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Evaluation of the relative feed value of indigenous savanna forage shrub species in Ghana

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Animal performance mainly depends on the quantity and quality of forage available as feed and animal feed represents one of the major costs in animal production. This research was conducted in the Faculty of Natural Resources and Environment Experimental Field at University for Development Studies, Nyankpala Campus to evaluate the relative feed value of four indigenous savanna forage shrubs. These shrubs were cultivated and their leaves harvested at 7, 10 and 13 weeks after establishment. Harvested leaves were pulverized to determine ash, crude fat, crude fiber, crude protein, neutral detergent fibre (NDF) and acid detergent fibre (ADF). Metabolisable energy, dry matter (DM), digestible dry matter (DDM), dry matter intake (DMI) and relative feed values (RFV) were also estimated. Ash, crude fat, crude fibre, CP, ADF and NDF contents ranged from 7.56 to 11.22%, 1.924 to 2.812%, 9.33 to 16.11%, 4.598 to 4.960%, 20.73 to 27.22% and 33.47 to 53.06%, respectively. The DDM, DMI and RFV ranged from 67.70 to 74.84%, 2.27 to 3.66% and 120.2 to 212.6%, respectively. The NDF, ADF contents of *Tephrosia purpurea* was significantly higher than those for *Cajanus cajan* (L), *Stylosanthes mucronata* and *Securinega virosa* (P < 0.05). The DDM and RFV of *S. virosa* and *S. mucronata* were significantly higher than those for *C. cajan* and *T. purpurea*. The DMI in *S. virosa* and *S. mucronata* was significantly higher than those for other shrubs. The carbohydrate contents of *S. virosa* were significantly higher than the other shrubs. In conclusion all the species studied offered considerable potential as high quality forage for ruminants during the acute periods of the year when the quantity and quality of forages are limited.

Key words: Relative feed value, indigenous shrubs, plant maturity, dry matter, livestock.

INTRODUCTION

Animal production, particularly ruminants, is one of the most significant socio-economic activities in the savanna zone of Ghana, where irregular rainfall and the seasonality of forage production makes consistent production of animal feed the greatest challenge to ruminant production in the zone (Adam et al., 2010; de Carvalho, 2017).

Animal feed represents one of the major costs in animal production (Khan et al., 2015). The significance of feeding on production and general characteristics of the meat and other products from small ruminants justifies the need for studies investigating the influence of the diet

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on the quality of these animals (Pereira et al., 2016). Animal performance mainly depends on the quantity and quality of forage available to livestock (Lazzarini et al., 2009; Woolley et al., 2009). It is important to determine the nutritional value of forage in livestock nutrition, because effective livestock production is related to the amount of nutrients in the forage (Schut et al., 2010). Indigenous vegetation, broadly, constitutes an important feed reserve for the herds of ruminants in the savanna zone, but in most cases, the native vegetation is not sufficient to meet the nutritional requirements of the animals, which results in low performance rates and low profitability for rural producers (de Carvalho, 2017). Livestock feeds is almost entirely dependent on grazing of natural pastures and rangelands within the Savannah woodlands, unimproved pastures and bush fallow, with extreme seasonal variation in quantity and quality.

In the Northern region of Ghana, the climate favours the production of forages, the use of which usually costs less compared to concentrate ingredients and are always used in high proportions in ruminants' diets (Nicory et al., 2015; Silva et al., 2016).

Savanna forage shrub species, such as *Securinega virosa, Cajanus cajan* and *Tephrosia purpureum* are considered important for the savanna ecological zone because of their abundance and nutritional characteristics, besides their productive and nutritional potential to be used to feed ruminants (de Carvalho, 2017). Adequate quality feed supply is the way to curb this trend and this can be achieved by conducting feed quality test into the forages especially the browse species used by livestock. The animal category to be fed dictates the forage quality that best matches their requirements. Hence, it is very important for livestock producers to be able to assess the feed quality of the forage their animals utilize on the rangeland. This study therefore sought to determine and compare the Relative Feed Values (RFVs) of four savanna forage shrub species.

MATERIALS AND METHODS

Location of study

The study was carried out at the experimental field of the Faculty of Natural Resources and Environment, University for Development Studies, Nyankpala Campus in the Tolon District of the Northern Region of Ghana in 2014 and 2015. The study area is located within the savanna ecosystem on latitude 09° 25' N and longitude 00° 55' W at an altitude of 183 m above sea level. Nyankpala Campus of the University for Development Studies is 16 km away from Tamale, the capital of Northern Region. The area experiences mean annual rainfall range of 1,034 -1,150 mm from April to early November with mean monthly temperature of 22°C. Maximum monthly relative humidity value of 80% can be recorded during the rainy season while a minimum monthly value of 42% during the dry season is observed. The vegetation is Guinea savanna with grasses as the dominant plant species and interspersed with economic but drought resistant trees such as *Vitellaria paradoxa*, *Adansonia digitata*, and *Tamarindus indica*. The soils are well drained with low nitrogen content due to the low organic matter cover (Ziblim et al., 2016).

Experimental design

Randomized Complete Block Design (RCBD) was used in this experiment involving four savanna forage shrub species (*C. cajan, Stylosanthes mucronata, T. purpurea* and *S. virosa*) as the treatments with four replications. Experimental plots of size 4 × 4 m were constructed. Viable and clean seeds of the shrub species were planted at a depth of 1 cm and spaced 1 m between rows and within rows. Each plot contained 16 plants. For the nutritional analysis, the leaves of four randomly selected plants, one from each replicate were hand harvested and this done for each of the shrub species.

Collection and preparation of samples

Green leaves of the various shrub species were hand harvested at 7, 10 and 13 weeks after establishment. The leaves were rinsed in distilled water to remove dust and other impurities. The leaves were then chopped, air-dried, pulverized to pass a 1 mm screen, and neatly bagged in well labeled sample poly-bags for the chemical analysis. All analyses were carried out in triplicate samples.

Determination of chemical composition

The pulverized shrub samples were transported to the Spanish Laboratory at University for Development Studies, Nyankpala Campus for nutrient analysis. Nutritional compositions (Moisture, crude protein (CP), crude fat, crude fiber, carbohydrates and ash) were performed using the AOAC procedures (AOAC, 1995). Nitrogen was determined using the Micro - Kjeldahl method (AOAC, 2000) and crude protein (CP) was calculated as N x 6.25.

Crude fat was determined by extracting a known weight of powdered sample with petroleum ether at 150°C using Soxhlet equipment. The ash contents were determined by incineration of a known weight of powdered sample at 550°C for 4 h. Crude fibre content was examined by hydrolysis with weak acid and base to dissolve organic component, save fibre and was further incinerated at 550°C. Total carbohydrates (Nitrogen Free Extract) were calculated by difference. That is 100 – (% moisture + ash + % fat + % crude fibre + % crude protein). The Neutral Detergent Fibre (NDF) and Acid Detergent Fibre (ADF) were analyzed according to Van Soest et al. (1991). The ADF analysis is used to predict the digestible dry matter (DDM) = (88.9 - (0.779 * % ADF)) and NDF to predict dry matter intake (DMI) = (120 / % NDF). For crude fiber samples were refluxed first with 1.25% H_2SO_4 and subsequently 1.25% NaOH for 30 min each to dissolve acid and alkali soluble components present in them. The residue containing the crude fibre was dried to a constant weight and the dried residue was ignited in muffle furnace, loss of weight on ignition was calculated to express it as crude fibre.

Estimation of relative feed value (RFV)

Relative feed value was calculated from the estimates of Dry Matter Digestibility (DMD) and Dry Matter Intake (DMI) (Rohweder et al., 1978). The calculation was based on the work of Rabah and Fodil (2014).

Data analysis

All data obtained were subjected to analysis of variance (ANOVA) where nutrient levels in the shrubs were compared in relation to period of harvest with the aid of Genstat software (Release 10.3 DE (2011). Significant treatment means were separated using Fisher's

Table 1. Means and standard errors for expressions of proximate composition of indigenous shrubs.

Shrub species	Proximate composition (%)						
	Ash	C. Fat	CP	CHO	CF	NDF	ADF
C. cajan	9.17^{b}	2.59^{a,d}	4.86^{a}	9.73^{b}	14.89^{b}	42.49$^{\mathbf{b}}$	27.22^{a}
S. mucronata	10.22^{a}	2.33^{a,c}	4.96^{a}	9.10^{b}	9.33^{c}	33.59^{c}	20.73^{b}
T. purpurea	7.56^{c}	2.81^{a}	4.83^{a}	10.28^{b}	16.11^{a}	53.06^{a}	26.54^{a}
S. virosa	8.90^{b}	1.92^{b}	4.60^{a}	18.16^{a}	9.89^{c}	33.47^{c}	18.03^{b}
SEM	0.21	0.13	0.14	1.37	0.27	1.42	1.59
LSD	0.62	0.37	0.42	4.00	0.79	4.16	4.65

SEM- standard error of means. LSD- least significant difference. Means bearing different superscripts within columns are statistically significant from each other (p < 0.05). C. Fat- Crude Fat, Crude protein, CHO- Carbohydrates, CF- Crude Fiber, NDF- Neutral Detergent Fibre, ADF- Acid Detergent Fibre.

Table 2. Effects of time of harvest on proximate composition of indigenous shrubs.

Proximate composition (%)	Period of harvest (WAE)			SEM	LSD
	7	10	13		
Ash	9.75^{a}	8.71^{b}	8.42^{b}	0.18	0.54
Crude fat	1.94^{c}	2.33^{b}	2.97^{a}	0.11	0.32
Crude protein	5.98^{b}	6.53^{a}	1.92^{c}	0.12	0.37
Carbohydrates	12.26^{a}	7.75^{b}	15.43^{a}	1.18	3.47
Crude fibre	12.33^{a}	12.83^{a}	12.50^{a}	0.23	0.69
Neutral detergent fibre	41.10^{a}	40.69^{a}	40.17^{a}	1.23	3.61
Acid detergent fibre	23.45^{a}	22.01^{a}	23.93^{a}	1.37	4.03

SEM- standard error of means. LSD- least significant difference. Means bearing different superscripts within rows are statistically significant from each other (p < 0.05).

Least Significant Difference at 5% probability.

RESULTS

Mean proximate composition of the shrubs

Some selected chemical compositions of the shrubs were determined during the study and their mean contents are presented in Table 1. It was observed from the analysis that mean ash content varied significantly ($p < 0.001$) among the shrubs. *S. mucronata* had the highest (10.22%) mean ash content while *T. purpurea* recorded the lowest (7.56%). There was significant ($p < 0.001$) variation of the mean crude fat content among the shrub species. The highest (2.812%) mean crude fat content was recorded in *T. purpurea* and *C. cajan* while *S. virosa* had the lowest (1.924%). Though the shrub species had no significant ($p = 0.357$) effect on CP content, *S. mucronata* had the highest (4.960%) mean CP while *S. virosa* recorded the lowest (4.598%) (Table 1).

Analysis of the mean carbohydrate content showed significant differences ($p < 0.001$) among the shrubs. *S. virosa* had a significantly higher mean carbohydrate content than all other shrub species with *S. mucronata* recording the lowest (Table 1). The crude fibre content of the shrubs showed that shrub species had significant ($p < 0.001$) influence on the mean crude fibre content. Mean crude fiber content was highest in *T. purpurea* but lowest in *S. mucronata* (Table 1). The Neutral Detergent Fibre (NDF) contents varied significantly ($p<0.001$) among the shrubs. *T. purpurea* recorded the highest mean NDF while *S. virosa* had the least. Time of harvest had no significant ($p = 0.866$) effect on NDF. Mean Acid Detergent Fibre (ADF) content varied significantly ($p < 0.001$) among the shrub species. *S. virosa* and *S. mucronata* were significantly lower in ADF (Table 1).

Time of harvest and mean proximate composition

The study showed a highly significant ($p < 0.001$) effects of time of harvest on the mean ash content of the shrubs. It was noted that mean ash content was significantly higher in shrubs harvested at 7 WAE (Table 4). The influence of time of harvest on crude fat, CP and carbohydrate contents was also highly significant ($p < 0.001$). Mean crude fat content was higher in shrubs harvested at 13 WAE and whereas mean CP content was significantly higher at 10 WAE, mean carbohydrate content was lowest for shrubs sampled at 10 WAE (Table 2). However, time of harvest had no significant (p =

Table 3. Estimated mean relative feed value of shrubs.

Shrub species	Estimated parameters			
	% DM	% DDM	% DMI	RFV
C. cajan	41.23[a]	67.70[b]	2.84[b]	149.2[b]
S. mucronata	35.94[b]	72.76[a]	3.63[a]	204.8[a]
T. purpurea	41.58[a]	68.23[b]	2.27[c]	120.2[c]
S. virosa	43.46[a]	74.84[a]	3.66[a]	212.6[a]
SEM	1.35	1.24	0.14	9.12
LSD	3.95	3.62	0.42	26.74

Means with similar superscripts within columns are not significantly different.

Table 4. Effects of harvesting time on relative feed values of shrubs.

Estimated parameter	Harvest times (WAE)			SEM	LSD
	7	10	13		
% DM	42.27[a]	38.15[b]	41.25[a,b]	1.17	3.42
% DDM	70.63[a]	71.76[a]	70.27[a]	1.07	3.14
% DMI	3.14[a]	3.05[a]	3.12[a]	0.12	0.37
RFV	173.80[a]	170.10[a]	171.20[a]	7.90	23.16

Means with similar superscripts within rows are not significantly different.

0.325, p = 0.598) influence on the mean crude fibre and mean ADF contents (Table 2).

Estimated DDM, DMI and RFV of the shrubs

The dry matter (DM) yields of the shrub species were determined while digestible dry matter, dry matter intake and relative feed values were estimated. Mean DM yield varied significantly *(p = 0.05)* among the shrub species. Apart from *S. mucronata*, which recorded significantly low DM yield, the other three were not significantly ($p < 0.05$) different from each other (Table 3). There was relative marginal significant effect of time of harvest on the DM yield of the shrubs. Dry matter yield was higher in shrubs harvested at 7 and 13 WAE (Table 4).

Digestible dry matter (DDM) also varied significantly ($p < 0.001$) among the shrub species. Mean DDM was significantly higher in *S. mucronata* and *S. virosa* (Table 3). The shrub species presented significant ($p < 0.001$) influence on the dry matter intake (DMI). *S. mucronata* and *S. virosa* recorded significantly higher mean DMI compared to *C. cajan* and *T. purpurea* (Table 3). Time of harvest had no significant ($p = 0.852$) influence on the DDM and DMI of the shrub species (Table 4). A significant ($p < 0.001$) variation in mean RFV of the shrub species was observed. The highest mean RFV was recorded in *S. virosa* and *S. mucronata* while *T. purpurea* had the lowest (Table 3). The influence of time of harvest on the mean RFV was not significant ($p = 0.943$) (Table 4).

DISCUSSION

Mean proximate composition

The variation in mean ash content among the shrubs could be related to the physiological differences. The ash content range of 7.56-10.22% obtained from this study was comparable to that observed by Atiya et al. (2011) (7.19-13.50%) on some top fodder tree and shrub leaves in Pakistan. It was also comparable to the ash content range of 5.02-13.41% reported by Barnes (1996) on some browse species in Ghana and that of Rabah and Fobil (2014) which ranged from 9.09% in *Astragalus armatus* to 10.26% in *Anabasis artculata*. Javed et al. (2008) also reported varied ash contents of fodder tree leaves from 3.5% (*Quercus incana)* to 8.1% (*Aesculus indica*).

Generally, it was observed that the ash content decreased with advancing maturity of the leaves. The decline in ash content in older leaves means that less amount of minerals will be present. Shrubs harvested at 7 WAE were higher in ash content than those harvested at 10 and 13 WAE. This observation was in disagreement with the findings of Kökten et al. (2012) who noted a significant increase in ash content with advancing maturity. It was also in contrast with Tolunay et al. (2009) and Haddi et al. (2003) who observed that ash content increased with maturation in kermes oak and halophyte shrubs, respectively. Parlak et al. (2011) also showed significant increase in ash content with advancing maturity.

There was significant ($p< 0.05$) variation of crude fat content among the shrub species. Similar variations in chemical composition have been reported for some fodder trees and shrubs of Algerian arid and semi-arid areas (Bouazza et al., 2012). This could partly be due to the physiological and genetic differences of the shrubs and also the bioclimatic conditions. The mean crude fat content varied from one species to another and this variability can be attributed to the bioclimatic and genetics of the species. The range of mean crude fat content established from this study (1.92 to 2.81%) was relatively lower than a range of 4.59 to 6.30% of some leguminous forage shrubs reported by Laamouri et al. (2015). Atiya et al. (2011) also reported a crude fat content range of 1.44 to 6.45% of some top fodder tree leaves and shrubs in Pakistan. It was, however, comparable to crude fat content range of 1.25 to 3.24% of some leguminous herbaceous plants (Laamouri et al., 2015). As livestock feed, fats function much like carbohydrates in that they serve as a source of heat and energy and for the formation of fat due to the larger proportion of carbon and hydrogen. However, fats liberate more heat than carbohydrates when digested, furnishing on oxidation approximately 2.25 times as much heat or energy per pound as compared to carbohydrates. The crude fat content of the species increased with maturity. Crude fat content was higher in plants harvested at 13 WAE and this could be attributed to the physiological and structural changes as the plants mature (Oduntan and Olaleye, 2012).

The mean CP contents of the shrub species studied were similar. The CP values obtained in this study were very low and inconsistent with those found by Blair (1990) who reported CP values between the range of 12- 32% with an average of 18%. They were also incomparable with the range of 11- 20% (Bayer, 1996; Larbi et al., 1993) and 15.59- 20.99% (Oji et al., 1998; Oji and Isilebo, 2000) reported for browse species in Southern Nigeria. Similarly, higher CP content range of 12 -30% for tropical tree legumes (Norton, 1998) and an average of 12.50% in West African browse species (Le Houerou, 1980) have been documented.

Generally, the CP contents of the shrubs were lower than the minimum requirement of 7 - 8% DM for optimum rumen microbial function in ruminants (Van Soest, 1994; Norton, 1998) and by extension, the function of the rumen microbes is affected when the CP level in a ration is less than 10%. This means that the shrubs have low potential as protein source in ruminant feeding and therefore supplementation with high protein feed will be required. However, the CP contents of shrubs were comparable to report by Lardy et al. (2004) who indicated that CP content of 5% is common in range forage during late fall and winter. They were also comparable with that of Rogosic et al. (2006) who reported CP values of leaves and twigs of some Mediterranean maquis shrubs ranged from 4.9 to 7.8%. The results were also in conformity with the observation by Villalobos et al. (1997) and Patterson et al. (2003) that nutrient deficiencies in a cow are more probable in fall and winter when nutrient contents of the grazed forages are low.

The relatively low CP content of the shrubs could have been influenced by the presence of condensed tannins limiting its availability (Yifei et al., 2009). Rittner and Reed (1992) observed that CT negatively correlated with N degradability and CP for that matter of fodder shrub leaves. The low CP contents of the shrubs could also be attributed to the low N content and by extension to low organic matter content of the soil (Oyinlola and Jinadu, 2012). The slight variation in mean CP content among the shrubs could possibly be due to differences in amount of NDF and ADF. This assertion is consistent with results of others (Haddi et al., 2003; Pecetti et al., 2007). The study observed that mean CP content of the shrubs declined as the shrubs advanced in maturity, which was in concordance with other investigations (Distel et al., 2005; Kökten et al., 2012). This is because as CP content in the plant declined protein synthesis is being inhibited by the weak photosynthesis at the more mature stage (Throop, 2005).

The variation in the carbohydrate levels in the shrubs could be genetic since they were exposed to the same environmental conditions. The range of carbohydrate content obtained from this study was lower than 21.38-47.67% reported by Farrukh and Mufakhirah (2009) in Pakistan. However, Farrukh and Mufakhirah (2009) reported that high carbohydrates content at late phenological stage of plants is less beneficial to livestock due to their low digestibility. The low carbohydrate contents are indicative that the shrubs could be poor sources of energy and the low carbohydrates could be caused by moisture stress since the experiment was carried out during the dry season. There was an increased trend of carbohydrates levels in the shrubs from 7 to 13 WAE. This means that carbohydrate contents in the shrubs increased as they advanced in maturity (Gąsecka et al., 2008). As the plants mature there could be accumulation of soluble sugars resulting in the high carbohydrate content. The reduction in carbohydrate contents at 10 WAE could have been influenced by temperature stress (Jaleel et al., 2009).

The high CF value for *T. purpurea* was in concordance with a 14.62% CF value reported by Mbomi et al. (2012) among other *Tephrosia* species. The range of CF values recorded in this study was lower than that of CF contents of browse trees reported by Ogunbosoye and Otukoya (2014) which ranged from 23.1% in *Leucaena leucocephala* to 38.1% in *Tamarindus indica*. However, it was comparable to CF contents of some browse plants with a range of 15.74% (*Mangifera indica*) to 19.24% (*Daniellia oliveri*) as reported by Ladipo and Akinfemi (2014). The relatively low CF content of the shrubs indicates that their digestibility (enzymatic degradation) will be high since the two are inversely related. Nutritionally, fibre has both physical and chemical attributes that are related to the mechanical processes of digestion and to enzymatic degradation associated with fermentation. The difference in the CF contents of the shrub species could be attributed to their physiological characteristics and their responses to climatic conditions of the study area. Analysis of the CF contents of the shrubs among the harvesting stages showed no significant difference. This means that period of harvest had little effect on the CF content of the shrubs investigated.

Neutral detergent fibre can be a significant determinant of forage quality and digestibility, which directly may affect intake of dry matter and animal performance (Linn, 2004). Mean NDF value varied significantly among the shrubs, where the highest value (53.06%) was recorded by *T. purpurea* and lowest value (33.47%) by *S. virosa.* According to NRC (2001), 36% NDF is ideal for forage for domestic animals. Greater than 36% NDF increases limits of intake due to rumen fill and less than 36% results in insufficient fibre for rumen scratch factor and proper rumen function. The NDF contents of *C. cajan* and *T. purpurea* were above the ideal NDF of 36% for domestic animals (NRC, 2001) while that of *S. mucronata* and *S. virosa* were less. However, the NDF contents of *S. mucronata* and *S. virosa* were within the range of 25-35% of DM as the optimum requirement which will maximize energy intake of cows in early lactation (NRC, 1989). NDF range of 35-40% has been recommended by El Shaer and Gihad (1994) to be within the normal range of nutritious fodders.

Fibre stimulates the cardinal region of the reticulum to induce regurgitation, rumination and ruminal motility. The high NDF (hemicellulose) content of *C. cajan* and *T. purpurea* could have been caused by genetic factors and also environmental factors such as temperature which might have aided the thickening of the cell walls (Wilson et al., 1991) and enhanced lignin synthesis, both of which lower digestibility (Buxton and Fales, 1994). The high NDF contents of *C. cajan* and *T. purpurea* in this case might be considered as a potential energy source for the rumen microorganisms.

Advance in maturity of the shrubs had no significant effect on the NDF content. This observation was inconsistent with Kökten et al. (2012) who documented a significant increase of NDF contents with age of plant. The observation may primarily be due to inadequate spacing among the periods of harvest used. The mean ADF content recorded in this study ranged from 18.03% (*S. virosa*) to 27.22% (*C. cajan*). The mean ADF contents were lower than that reported by Ogunbosoye and Babayemi (2012) of some browse plants in Southern Nigeria. However, the ADF contents of the shrubs were comparable to the recommended dietary minimum range of 19- 21% for dairy cows (NRC, 1989). The mean ADF contents obtained were also within the range of ADF values reported by Kökten et al. (2012). The mean ADF values were comparable to those reported by Daryl et al. (2006) of foliages of some savanna plants. High fibre content (NDF and ADF) reduces forage digestibility. It was revealed in this study that there was no significant influence of time of harvest on mean ADF values of the shrubs, however, means ADF content was highest in plants harvested at 13 WAE. This observation was consistent with the findings of Kramberger and Klemencic (2003) and Sultan et al. (2007) who reported increased ADF with maturity of grasses.

Estimated DDM, DMI and RFV of the shrubs

The variations in DM content could be related to physiology of the various shrubs and their response to environmental conditions of the study site. The mean DM content obtained from this study was similar to those reported by Yavuz (2007) and Ogunbosoye and Babayemi (2012) of some browse plants. The DM results were also comparable to DM values obtained by Bouazza et al. (2012) on some forages in Algeria. Relatively, the DM content of the shrubs was higher than that obtained by Gonzalez-Garcia et al. (2009) on *Leucaena leucocephala* cultivars in both dry and wet seasons. The shrubs, therefore, would be able to provide enough dry matter as feed for ruminant animals in the study area.

The marginal decrease in DM contents with advancing maturity of the shrub species is in agreement with the findings of Kamalak (2006) and Khazaal et al. (1993) who noted decreased DM contents with the advancing maturity of Lucerne hay. The decrease in DM content may presumably be due to an increase in the number of senesce leaves as the plants aged. The estimated parameters (DDM, DMI, and RFV) varied significantly among the shrub species and could be due to the different physiology of the shrubs and their response to the environmental conditions of the site. The highest DM, DDM, DMI and RFV contents were determined in *S. virosa*. The relative feed values ranged from 120.20 (*T. purpurea*) to 212.60 (*S. virosa*) and the range was within the standards quoted by Hay Market Task Force of American Forage and Grassland Council (Rabah and Fodil, 2014). Based on these standards, *S. mucronata* and *S. virosa* would be considered prime feed ingredients (RFV>151). It was observed that shrubs with higher RFVs had lower NDF and ADF contents indicating the influence of the fibre content on the feeding values of the shrubs. Consequently, as percent NDF and ADF decreased the RFV increased and this observation is in concordance with the findings of Shroeder (1994) and Appiah et al. (2012). Larger RFV of a shrub species could indicate higher feed quality. The estimated parameters of all the shrub species decreased with increased in the age of the leaves (Kökten et al., 2012). The estimated parameters were highest in leaves harvested at 7 WAE.

Conclusion

Maturity (age) of shrub species affected the proximate compositions. Though the protein content was relatively low in the shrubs, the other proximate compositions were within the requirements for the different categories of animals. *S. mucronata* and *S. virosa* were considered prime feed ingredients (RFV>151).

CONFLICT OF INTERESTS

The author has not declared any conflict of interests.

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