Effect of species within season on techniques used to measure nutritive value and anti-nutritional factors in browse tree leaves

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Abstract: Eight trees leave foliages (*Acacia nilotica, Acacia karroo, Acacia tortilis, Acacia rhemniana, Acacia galpinii, Acacia sieberiana, Acacia hebeclada* and *Dichrostachys cineria*) were collected in winter, summer and spring to determine crude protein, acid and neutral detergent fibre, packed volume, total phenolics, radial diffusion, extracted condensed tannins, hydrolysable tannins and condensed tannins in acid and neutral detergent fibre content. The experimental design was completely randomized design. From this study all species expect *A. galpinii* and *A. rhemniana* in summer and spring and species *A. sieberiana* and *A. hebeclada* in winter were expected to have high intake, due to low packed volume. Species *A. sieberiana*, *A. hebeclada* and *D. cineria* in all seasons have high crude protein contents than the other species. Species *A. hebeclada* and *A. sieberiana* had low levels of total phenolics and extracted condensed tannins in all seasons. During ranking analysis, species *A. sieberiana* and *A. hebeclada* in all seasons have high crude protein content, low packed volume, and low anti-nutritional factors as compared to *A. rhemniana*. The level of nutritive value and anti-nutritional factors for other species varies among seasonal changes. This result implies that there were effects of species within season on nutritive value and anti-nutritional factors of browse tree leaves. These suggest a need for a detailed study on effects of season on nutritive value and anti-nutritional factors over a number of years.
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1. Introduction

Tree fodders are important in providing nutrients to grazing ruminants in arid and semi-arid environments where inadequate feeds are major constraint for livestock production. Tree fodders maintain higher protein and mineral contents during growth than do grasses, which decline rapidly in quality with progress to maturity (Aganga and Tshwenyane 2003). Tree fodders are important sources of high quality feed for grazing ruminants and as supplements to improve the productivity of herbivores fed on low quality feed. Leguminous trees and shrubs often have thorns, fibrous foliage and growth habits which protect the crown of the tree from defoliation.

Secondary chemical compounds exist in a wide variety of plant species. Bate – Smith and Metcalf (1957) have reported that 80% of woody perennial dicots and 15% of annual and herbaceous perennial dicots contains tannins. Secondary chemical compounds especially tannins play a very important role in affecting forage preference and quality. It has been speculated that they are an ecologically developed defence mechanism. Tannins are polyphenols with high molecular weight which can bind to both proteins and carbohydrates. Their binding ability varies according to their chemical structures. They are classed into two major categories, the hydrolysable and condensed tannins. Hydrolysable tannins are esters of glucose and phenolics acids, while condensed tannins are polymers of condensed flavan - 3- ols units (Burritt et al. 1987). Although hydrolysable and condensed tannins are structurally different, both tannins are capable of forming strong complexes with certain types of proteins (Hagerman and Klucher, 1986). However, the effect of condensed tannins in binding affinity is far more pronounced. The reason of secondary compounds in plants seems to be as a way of storing nutrient or as a means of defending their structure and reproductive elements (Harborne 1989). These compounds influence the behavior, growth, or survival of herbivores. These chemical defenses can act as repellents or toxins to herbivores, or reduce plant digestibility through seasons. Other defensive strategies used by plants include escaping or avoiding herbivores in time or in place, for example by growing in a location where plants are not easily found or accessed by herbivores, or by changing seasonal growth patterns.

In fact, plants contain thousands of compounds which, depending upon their situations, can have beneficial or deleterious effect on organisms consuming them. They diminish animal productivity but may also cause toxicity during periods of scarcity or confinement when the feed rich in these substances is consumed by animals in large quantities. Seasonal changes could affect the nutritive value and anti-nutritional factors of browse. Therefore, the main aim of this paper was to compare species within season on techniques used to measure nutritive value and tannins activity on browse tree leaves.

2. Material and Methods

The young leaves from eight tree foliages (*Acacia nilotica*, *Acacia karroo*, *Acacia tortilis*, *Acacia rhemniana,* *Acacia galpinii*, *Acacia sieberiana*, *Acacia hebeclada* and *Dichrostachys cineria*) were collected in three seasons (summer, winter and spring). After collection, the young leaves were let to dry at room temperature in a well-ventilated laboratory until a constant dry weight was reached, and then stored in brown paper bags pending grinding. Dry herbage was ground to pass through a 1 mm (millimeter) screen for analysis of crude protein, neutral and acid detergent fibre and packed volume. Samples for polyphenolic analysis were further ground to pass through a 0.2mm (millimeter) screen.

The nitrogen contents of the feed were determined using the methods of the AOAC (1998). The acid detergent fibre (ADF) and neutral detergent fibre (NDF) of the leaf sample was measured by the method of Van Soest et al. (1991). Packed volume was determined using a slight modification of the method described by Seoane et al.(1981).Total phenolics were determined using the Folin-Ciocalteau method and expressed as tannic acid equivalent (g/kg DM) (Waterman and Mole 1994). Condensed tannin was determined using Butanol-HCl method and expressed as leucocyanidin equivalent (g/kg DM) (Porter et al. 1986). Total condensed tannin in neutral and acid detergent fibre was also determined (Makkar and Singh 1991). Hydrolysable tannin was determined using potassium iodate (Willis and Allen 1998). Radial diffusion assay was determined using bovine serum albumin and agarose (Hagerman 1987).

Statistical analysis was done separately for each season using a one-way analysis of variance, with species as the source of variation for a general linear model procedure (SAS 2003). Ranking analysis was used to compare the eight types of foliage species using packed volume, neutral detergent fibre, crude protein, total phenolics, extracted condensed tannins and radial diffusion within each season (summer, winter and spring). Ranks were assigned based on the species means of each trait, with the value of one assigned to species adjudged best in a given trait on the basis of the effect on that trait on nutritive value and anti-nutritional factors and eight given to the worst. These ranking were then summed within species per season and the sums used to give overall ranking for each species per season.

3. Results

There were signification species effects ($p < 0.05$) on nutritive value and anti-nutritional factors in summer (Table 1). Species *A. hebeclada* had the highest crude protein content of 104.11 percentage point more than values for species *A. karroo*. *A. galpinii* had the highest neutral detergent fibre as compared to species *A. nilotica*. Species *A. hebeclada* and *A. sieberiana* had the lowest acid detergent fibre content as compared to species *A. karoo*. Packed volume, total phenolics, extracted condensed tannins in acid and neutral detergent fibre and radial diffusion was low in *A. sieberiana* and *A. hebeclada* (Table 1).

There were significant species effects ($P < 0.05$) on nutritive value and anti-nutritional factors in winter (Table 2). Crude protein content differed by 73.82 percentage points between species *A. hebeclada* (being highest) and species *A. karroo* (being lowest). Neutral detergent fibre content differed by 83.85 percentage points between species *A. tortilis* (being highest) and species *A. nilotica* (being lowest) (Table 2). Species *A. hebeclada* and *A. sieberiana* had the lowest acid detergent fibre content as compared to species *A. karroo*. Packed volume, total phenolics, extracted condensed tannins, condensed tannins in acid and neutral detergent fibre and radial diffusion was low in *A. sieberiana* and *A. hebeclada*.

There were significant species effects ($P < 0.05$) on nutritive value and anti-nutritional factors in spring (Table 3). Crude protein contents differed by approximately 99.23 percentage points respectively between species *A. sieberiana* (being highest) and species *A. rhemniana* (being lowest). Species *A. hebeclada* had the highest neutral detergent fibre content as compared to species *A. nilotica* (Table 3). Species *A. karroo* had the highest acid detergent fibre as compared to species *A. hebeclada*. Packed volume, total phenolics, extracted condensed tannins, condensed tannins in acid and neutral detergent fibre and radial diffusion was low in *A. sieberiana* and *A. hebeclada*.

The ranking consistently shows *A. hebeclada* and *A. sieberiana* to have better nutritive indices in all seasons for all traits except NDF (Table 4 to 6) and consequently rank high overall (Table 7). However, species *A. rhemniana* shows to have poor nutritive value in all season and rank low overall (Table 4 to 7). Species *A. karroo*, *A. nilotica* and *A. galpinii* rankings are variable across seasons and across traits within a season indicating potential for manipulation to increase feeding value.

Table 1 Mean (± s.e) nutritive value and anti-nutritional factors of acacia species in summer

SPECIES	CP %DM	NDF % DM	ADF % DM	PKD ml/g	TP % DM	EXCT % DM	NDFCT % DM	ADFCT % DM	RD cm^2
AK	11.08^{e}	50.59^{b}	46.42^{a}	2.38^{cd}	46.54^{b}	41.46^{b}	22.46^{d}	22.36^{c}	147.31^{b}
AN	14.65^{d}	35.30^{c}	31.11^{de}	2.34^{cd}	56.70^{a}	32.32^{c}	34.20^{c}	17.49^{d}	123.02^{c}
AT	17.35^{bc}	67.51^{a}	28.58^{e}	2.80^{b}	27.61^{c}	22.52^{d}	42.46^{ab}	22.82^{c}	130.47^{c}
AG	18.58^{b}	67.72^{a}	36.73^{bc}	3.30^{a}	47.45^{b}	22.72^{d}	41.87^{ab}	27.81^{b}	193.23^{a}
AS	22.51^{a}	51.28^{b}	16.52^{f}	2.10^{d}	1.63^{d}	1.68^{e}	17.57^{e}	16.36^{d}	5.15^{d}
AH	22.62^{a}	37.86^{c}	14.51^{f}	2.10^{d}	0.58^{d}	1.56^{e}	13.89^{f}	7.83^{e}	0^{d}
AR	15.06^{cd}	59.58^{ab}	33.14^{cd}	3.20^{a}	45.73^{b}	55.72^{a}	39.88^{b}	32.33^{a}	131.68^{c}
DC	18.85^{b}	64.94^{a}	38.91^{b}	2.52^{bc}	42.62^{b}	24.68^{d}	44.55^{a}	26.37^{b}	133.51^{bc}
s.e	0.702	4.072	1.554	0.115	1.804	0.815	0.999	0.919	4.873

[a, b, c, d, e, f] Column means with common superscripts do not differ (P > 0.05)
AK = *Acacia karroo*, AN = *Acacia nilotica*, AT = *Acacia tortilis*, AG = *Acacia galpinii*, AS = *Acacia sieberiana*, AH = *Acacia hebeclada*, AR = *Acacia rhemniana* and DC = *Dichrostachys cineria*.
CP = Crude protein, NDF = Neutral detergent fibre, ADF = Acid detergent fibre, PKD = Packed volume, TP = Total phenolics, EXCT = Extracted condensed tannins, RD = Radial diffusion, NDFCT = Condensed tannins in neutral detergent fibre and ADFCT = Condensed tannins in acid detergent fibre.

Table 2 Mean (± s.e) nutritive value and anti-nutritional factors of acacia species in winter

SPECIES	CP %DM	NDF % DM	ADF % DM	PKD ml/g	TP % DM	EXCT % DM	NDFCT % DM	ADFCT % DM	RD cm^2
AK	13.19^{f}	52.43^{c}	50.76^{a}	3.30^{c}	75.47^{b}	63.12^{d}	33.14^{d}	25.76^{d}	261.16^{b}
AN	15.10^{e}	33.43^{d}	31.94^{bc}	3.30^{c}	74.78^{bc}	66.54^{c}	49.31^{b}	37.32^{a}	302.84^{a}
AT	17.81^{cd}	61.47^{a}	27.86^{c}	3.52^{c}	72.65^{c}	51.76^{e}	48.58^{b}	36.52^{a}	227.44^{d}
AG	16.38^{de}	60.57^{a}	32.32^{bc}	4.50^{a}	73.40^{bc}	74.76^{b}	55.11^{a}	37.49^{a}	226.44^{d}
AS	19.60^{b}	56.84^{b}	17.36^{d}	2.44^{d}	2.44^{e}	3.64^{f}	24.91^{e}	20.20^{c}	8.65^{e}
AH	22.93^{a}	56.19^{b}	14.54^{d}	2.52^{d}	1.48^{e}	2.37^{f}	25.45^{e}	12.46^{e}	0^{e}
AR	15.39^{e}	60.59^{a}	30.71^{c}	4.08^{b}	82.64^{a}	84.76^{a}	42.54^{c}	33.46^{b}	229.84^{cd}
DC	19.21^{bc}	53.37^{c}	35.89^{b}	4.00^{b}	67.46^{d}	51.14^{e}	55.44^{a}	36.30^{a}	239.29^{c}
s.e	0.523	0.138	1.707	0.134	0.758	0.775	1.011	0.718	4.017

[a, b, c, d, e, f, g] Column means with common superscripts do not differ (P > 0.05)
AK = *Acacia karroo*, AN = *Acacia nilotica*, AT = *Acacia tortilis*, AG = *Acacia galpinii*, AS = *Acacia sieberiana*, AH = *Acacia hebeclada*, AR = *Acacia rhemniana* and DC = *Dichrostachys cineria*.
CP = Crude protein, NDF = Neutral detergent fibre, ADF = Acid detergent fibre, PKD = Packed volume, TP = Total phenolics, EXCT = Extracted condensed tannins, RD = Radial diffusion, NDFCT = Condensed tannins in neutral detergent fibre and ADFCT = Condensed tannins in acid detergent fibre.

Table 3 Mean (± s.e) nutritive value and anti-nutritional factors of acacia species in spring

SPECIES	CP %DM	NDF % DM	ADF % DM	PKD ml/g	TP % DM	EXCT % DM	NDFCT % DM	ADFCT % DM	RD cm^2
AK	13.27^{e}	44.38^{de}	48.11^{a}	2.44^{c}	36.71^{c}	24.50^{d}	25.99^{c}	24.77^{ab}	152.29^{b}
AN	15.35^{d}	41.81^{e}	30.46^{b}	2.48^{c}	58.31^{a}	55.50^{a}	37.69^{b}	18.99^{c}	171.12^{ab}
AT	17.84^{c}	59.67^{b}	30.12^{c}	2.32^{c}	37.68^{c}	36.42^{c}	34.88^{b}	24.58^{ab}	176.89^{a}
AG	11.96^{e}	54.05^{bc}	34.54^{b}	3.92^{a}	56.79^{a}	36.48^{c}	43.23^{a}	25.79^{ab}	58.82^{c}
AS	23.36^{a}	57.19^{b}	12.42^{d}	2.60^{c}	1.66^{d}	1.58^{e}	16.40^{d}	12.65^{d}	6.34^{d}
AH	20.88^{b}	67.37^{a}	15.81^{d}	2.18^{c}	0.95^{d}	1.32^{e}	12.61^{d}	8.57^{e}	0^{d}
AR	11.72^{e}	60.37^{ab}	44.12^{b}	3.40^{b}	55.76^{a}	49.25^{b}	33.87^{b}	26.76^{a}	152.78^{b}
DC	18.65^{c}	49.39^{cd}	41.77^{b}	2.44^{c}	48.36^{b}	34.71^{c}	37.11^{b}	23.81^{b}	152.29^{b}
s.e	0.599	1.755	1.306	0.158	0.964	1.239	1.374	0.814	6.546

a, b, c, d, e, f, g Column means with common superscripts do not differ (P > 0.05)

A K = *Acacia karroo*, AN = *Acacia nilotica*, AT = *Acacia tortilis*, AG = *Acacia galpinii*, AS = *Acacia sieberiana*, AH = *Acacia hebeclada*, AR = *Acacia rhemniana* and DC = *Dichrostachys cineria*.

CP = Crude protein, NDF = Neutral detergent fibre, ADF = Acid detergent fibre, PKD = Packed volume, TP = Total phenolics, EXCT = Extracted condensed tannins, RD = Radial diffusion, NDFCT = Condensed tannins in neutral detergent fibre and ADFCT = Condensed tannins in acid detergent fibre.

Table 4 Rankings of species in summer based on selected traits

	Species							
Traits	AK	AN	AT	AG	AS	AH	AR	DC
CP	8	6	5	3	1	1	6	3
NDF	3	1	5	5	3	1	5	5
PKD	3	3	6	7	1	1	7	5
TP	4	8	3	4	1	1	4	4
EXCT	7	6	3	3	1	1	8	3
RD	6	3	3	8	1	1	3	7
TOTAL	31	27	25	30	9	6	33	27
AVERAGE RANK	7	4	3	6	2	1	8	4

CP = Crude protein, NDF = Neutral detergent fibre, PKD = Packed volume, TP = Total phenolics, EXCT = Extracted condensed tannins and RD = Radial diffusion.

AK = *Acacia karroo*, AN = *Acacia nilotica*, AT = *Acacia tortilis*, AG = *Acacia galpinii*, AS = *Acacia sieberiana*, AH = *Acacia hebeclada*, AR = *Acacia rhemniana* and DC = *Dichrostachys cineria*.

Table 5 Rankings of species in winter based on selected traits

	Species							
Traits	AK	AN	AT	AG	AS	AH	AR	DC
CP	8	6	4	5	2	1	6	2
NDF	2	1	6	6	4	4	6	2
PKD	3	3	3	8	1	1	6	6
TP	7	5	4	5	1	1	8	3
EXCT	5	6	3	7	1	1	8	3
RD	7	8	3	3	1	1	5	6
TOTAL	32	29	23	34	10	9	39	22
AVERAGE RANK	6	5	4	7	2	1	8	3

CP = Crude protein, NDF = Neutral detergent fibre, PKD = Packed volume, TP = Total phenolics, EXCT = Extracted condensed tannins and RD = Radial diffusion. AK = *Acacia karroo*, AN = *Acacia nilotica*, AT = *Acacia tortilis*, AG = *Acacia galpinii*, AS = *Acacia sieberiana*, AH = *Acacia hebeclada*, AR = *Acacia rhemniana* and DC = *Dichrostachys cineria*.

Table 6 Rankings of species in spring based on selected traits

	Species							
Traits	AK	AN	AT	AG	AS	AH	AR	DC
CP	6	5	3	6	1	2	6	3
NDF	2	1	5	4	5	8	7	3
PKD	1	1	1	8	1	1	7	1
TP	3	6	3	6	1	1	6	5
EXCT	3	8	4	4	1	1	7	4
RD	4	7	8	3	1	1	4	4
TOTAL	19	28	24	31	10	14	37	20
AVERAGE RANK	3	6	5	7	1	2	8	4

CP = Crude protein, NDF = Neutral detergent fibre, PKD = Packed volume, TP = Total phenolics, EXCT = Extracted condensed tannins and RD = Radial diffusion.
AK = *Acacia karroo*, AN = *Acacia nilotica*, AT = *Acacia tortilis*, AG = *Acacia galpinii*, AS = *Acacia sieberiana*, AH = *Acacia hebeclada*, AR = *Acacia rhemniana* and DC = *Dichrostachys cineria*.

Table 7 Overall ranking of species within each season

	Summer	Winter	Spring
AK	7	6	3
AN	4	5	6
AT	3	4	5
AG	6	7	7
AS	2	2	1
AH	1	1	2
AR	8	8	8
DC	4	3	4

AK = *Acacia karroo*, AN = *Acacia nilotica*, AT = *Acacia tortilis*, AG = *Acacia galpinii*, AS = *Acacia sieberiana*, AH = *Acacia hebeclada*, AR = *Acacia rhemniana* and DC = *Dichrostachys cineria*.

For hydrolysable tannin assays using potassium iodate, all species had a flat peak in all seasons except *A. nilotica* which showed significant quantities in all seasons (Figure 1).

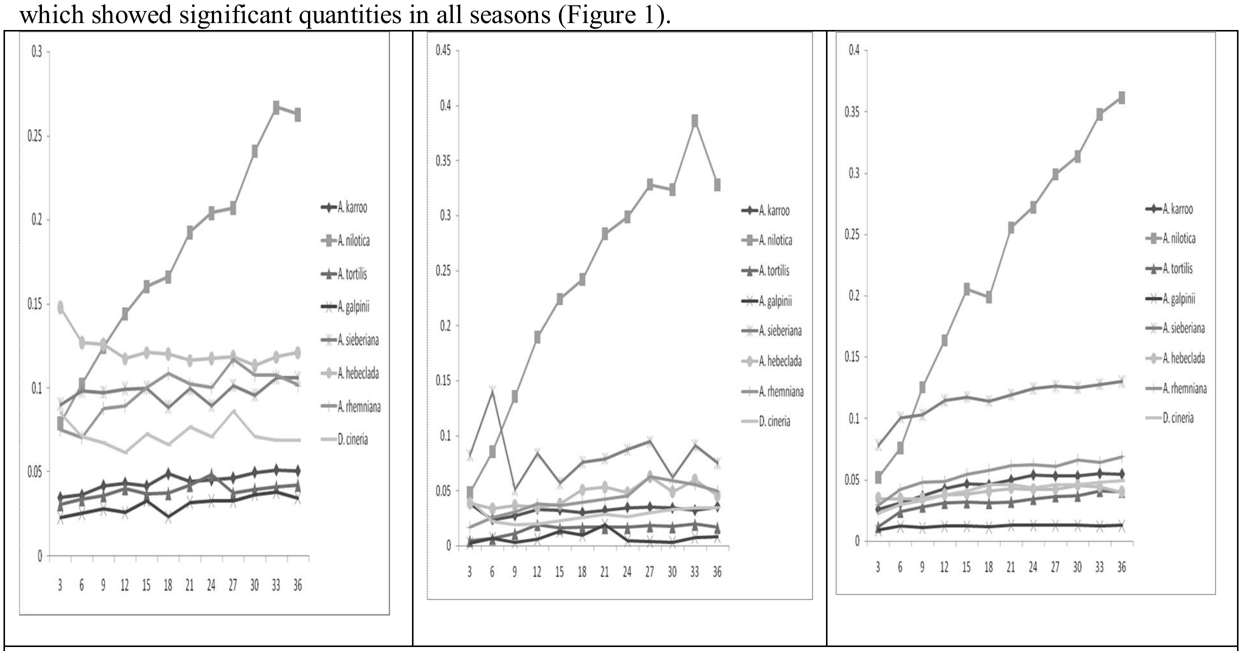

Figure 1 Hydrolysable tannins using potassium iodate in winter, summer and spring for foliage species

4. **Discussion**

The physical and chemical characteristics of browse growing in tropical regions have received limited attention in literature. Seasonal changes could affect the nutritive value of browse. In this experiment preliminary data were collected over a 12 months period and because of lack of replication analysis was done within season and seasons were not compared among themselves.

Physical methods gave new information about the nutritive value of feedstuffs for ruminants and they can be used to differentiate between feedstuffs (Giger-Riverdin 2000). Physical characteristics like packed volume influence the bulk effect of the feeds. It has been postulated that legume species with packed volume of less than 2.98 ml/g will have a high intake (Seoane et al. 1981). From this study all species except *A. galpinii* and *A. rhemniana* in summer and spring are expected to have high intake. In winter only species *A. sieberiana* and *A. hebeclada* are expected to have high intake.

Feeds containing less than 80 g/kg DM crude protein are considered deficient as they cannot provide the minimum ammonia levels required (Norton 1994). Species *A. sieberiana*, *A. hebeclada* and *D. cineria* in all seasons have high crude protein contents than the other species. However all forage tree legumes studied in this experiment had crude protein contents higher than 80 g/kg DM, and may be judged adequate in protein. The high crude protein content in these acacia species were comparable to those reported by Abdulrazak et al. (2000) and Rubanza et al. (2003).

Species *A. hebeclada* and *A. sieberiana* in season's summer and winter have low acid detergent fibre as compared to species *A. karroo* and *D. cineria* in the same seasons. The low acid and neutral detergent fibre contents of *A. hebeclada*, *A. sieberiana* and *A. nilotica* leaves were comparable to those reported by Rubunza et al. (2003) and Rubunza et al. (2005). Low neutral and acid detergent fibre values in acacias species could be associated with high digestibility, although the neutral detergent soluble might also represent neutral detergent polyphenolics.

Phenolics compounds are the major group of secondary compounds in plants (Lowry et al. 1996). These include the polyphenols that are found in nearly every species of higher plants (Deshpande et al. 1986). In our study *A. hebeclada* and *A. sieberiana* had low levels of total phenolics in all seasons, compared to other acacia species.

Analysis of condensed tannins in leaf samples of different browse trees indicated significant differences in concentrations between species. The ideal condensed tannin concentration for ruminant animal nutrition has been suggested to be in the range of 20 to 40 g/kg DM based on butanol – Hcl method (Barry and Duncan, 1984). Species *A. sieberiana* and *A. hebeclada* had low content of extracted condensed in all seasons, thus considered to be nutritionally safe (Barry and Manley 1986; Reed 1995). These two species may results in improved animal performance. Condensed tannins of *A. rhemniana* will result in decreased growth rate and body weight gain, inhibition of digestive enzymes (Yan and Bennick 1995; Wood and Plumb 1995). The average levels of extracted condensed tannins reported here were also comparable to those found in many tropical trees (Lowry et al. 1996; Sotohy et al. 1997; Getachew et al. 2000). The lowest concentration of condensed tannins was recorded in summer and spring as compared to winter which followed a characteristics pattern that was similar for all species observed by Akkari et al. (2008). Nastis and Malechek (1981) also reported a decrease in tannin content from June to August by 20 %.

Our results are in agreement with findings of Reed (1986) testing east African browse species and Burritti et al. (1987) testing woody species. The observed pattern of seasonal variation in levels of condensed tannins was due to the influence of leaf maturation, i.e. levels of condensed tannins reaching a peak as the leaves mature and then starting to decline thereafter. Most of the plants had their youngest leaves between spring and summer, explaining why condensed tannins concentrations during this period were at their lowest. A similar trade-off between leaf growth and accumulation of phenolics has been reported by Riipi et al. (2002) who observed a rapid decline in the soluble condensed tannin of leaves after an initial increase in young leaves during spring. Environmental or climatic stress e.g disease, predators and drought is an important factors contributing to temporal and seasonal changes in levels of polyphenolics in plants. Levels are known to increase under these conditions (Aerts et al. 1999).

The study showed that more CTs exist in bound form in NDF compared to ADF and that NDF represents not only hemicelluloses, cellulose, lignin and silica fractions but also proanthocyanidins in the leaves of tree species. Moreover, the presence of CT in the fibre fractions as high levels may affect their digestion kinetic parameters and confound the relationship between measurements and fibre composition (Makkar and Singh 1991).

Willis and Allen (1998) suggested and improved protocol for the determination of gallo- and ellgitannins, which yield a pink reaction product with the potassium iodate. However, in our laboratory, all species yielded a brown rather than pink reaction product with potassium iodate reagent in all seasons. All species had very flat peak, similar to those obtained for hemlock by Willis and Allen (1998). This was probably due to gallotannins. Gallotannins have a lower sensitivity to potassium iodate and hence a lower absorbance than ellagitannins (Willis and Allen 1998). One limitation to this procedure is that the reagent is differently sensitive to various types of hydrolysable tannins, which means that it is impossible to obtain true concentrations. However, it does show changes between species. For this reason, it is a very valuable tool for ecological experiments and for rapid screening of forage species in a breeding or selection program.

The radial diffusion assay (Hagerman 1987) is a more recently developed protein precipitation method that depends on the formation of tannin complexes with bovine serum albumin embedded in an agar and allowed to diffuse through the agar. Radial diffusion assay results varied among different species which ranges from 0 to 302.84 cm. In all season, species *A. hebeclada* does not have any levels of tannins. However species *A. sieberiana* have fewer amounts of tannins in all season as compared to other species.

Conclusion

There were significant species within season effect on nutritive value and anti-nutritional factors in browse tree leaves. In all season's species *A. Sieberiana* and *A. hebeclada* had a good nutritive value and low anti-nutritional factors as compared to species *A. rhemniana* (with low nutritive value and high anti-nutritional factors). The study suggests a need for a detailed study of effect of season on nutritive value and anti-nutritional factors of leaves of browse tree over a number of years with the variable climatic conditions.

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