg DM, which was the highest CP content at the late period. *Balanites aegyptiac*a also showed a least reduction in CP content at the late period, and contained a fair amount of CP at the early period. For condensed tannins, *Z. spina-christi* contained the highest level of tannins (32 g/kg DM) at the early period, which increased to 55 g/kg DM at the late period. *B. aegyptiaca* contained the least level of condensed tannins at both periods of dry season among the 7 tree species studied. *A.*

**Table 1.** Organic matter (OM), crude protein (CP) and condensed tannis (CT) content (g/kg DM) of the fodder tree leaves at early (late October) and late dry season (early June) in Butana of central Sudan

| | OM | | | CP | | | CT | | |
|---|---|---|---|---|---|---|---|---|---|
| | Early | Late | Pe[#] | Early | Late | Pe | Early | Late | Pe |
| *A. tortilis* | 895 | 924 | ** | 257[c] | 156[a] | *** | 18[f] | 17[c] | *** |
| *A. mellifera* | 924 | 881 | ** | 218[b] | 177[b] | *** | 14[b] | 57[g] | *** |
| *A. seyal* | 921 | 891 | ** | 197[a] | 165[a] | *** | 12[c] | 30[e] | *** |
| *A. ehrenbergiana* | 923 | 931 | NS | 274[d] | 184[bc] | *** | 15[e] | 19[d] | *** |
| *A. nubica* | 919 | 901 | NS | 285[d] | 193[c] | *** | 4[b] | 13[b] | *** |
| *Z. spina-christi* | 891 | 935 | ** | 262[c] | 251[d] | ** | 32[g] | 55[f] | *** |
| *B. aegyptiaca* | 903 | 897 | NS | 215[b] | 195[c] | *** | 3[a] | 2[a] | *** |
| SEM | 3 | 2 | | 2 | 2 | | 0.1 | 0.1 | |

[a,b,c] Means in the same column with different superscripts differ (p<0.05).
[#] Period effect.
NS: Not significant; ** p<0.01; *** p<0.001.
SEM: Standard error of the mean.

*nubica* also contained a lower level of condensed tannins (4 g/kg DM) at the early period but increased to the level of 13 g/kg DM at the late period.

Changes in ether extract (EE) among fodder tree species were minimum and inconsistent, with the exception of *A. seyal* and *Z. spina-christi* which changed from about 3 to 5 g/kg DM and 1 to 4 g/kg DM respectively, with the progress of the dry season.

Fibrous fractions such as NDF, ADF and lignin were about 200, 160 and 19 g/kg DM, respectively at the early period, and significantly increased at the late period in all fodder tree species, except for the lignin of *Z. spina-christi* (table 2). The increment of NDF and ADF, however, ranged from 7 g/kg DM for Z. *spina-christi* to 101 g/kg DM for *A. tortilis*, and from 7 g/kg DM for *Z. spina-christi* to 70 g/kg DM for *A. tortilis*, respectively. *Z. spina-christi* showed no significant change in lignin with the progress of the dry season. *A. seyal* contained about the same level of NDF and ADF as *Z. spina-christi* at the early and the late period, but its lignin content increased 3 folds of *Z. spina-christi* at the late period of the dry season. The highest level of NDF and ADF were recorded in *B. aegyptiaca* at both periods of the dry season. The increment of fibrous fractions at the late period ranged from 73 g/kg DM for ADF to 80 g/kg DM for NDF in *B. aegyptiaca*.

Table 3 shows the mineral concentration of fodder tree leaves at the early and the late period of the dry season. All fodder tree leaves contained more than 12 g/kg DM of Ca at both periods of the dry season. Changes in Ca concentration with the progress of the dry season were inconsistent among fodder tree species. *A. seyal* contained about 30 to 50 g/kg DM of Ca at the late and early period of the dry season, while *Z. spina-christi* contained 12 to 15 g/kg DM at the respective period. Other species showed intermediate values between them. Phosphorus concentration was as low as 1 to 2 g/kg DM for all fodder tree leaves at both periods. The magnesium levels changed inconsistently to the progress of the dry season among tree species. A lower level of 1 to 3 g/kg DM was found in *A. seyal* and *A. ehrenbergiana*, while *A. mellifera*, *A. nubica* and *Z. spina-christi* showed a moderate level of 6 to 10 g/kg DM at both periods. Potassium concentration showed a higher level of 20 to 30

**Table 2.** Fibrous fractions content (g/kg DM) of the fodder tree leaves

| | NDF | | | ADF | | | Lignin | | |
|---|---|---|---|---|---|---|---|---|---|
| | Early | Late | Pe[#] | Early | Late | Pe | Early | Late | Pe |
| *A. tortilis* | 203[c] | 304[e] | *** | 165[c] | 235[e] | *** | 23[c] | 28[e] | *** |
| *A. mellifera* | 215[d] | 291[d] | *** | 167[c] | 222[d] | *** | 18[b] | 21[c] | *** |
| *A. seyal* | 202[c] | 228[bc] | *** | 160[bc] | 180[b] | *** | 18[b] | 49[f] | *** |
| *A. ehrenbergiana* | 191[b] | 233[c] | *** | 154[b] | 205[c] | *** | 18[b] | 25[d] | *** |
| *A. nubica* | 182[a] | 190[a] | * | 133[a] | 148[a] | *** | 24[c] | 21[c] | *** |
| *Z. spina-christi* | 214[d] | 221[bc] | * | 164[c] | 171[b] | * | 15[a] | 15[b] | NS |
| *B. aegyptiaca* | 222[d] | 302[e] | *** | 184[d] | 257[f] | *** | 24[c] | 14[a] | *** |
| SEM | 2 | 2 | | 2 | 2 | | 0.3 | 0.1 | |

[a,b,c] Means in the same column with different superscripts differ (p<0.05).
[#] Period effect.
NS: Not significant; * p<0.05, p<0.001.
SEM: Standard error of the mean.

**Table 3.** Mineral composition (g/kg DM) in fodder tree leaves

| | Ca | | | P | | | Mg | | | K | | | Na | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Early | Late | Pe$^{\#}$ | Early | Late | Pe | Early | Late | Pe | Early | Late | Pe | Early | Late | Pe |
| *A. tortilis* | $28^{e}$ | $14^{b}$ | *** | $1.8^{c}$ | $1.4^{c}$ | *** | $4.7^{c}$ | $2.6^{b}$ | *** | $32.1^{f}$ | $10.28^{a}$ | *** | $0.5^{b}$ | $0.5^{b}$ | NS |
| *A. mellifera* | $21^{c}$ | $25^{c}$ | *** | $0.8^{a}$ | $1.1^{a}$ | *** | $5.9^{e}$ | $7.1^{e}$ | *** | $15.9^{c}$ | $20.3^{b}$ | *** | $0.5^{b}$ | $0.5^{b}$ | NS |
| *A. seyal* | $49^{f}$ | $29^{d}$ | *** | $1.8^{c}$ | $1.5^{d}$ | *** | $1.3^{a}$ | $3.2^{c}$ | *** | $4.1^{a}$ | $18.2^{b}$ | *** | $0.8^{d}$ | $0.6^{c}$ | *** |
| *A. ehrenbergiana* | $25^{d}$ | $14^{b}$ | *** | $1.9^{d}$ | $1.5^{d}$ | *** | $2.3^{b}$ | $1.3^{a}$ | *** | $22.1^{d}$ | $19.9^{b}$ | *** | $0.5^{b}$ | $0.6^{c}$ | *** |
| *A. nubica* | $21^{c}$ | $32^{e}$ | *** | $1.3^{b}$ | $1.6^{e}$ | *** | $5.1^{d}$ | $10.4^{g}$ | *** | $10.3^{b}$ | $22.4^{b}$ | *** | $0.4^{a}$ | $0.5^{b}$ | *** |
| *Z. spina-christi* | $15^{b}$ | $12^{a}$ | *** | $2^{e}$ | $1.5^{d}$ | *** | $6.5^{f}$ | $7.2^{f}$ | *** | $32.2^{f}$ | 20.4 | *** | $0.6^{c}$ | $0.6^{c}$ | NS |
| *B. aegyptiaca* | $14^{a}$ | $27^{cd}$ | *** | $0.8^{a}$ | $1.3^{b}$ | *** | $5.2^{d}$ | $3.9^{d}$ | *** | $24.9^{e}$ | $20.3^{b}$ | *** | $0.4^{a}$ | $0.4^{a}$ | NS |
| SEM | 0.13 | 0.45 | | 0.006 | 0.003 | | 0.033 | 0.004 | | 0.03 | 0.11 | | 0.003 | 0.002 | |

g/kg DM for all tree species with some exceptions of *A. seyal* (4.1 g/kg DM at the early period) and *A. nubica* (10.3 g/kg DM at the early period). The concentration of sodium resulted in very low levels for all tree species, although the differences in concentration were not great among species and between the periods.

Table 4 shows the results of *in situ* OM or N degradability, *in vitro* OM digestibility (IVOMD) and estimated metabolizable energy (EME) for fodder tree leaves. The *in situ* OM degradability significantly decreased at the late period of the dry season. Yet, values remained as high as over 600 g/kg OM for all tree species at the late period. The highest value was recorded for *Z. spina-christi* at both periods. *A. mellifera* showed the second highest value of 791 g/kg OM at the early period and *A. nubica* was third. At the late period, however, *A. nubica* showed the second highest value of 681 g/kg OM. The lowest value was found in *A. seyal* at both periods. The results of IVOMD showed a similar trend to those of *in situ* OM degradability for all tree species, except for *A. seyal* which showed a significant increase at the late period. The EME ranged from 7.2 MJ/kg DM for *A. seyal* to 9.3 MJ/kg DM for *A. ehrenbergiana* at the early period and from 7.3 MJ/kg DM for *A. nubica* to 9.7 MJ/kg DM for *Z. spina-christi* at the late period. The EME significantly decreased at the late period of the dry season compared with those at the early period, except for *A. seyal* and *Z. spina-christi* which showed a significant increase at the late period.

The N degradability ranged from 419 g/kg N for *Z. spina-christi* to 621 g/kg N for *B. aegyptiaca* at the early period of the dry season and 338 g/kg N for *Z. spina-christi* to 600 g/kg N for *B. aegyptiaca* at the late period. *A. nubica* showed the second highest values at both periods. N degradability less than 400 g/kg N was found in *A. mellifera*, *A. seyal*, and *Z. spina-christi* at the late period of the dry season.

The content of CP was significantly and positively correlated with IVOMD or *in situ* OM degradability ($r=0.68$, $p<0.05$; $r=0.77$, $p<0.05$, respectively). A significant and negative correlation was found between condensed tannins and N degradability ($r=-0.87$, $p<0.01$). A significant correlation was also found between *in situ* OM degradability and IVOMD ($r=0.85$, $p<0.01$), and the following regression equation was obtained: IVOMD=2+0.82(±0.13)OM degradability; se, ±10. The increase in fibrous fractions (NDF, ADF and lignin) tended to decrease *in situ* OM degradability and IVOMD, although no significant correlation was found.

**Table 4.** *In situ* organic matter degradability (Deg OM, g/kg OM), nitrogen degradability (Deg N, g/kg N), *in vitro* organic matter digestibility (IVOMD, g/kg OM) and estimated metabolizable energy (EME, MJ/kg DM) of the fodder tree leaves

| | Deg OM | | | Deg N | | | IVOMD | | | EME | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Early | Late | Pe$^{\#}$ | Early | Late | Pe | Early | Late | Pe | Early | Late | Pe |
| *A. tortilis* | 737 | 633 | *** | 519 | 520 | NS | 575 | 504 | *** | 9.1 | 7.7 | *** |
| *A. mellifera* | 791 | 656 | *** | 489 | 354 | *** | 582 | 541 | *** | 8.8 | 7.9 | *** |
| *A. seyal* | 681 | 603 | *** | 473 | 350 | *** | 517 | 557 | *** | 7.2 | 8.0 | * |
| *A. ehrenbergiana* | 709 | 614 | *** | 448 | 442 | NS | 621 | 521 | *** | 9.3 | 7.9 | *** |
| *A. nubica* | 770 | 681 | *** | 520 | 546 | *** | 608 | 550 | *** | 8.4 | 7.3 | *** |
| *Z. spina-christi* | 881 | 819 | *** | 419 | 338 | *** | 800 | 692 | *** | 8.3 | 9.7 | *** |
| *B. aegyptiaca* | 699 | 661 | *** | 621 | 600 | *** | 574 | 575 | NS | 8.0 | 8.0 | NS |
| SEM | 2.4 | 2.4 | | 4 | 2.2 | | 2 | 2.1 | | 0.12 | 0.03 | |

$^{a,b,c}$ Means in the same column with different superscripts differ ($p<0.05$).

$^{\#}$ Period effect.

NS: Not significant; * $p<0.05$, *** $p<0.001$.

SEM: Standard error of the mean.

## DISCUSSION

Leaves of fodder tree species examined in the present study maintained a relatively constant level of OM throughout the dry season with little variation among tree species. The content of CP in leaves was comparable to those reported by Dougal et al. (1964) and Larbi et al. (1998), but was higher than the results obtained by Elginaid (1997) in which study included twigs for nutritional evaluation. This difference may have caused a lower CP concentration reported by Elginaid (1997), since twigs generally contain lower CP than leaves (Walker, 1980). The present study revealed that *Z. spina-christi* at the early period of the dry season contained a higher level of CP that decreased by a less extent at the late period. *B. aegyptiaca* showed the least reduction in CP content at the late period with a fair amount of CP at the early period. Three species of acacia, that is, *A.tortilis*, *A. ehrenbergiana*, and *A. nubica* also contained a higher level of CP at the early period of the dry season, but greatly reduced CP contents at the late period. Among the three acacia species, *A.nubica* showed a comparable level of CP to that of *B. aegyptaica* at the late period. Although the CP concentration at the late period of the dry season decreased as reported by Skarpe and Bergstrom (1986), the minimum CP content of fodder tree species at the late period was more than twice that of the grasses at the early dry season (Skarpe and Bergstrom, 1986; Mohammed and Salih, 1991). Fodder tree leaves, therefore, may provide a good source of supply of nitrogen to animals in the dry season.

The N in fodder tree leaves showed low ruminal degradability at both periods of the dry season. The fodder tree leaves contained a high level of condensed tannins at the early period of the dry season and increased at the late period. The level of condensed tannins negatively correlated with the N degradability of fodder tree leaves, which agrees with the result of Rittner and Reed (1992). A low level of N degradability may be attributed to the presence of a higher level of condensed tannins in the leaves. *Z. spina-christi*, therefore, may provide a little supply of N in the rumen for the microbial fermentation because of a higher condensed tannins level, and thus the least N degradability at the late period, even though it contained the highest level of CP. While *A. nubica* reduced its CP concentration in the leaves at the late period of the dry season, it contained a fair amount of CP and a low level of condensed tannins, and thus showed a relatively high N degradability at the late period. These facts may support a relatively higher level of OM degradability or IVOMD for *A. nubica* at the late period of the dry season. If this is the case, *Z. spina-christi* may have provided a sufficient amount of N for rumen microbes, since it showed the highest level of OM degradability or IVOMD at the late period. Even though it contained a higher level of condensed tannins and showed a lower level of N degradability, it contained the highest level of CP at the late period of the dry season. When the amount of N degraded in the rumen is calculated using the CP content and N degradability at the late period for *Z. spina-christi*, it will provide 14 g of degradable N/kg DM, which is fairly comparable to 17 g supplied by *A. nubica*. *B. aegyptiaca* also contained a comparable amount of CP content to *A. nubica*, and it contained the least level of tannin with the highest N degradability. Its leaves are calculated to provide 19 g of degradable N/kg DM at the late period of the dry season. Thus, OM degradability for *B. aegyptiaca* was comparable to that of *A. nubica*. On the other hand, *A. seyal* contained 165 g of CP/kg DM at the late period, and may have provided about 9 g of degradable N/kg DM. This may be responsible for the lowest level of OM degradability for *A. seyal* at the late period. In consideration of CP contents in the late period and an estimated supply of degradable N in the rumen, *A. tortilis*, *A. mellifera* and *A. seyal* have less potential to supply CP to the animals at the late period of the dry season in Sudan.

The ranges of NDF and ADF contents of the present study were similar to those of fodder trees reported by Abdulrazak et al. (2000), but lower than those of the twigs shown by Elginaid (1997). Generally, fibrous fractions including lignin were greater at the late period than the early period, which agrees with Walker (1980). Increase in fibrous fractions at the late period of the dry season reflected a decrease in OM degradability or IVOMD for leaves of fodder trees. An increase in NDF or ADF at the late period of dry season, therefore, may decrease the digestion of the leaves of fodder trees after the ingestion by animals as dry season progressed. As far as fibrous fractions are concerned, it may be required to find other methods for possible and alternative ways of harvesting fodder tree leaves during wet season and preserving them as a supplement during dry season.

Fodder tree leaves contained a relatively higher Ca level of over 12 g/kg DM in dry season, which well agrees with the results obtained by Abdulrazak et al. (2000) and Aganga et al. (2000). The leaves of fodder trees examined in the present study exceeded the recommended level of calcium for lactating ewes (11 g/kg DM) suggested by NRC (1985), at both periods of the dry season. Therefore, the 7 fodder tree species may provide a good source of Ca supply even in the dry season. The concentration of phosphorus, however, was extremely low in the leaves of fodder trees studied, compared to the critical level (7.7 g P/kg DM) suggested by NRC for lactating ewes. Similarly, Mtimuni (1982) and Elginaid (1997) reported far lower values in grasses and crop residues. This extremely low level of phosphorus resulted in such a higher ratio of Ca:P as reported by Abdulrazak et al. (2000). The higher ratio of

Ca:P may interfere with an efficient utilization of Ca by animals, even though the leaves contained an appropriate level of Ca.

As for potassium and sodium, the concentration of those minerals showed the characteristics of a plant, that is, high in K and low in Na. The level of magnesium for fodder tree leaves may provide a moderate source of this mineral.

The EME of fodder tree leaves was generally higher at the early period than the late period in the dry season, which agrees with the results of Walker (1980). The level of EME for fodder tree leaves satisfied the recommendation level for the maintenance of ewes (8.4 MJ/kg DM) presented by NRC (1985) in the early period, except for *A. seyal*, *Z. spina-christi*, and *B. aegyptiaca*. While all fodder tree species failed to satisfy the recommended level of NRC (1985), the *Z.spina-christi* passed which may be attributed to a high increase in EE, in the late period. As *Z. spina-christi* in the early period showed a slightly less EME than the recommended level, it may also be useful for an energy source in the dry period. On the other hand, *A. tortilis*, *A. mellifera* and *A. ehrenbergiana* all contained EME well above the NRCs recommended level at the early period of the dry season, but they decreased to a value lower than the recommended level at the late period. Similarly, *A. nubica* showed the same level as the recommended value at the early period, but it decreased its value far below the recommended level at the late period. *A. seyal* contained less EME than the recommended level at both periods.

Considering the results of the present study, *Z. spina-christi* potentially has a good nutritive value for dry season feed or supplement, while *A. seyal* tends to be less promising as a potential feed for dry season. *A. nubica* and *B. aegyptiaca* may be a useful source of CP supplement providing degradable N for rumen microbes, even though they may have a limited supply of energy to animals. *A. tortilis*, *A. mellifera* and *A. ehrenbergiana* may have potential value for a supplementation of energy or protein, if they were harvested at the early period of the dry season or in the wet season for preserved feed. It is strongly recommended to supplement using an appropriate amount of phosphorus, when fodder tree leaves described above are used as a diet or a supplementary feed for animals in the dry season.

All of the indigenous browse in Sudan examined in the present study, however, may provide a considerable part of animals' demand for energy, protein and macro-minerals to overcome the negative impact of the dry season, except for phosphorus.

Further study is needed to determine a possible way to harvest and to preserve fodder tree leaves at the early period or in the wet season, and to evaluate the availability of browse as a supplementary feed for dry grasses and crop residues.

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## REFERENCES

Abdulrazak, S. A., T. Fujihara, J. K. Ondiek and R. E. Ørskov. 2000. Nutritive evaluation of some Acacia tree leaves from Kenya. Anim. Feed Sci. Technol. 85:89-98.

Abu Sin, M. E. 1990. Literature survey. Baseline information and a profile of Central Butana. UNDP, Areas Development Program, Khartoum, Sudan.

Aganga, A. A., T. Adogla-Bessa, U. J. Omphile and K. Tshireletso. 2000. Significance of browse in the nutrition of Tswana goats. Arch. Zootec. 49:469-480.

Aiple, K. P., H. Steingass and K. H. Menke. 1992. Suitability of a buffered fecal suspension as the inoculum in the Hohenheim gas test. J. Physiol. Anim. Nutr. 67:57-66.

AOAC. 1984. Association of Official Analytical Chemists. Official Methods of Analysis. Washington, DC.

Dougal, H. W., V. M. Drysdale and P. E. Golver. 1964. The chemical composition of Kenya browse and pasture herbage. E. Afr. Wildl. J. 2:86-121.

Elginaid, E. M. 1997. Feeding potential of important natural pastures and crop residues in Butana, Estern Sudan. Ph. D. Dissertation. University of Goethingen. Germany.

El-Hag, M. G. 1985. Animal Feed Resources in the Sudan, Potential, Supply and Problems, a paper presented at a Workshop on, Livestock Policy, Range and Feed Utilization Guideline for Drought-prone, African countries. Khartoum, Sudan.

FAO. 1998. Statistical database. Internet.

Goering, H. K. and P. J. Van Soest. 1970. Forage fiber analysis (Apparatus, Reagent, Procedures and some Application). Agricultural HandBook No. 379. Agricultural Research Service. USDA, Washington, DC.

Larbi, A., J. W. Smith, I. O. Kurdi, I. O. Adekunle, M. J. Raji and D. O. Ladipo. 1998. Chemical composition, rumen degradation and gas production characteristics of some multipurpose fodder trees and shrubs during wet and dry seasons in the humid tropics. Anim. Feed Sci. Technol. 72:81-96.

Menke, K. H. and H. Steingass.1988. Estimation of the energetic feed value obtained from chemical analysis and in vitro gas production using ruminant fluid. Anim Res. Dev. 28:7-55.

Mohammed, T. A. and F. E. Salih. 1991. Effects of stage of maturity on the nutritive value of low rain woodland Savannah pasture. Sudan J. Anim. Prod. 4(1):23-36.

Mtimuni, J. P. 1982. Identification of mineral deficiencies in soil, plant and animal tissues as constraints to cattle production in Malawi. Ph. D. Dissertation. University of Florida, Gainesville. Florida.

NRC. 1985. National Research Council. Nutrient Requirements of Sheep (6th Ed.). National Academy Press. Washington, DC.

Ørskov, E. R., F. D. Hovell and F. Mould. 1980. The use of nylon bag technique for the evaluation of feedstuff. Trop. Anim. Prod. 5:195-213.

Price, M. L., V. S. Scoyoc and L. G. A. Butler. 1978. A critical evaluation for the vanillin reaction as an assay for tannins in sorghum grain. J. Agric. Food Chem. 26:1214-1218.

Rittner, U. and J. D. Reed. 1992. Phenolics and *in vitro* degradability of protein and fiber in West African browse. J. Sci. Food Agric. 58:21-28.

SAS. 1993. User’s guide. 6th Ed., SAS Inc. Cary NC.

Skarpe, C. and R. Bergstrom. 1986. Nutrient content and digestibility of forage plants in relation to plant phenology and rainfall in the Kalahari, Botswana. J. Arid Environ. 11:147-164.

Walker, B. H. 1980. A review of browse and its role in livestock production in Southern Africa. In: Browse in Africa. (Ed. H. N. Le Houerou). The Current State of Knowledge. Addis Ababa, Ethiopia. ILCA. p. 355.

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