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NUTRITIVE VALUE OF MEDITERRANEAN SHRUBS

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ABSTRACT

Nutritive values of the leaves of Mediterranean shrubs *Quercus coccifera, Calicotome villosa*, *Rhamnus oleoides* ssp. *graecus, Pistacia terebinthus, Paliurus spina-christi* and *Phillyrea latifolia, and Leuceana leucocephala,* an introduced species were studied. These shrubs were hand harvested from three plots established in the experimental field at before flowering, flowering and bear fruit stages. The nutritive values were evaluated in terms of the chemical composition, dry matter (DM), organic matter (OM), relative feed value (RFV), dry matter intake (DMI) as well as digestible dry matter (DDM).Maturity had a significant effect on the chemical composition, DM, OM and estimated parameters (DDM, DMI and RFV) of the leaves of the shrub species. Neutral detergent fiber (NDF), acid detergent fiber (ADF) and condensed tannin (CT) contents increased with increasing maturity whereas the crude protein decreased. DM and estimated parameters also decreased with increasing maturity. CP, ADF, NDF, Ash and CT contents ranged from 6.4 to 33.3%, from 6.9 to 39.1%, from 10.1 to 50.5%, from 2.9 to 6.8% and from 0.7 to 15.8%, respectively. The OM and DM ranged from 93.2 to 97.1% and from 28.5 to 70.8%, respectively. The digestibility DM, DM intake and RFV ranged from 58.4 to 83.5%, from 2.4 to 11.9% and from 107.7 to 769.3, respectively ADF, NDF and condensed tannin contents of the leaves of the shrub species harvested at bear fruit stage were significantly higher than those harvested at before flowering and flowering stages, while CP contents and estimated parameters of the leaves of the shrub species harvested at flowering stage were significantly higher than those harvested at before flowering and bear fruit stages. The biplot analysis indicated negative correlation of CP content with OM and DM, whereas it is positively correlated with CT and ash contents. On the other hand, ADF was positively correlated with NDF, whereas it is negatively correlated with estimated parameters. The shrub species harvested at the proper stage of maturity offers considerable potential as high quality forage for ruminants during critical period in the semi arid and arid regions.

Keywords: Mediterranean shrubs; Nutritive value; Condensed tannin; Ash; Biplot.

INTRODUCTION

Traditional livestock raising in the Eastern Mediterranean region has been very extensive since biblical times, with natural rangelands being the main source of forage (Perevolotsky and Landau, 1992). These rangelands contain a significant woody component and comprise shrubland (garrigue), woodland and scrubland (maquis). Most of the natural vegetation in the Mediterranean region is composed of woodland in various stages of degradation as secondary succession created by the long history of man's activities (Hadjibiros, 2001; Tarrega *et al.,* 2001). Lands dominated by woody species, namely shrublands, savannas and forest ranges, are a substantial portion of the world's rangelands (Stoddart *et al*., 1975). They play an important role in areas with a long dry period and harsh environmental conditions as of Mediterranean regions. They provide green forage for grazing animals throughout the year (evergreen species) or at specific critical periods of the year (deciduous species).

Many researchers have demonstrated the potential of woody species to produce palatable and nutritious foliage even during the dry season (Dzowela *et al.,* 1995; Tolera *et al.,* 1997; Kamalak, 2006; Narvaez *et al.,* 2010). Many woody species are able to provide green and nutritious forage in summer exceeding qualitatively that of the herbaceous species. They develop long roots reaching deeper soil layers than the herbaceous vegetation, and are able to maintain green phytomass late in the season when the herbaceous layer is dry (Le Houerou, 1987; Olea *et al*., 1992). The establishment of a silvopastoral system by introducing woody and especially leguminous species into these grasslands could be an effective means of improving the overall forage quality, while ameliorating the supply demand ratio. Several studies have been carried out involving *Quercus durata* and *Adenostoma fasciculatum* (Narvaez *et al.,* 2010), *Rhamnus oleoides* ssp. *graecus* and *Pistacia terebinthus* ssp. *palaestina* (Altınözlü, 2004), *Calicotome villosa* and *Quercus calliprinos* (Kababya *et al*., 1998), *Leuceana leucocephala* and *Combretum aculeatum* (Bosma and Bicaba, 1997), *Quercus coccifera, Paliurus spina-christi* and *Phillyrea latifolia* (Guvensen and Ozturk, 2003). It is well documented also that woody species significantly help to decrease the risk of soil erosion, improve wildlife habitat, improve the aesthetics of the landscape and enrich the upper soil layer with nutrients (Le Houerou, 1993).

The use of browse species as fodder for ruminant animals is becoming important in many parts of the world. The presence of tannins and other phenolic compounds in a large number of nutritionally important shrubs and tree leaves hampers their utilization as animal feed (Tolera *et al.,* 1997). High levels of tannins in leaves restrict the nutrient utilization and decrease voluntary food intake, nutrient digestibility and N retention (Kumar and Vaithiyanathan, 1990; Silanikove *et al.,* 1996; 2001).

The aim of this study was to assess the potential nutritive value of leaves of *Quercus coccifera, Calicotome villosa*, *Rhamnus oleoides* ssp. *graecus, Pistacia terebinthus, Leuceana leucocephala, Paliurus spina-christi* and *Phillyrea latifolia* harvested at before flowering, flowering and bear fruit stages based on their chemical composition.

MATERIALS AND METHODS

Study Area: The study area is located on a hillside near the city of Adana (37° 21 ′N, 35° 10 ′E), Turkey, 170 m above sea level and 70 km from the Mediterranean Sea. Generally, the soils of the study area are slightly basic and formed of very calcareous and soft clay materials originating from the Pliocene, and of conglomerates, which formed the old alluvial terraces in the Pleistocene. The soil, mainly of limestone, is characterized by low concentration of nutrients (Özbek *et al.,* 1974).

The Mediterranean climate in the study area is characterized by long summer droughts and mild and rainy winters. The mean annual precipitation is about 646.6 mm, while the monthly precipitation approximates 6.9 mm in July and 144.4 mm in January. The mean maximum temperatures range from 14.8 ºC in January to 34.6 ºC in August and the mean minimum temperatures range from 5.1 ºC in January to 22.9 ºC in July. According to the average climatic data from 1997 to 2010 obtained from the Meteorological Station of Adana, the dry period for the study area is from May to October.

The natural vegetation of the study area has been under protection since 1970. It is a typical Mediterranean macchia plant community mainly composed of *Quercus coccifera, Calicotome villosa, Cistus cretius, Phillyrea latifolia, Pistacia terebinthus* ssp. *palaestina, Rhamnus oleoides* ssp. *graecus, Olea europaea* var. *sylvestris, Daphne sericea, Lithodora hispidula* and *Paliurus spina-christi*. There is a macchia area of about 126,689 ha in Adana province (Tükel and Hatipoğlu, 1990), but most of it is disturbed by humans for various reasons and purposes.

Plant Material: Foliages, tillers, flowers and pods of native shrub species such as *Quercus coccifera, Calicotome villosa*, *Rhamnus oleoides* ssp. *graecus, Pistacia terebinthus, Paliurus spina-christi* and *Phillyrea latifolia* as well as those of *Leuceana leucocephala,* an introduced shrub species, were hand-harvested at three stages from the experimental area of Cukurova University, Adana, Turkey.

Chemical Analyses: Shrub specimens were transported to the laboratory and oven-dried at 70°C for 48 h to determine dry matter (DM) content. Shrub samples were analyzed for ash, and crude protein (CP) according to AOAC (2000). Neutral detergent fiber (NDF) and acid detergent fiber (ADF) were determined by the method of Van Soest *et al*. (1991). Condensed tannin (CT) contents of the plant materials were determined by the method of Makkar *et al*. (1995).

Relative feed value (RFV) is a term that has been used in evaluating hay (Rohweder *et al.,* 1978). It is a single number that can be calculated for pure grass and legume or mixed hay. The RFV does not consider protein, but higher RFV values usually would be associated with higher protein. 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). RFV is calculated by multiplying digestible dry matter by dry matter intake and then dividing by 1.29.

Statistical Analysis: The experimental design was completely randomized design with 3 replications. Data were analyzed by using MSTATC (V.1.2, Michigan State University, USA) Biplot analysis was done to explain the correlations between nutritive value (DM, CP, NDF, ADF, CT, RFV, DDM, DMI, OM and Ash) and the some shrub species (*Quercus coccifera, Calicotome villosa*, *Rhamnus oleoides* ssp. *graecus, Pistacia terebinthus, Leuceana leucocephala, Paliurus spina-christi* and *Phillyrea latifolia*) by the method of Yan and Kang (2003).

RESULTS AND DISCUSSION

Chemical Composition: Chemical compositions of the leaves of shrub species harvested at three different maturity stages are given in Table 1. There were significant differences among shrub species in the chemical composition of the leaves harvested at different maturity stages. CP contents of the leaves ranged from 6.4 to 33.3%, depending on the species and harvest stage. CP content of leaves of all shrub species, except *P.*

terebinthus, decreased with advancing maturity. CP contents of the leaves of the shrub species harvested before flowering stage were significantly higher than those harvested at flowering and bear fruit stages. The results have shown that CP contents of leaves of the shrub species harvested at before flowering and flowering stages were sufficiently high to warrant consideration of their use as protein supplements in low quality diets. These findings are in agreement with the results of Kamalak (2006) and Larbi *et al.* (1998). When considered averaged values over the stages, *L. leucocephala* gave a significantly higher CP content than the other shrub species.

NDF and ADF contents of leaves were significantly increased by advancing maturity (Table 1). NDF content ranged between 10.1 and 50.5%., depending on the species and harvest stage. ADF content varied from 6.9 to 39.1%, depending on the species and harvest stage. These results are in line with the findings of Dzowela *et al*. (1995) and Kamalak (2006) who indicated that cell wall content (NDF and ADF) increased with advancing maturity. On the average over the stages, the highest ADF and NDF were obtained from *P. latifolia* and *C. villosa,* respectively, while the lowest ADF and NDF were obtained from *P. terebinthus*.

CT contents of the leaves of all shrub species, except for *P. spina-christi*, were significantly increased by advancing maturity. CT contents of the leaves of the shrub species ranged from 0.7 to 15.8%, depending on the species and harvest stage. Barry and Duncan (1984) reported depressed intake and growth of animals when CT contents of forages were in the range of 60–100 g/kg DM. CT contents of the leaves of the shrub species harvested before flowering stage were lower than this range. However, CT content of the leaves of the shrub species, except for *C. villosa* and *P. latifolia*, harvested at flowering stage fall into this range. On the other hand, CT contents of the leaves of *L. leucocephala* harvested at flowering and bear fruit stages were higher than the upper level of this range.

Ash contents of leaves of *Q. coccifera* and *C. villosa* were significantly increased by advancing maturity. Ash content ranged between 2.9 and 6.8%, depending on the species and harvest stage. On the average over the stages, the highest ash content was obtained from *L. leucocephala,* while the lowest ash content was obtained from *P. latifolia*. Variation in chemical composition among species could be partly due to genotypic factors that control accumulation of foliage nutrients (Rubanza *et al.,* 2005). Although CP content of *Quercus coccifera* was considerably higher than that obtained by Karabulut *et al.* (2006), ash content of *Quercus coccifera* was comparable with the findings of Karabulut *et al.* (2006). This might be due to differences in growth site.

The main chemical feature that attracts nutritionists to evaluate Mediterranean shrubs as a potential feedstuff for ruminants in the tropics is its high CP content. However, wide variations have been reported in the chemical composition of the shrub plant depending on soil fertility (Palmer and Schlink, 1992; Duguma *et al.,* 1994; Jackson *et al.,* 1996) and stage of growth or age (Kaitho *et al.,* 1993; Dzowela *et al.,* 1995). Similar variations in chemical composition have been reported for some other tropical browses like *Gliricidia sepium* and *Leucaena leucocephala* (Abdul Razak, 1995). This study also shows large differences in chemical composition between different parts of the shrub species. In general, older leaves contained less CP, more fibre and more ash than the young leaves. These observations are in agreement with the results of Kaitho *et al.* (1993).

Organic Matter, Dry Matter and Estimated Parameters: Organic matter (OM), dry matter (DM) contents and estimated parameters of the leaves of shrub species harvested at three different maturity stages are given in Table 2. The highest OM content was obtained from *P. terebinthus* with 97.1% at before flowering stage, while the lowest OM was obtained from *L. leucocephala* with 93.2% at the same stage. This result is in agreement with the findings of Larbi *et al.* (1998) and Abdul Razak *et al*. (2000) but contrast with those of Tolera *et al.* (1997) who found that the OM content was highest in gorse (*Ulex europaeus*) at the flowering stage followed by tagasaste (*Chamaecytisus palmensis*). On the average over the stages, there were no significant differences among *P. terebinthus, P. latifolia* and *C. villosa* in OM content. However, thee shrubs yields significantly higher OM content than the other shrubs.

DM contents of the leaves of all shrub species, except for *R. oleoides* ssp. *graecus* and *P. terebinthus*, were increased by advancing maturity. This result is in contradiction with the findings of Kamalak (2006) and Khazaal *et al.* (1993) who noted decreased DM content with the advancing maturity of Lucerne hay. DM contents of the leaves of the shrub species ranged from 28.5 to 70.8%, depending on the species and development stages. When considered averaged values over the stages, the highest DM content was determined in *Q. coccifera* (59.9 %). There were no significant differences among *R. oleoides* ssp. *graecus*, *P. latifolia* and *P. spina-christi* in DM content. They gave significantly higher DM than *C. villosa, P. terebinthus* and *L. leucocephala*.

Estimated parameters (DDM, DMI and RFV) of the leaves of all shrub species were decreased by increasing maturity. DDM, DMI and RFV of the leaves of the shrub species ranged from 58.4 to 83.5%, from 2.4 to 11.9% and from 107.7 to 769.3, respectively. Averaged over the stages, the highest estimated parameters were determined in *P. terebinthus*. It gave significantly higher DDM, DMI and RFV than the other shrubs.

Biplot Analysis: Biplot analysis was used to compare shrub species on the basis of their nutritive values and to identify species or groups of shrubs that are particularly good in certain aspects (Yan and Kang, 2003). The biplot (Figure 1) displays 81% of the information in the standardized data of the 7 shrub species for nutritive values, which is presented in Table 1 and 2. This biplot can be visualized from two perspectives. First, it shows the associations among the traits across the 7 shrub species: (i) a positive correlation (acute angle) between OM and DM; between DDM, DMI and RFV; between CT, CP and Ash; between ADF and NDF, (ii) a negative correlation (obtuse angle) between ash, and OM and DM, and (iii) a negative correlation (obtuse angle) between NDF, and DMI and RFV, (iv) a negative correlation (obtuse angle) between ADF and DDM. These results are in agreement with the findings of Khazaal and Orskov (1994) and Balogun *et al.* (1998), but contrast with those of Abdul Razak *et al.* (2000) and Kamalak (2006). Second, it shows the trait profiles of the shrub species, particularly those that are placed farther away from the biplot origin. For example, it shows that *L. leucocephala* had extremely high ash, CP and CT but low OM and DM; *P. terebinthus* had extremely high estimated parameters but lower levels for ADF and NDF; and *C. villosa* had extremely high NDF but lower levels for estimated parameters (Table 1, Table 2 and Figure 1).

Table 1. Chemical compositions of leaves of shrub species harvested at three stages

Shrub species	Stages	CP	NDF	ADF	CT	Ash
Calicotome villosa	Before flowering	21.7 c	41.0 d	16.4 kl	0.7 j	3.5 hj
	Flowering	18.7 de	45.3 c	17.4 ıj	1.0 j	3.5 hj
	Bear fruit	16.2 g	48.4 b	23.0 e	1.0 j	3.8 gı
	Average	**18.9 B[1]**	**44.9 A**	**19.0 C**	**0.9 E**	**3.6 D**
Quercus coccifera	Before flowering	15.5 hı	21.5 ı	16.8 jk	2.3 h	4.0 fı
	Flowering	15.1 ıj	25.4 h	20.3 f	2.4 h	4.2 fh
	Bear fruit	6.4 p	50.5 a	39.1 a	6.5 c	4.4 eg
	Average	**12.3 F**	**32.5 C**	**25.4 B**	**3.8 D**	**4.2 C**
Rhamnus oleoides ssp. *graecus*	Before flowering	15.4 ıj	18.9 j	17.9 hı	4.4 f	4.7 ef
	Flowering	15.4 ıj	19.4 j	18.9 g	5.2 e	5.5 cd
	Bear fruit	11.0 m	21.3 ı	20.4 f	5.7 d	3.8 gı
	Average	**13.9 E**	**19.9 E**	**19.1 C**	**5.1 B**	**4.7 C**
Pistacia terebinthus	Before flowering	15.8 gh	10.1 n	6.9 o	0.9 j	2.9 j
	Flowering	24.5 b	14.2 m	13.7 m	5.6 de	4.5 eg
	Bear fruit	14.9 jk	17.6 k	16.3 kl	6.9 c	3.3 ıj
	Average	**18.4 C**	**14.0 G**	**12.4 E**	**4.5 C**	**3.6 D**
Leuceana leucocephala	Before flowering	33.3 a	15.4 l	14.1 m	3.1 g	6.8 a
	Flowering	18.8 d	18.6 jk	15.8 l	12.8 b	5.6 bd
	Bear fruit	18.3 e	19.8 j	16.5 kl	15.8 a	6.3 ab
	Average	**23.4 A**	**18.0 F**	**15.5 D**	**10.6 A**	**6.3 A**
Paliurus spina-christi	Before flowering	21.5 c	19.1 j	12.8 n	5.2 de	6.1 bc
	Flowering	17.0 f	25.9 h	16.2 kl	2.4 h	4.6 ef
	Bear fruit	12.1 l	29.6 g	18.3 gh	3.1 g	5.0 de
	Average	**16.9 D**	**24.9 D**	**15.8 D**	**3.6 D**	**5.2 B**
Phillyrea latifolia	Before flowering	14.6 k	34.3 f	25.8 d	0.9 j	3.3 ıj
	Flowering	9.1 n	37.8 e	27.0 c	1.0 j	3.4 ıj
	Bear fruit	8.1 o	38.2 e	29.7 b	1.5 ı	3.0 j
	Average	**10.6 G**	**36.8 B**	**27.5 A**	**1.1 E**	**3.2 D**

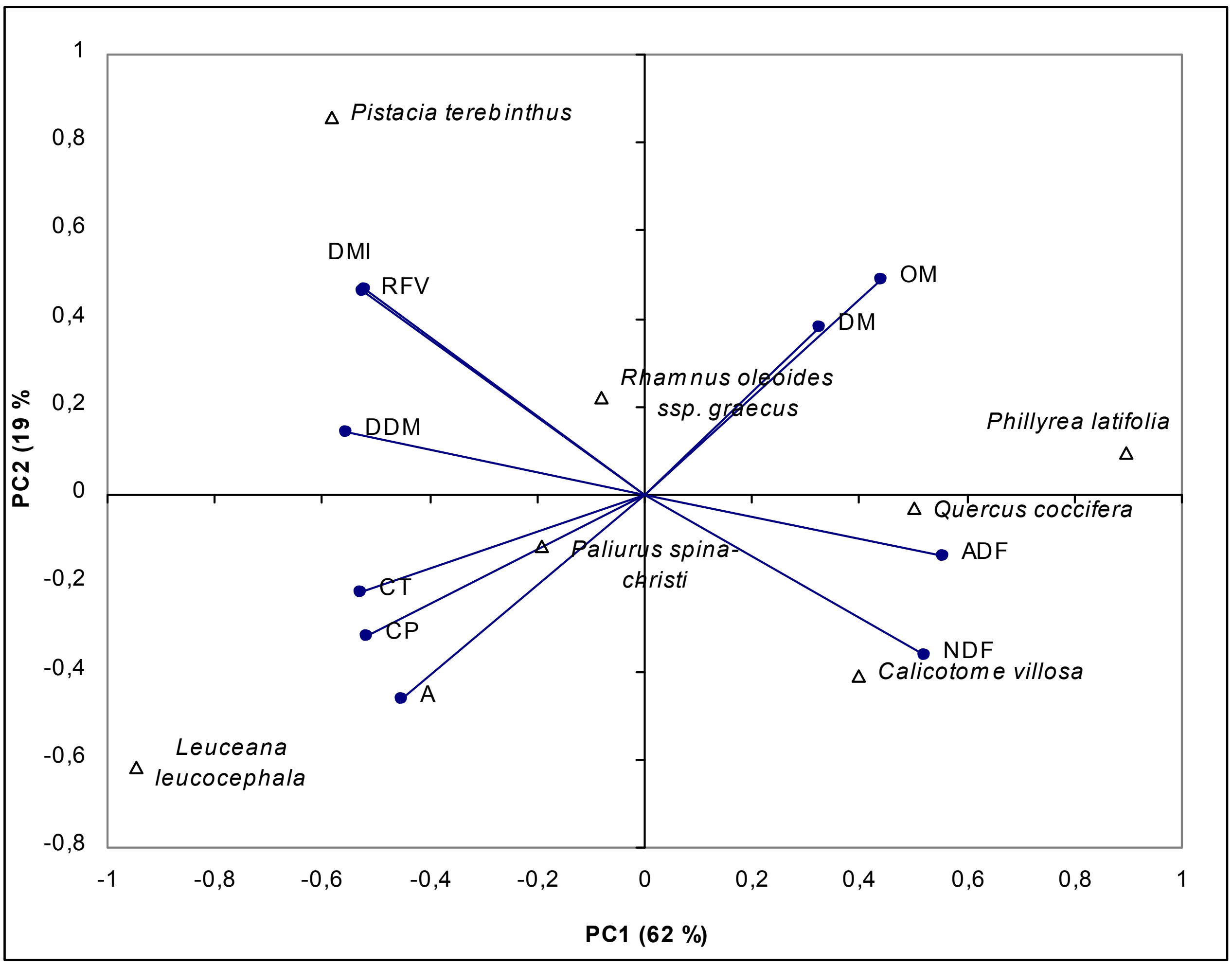
[a-o] Means with the same lower latter in a column are not statistically significant different from each other (P ≤0.005).
[A-F] Means with the same capital latter in a column are not statistically significant different from each other (P ≤0.005).

Table 2. Organic Matter, Dry Matter, Digestibility Dry Matter, Dry Matter Intake and Relative Food Value of leaves of some shrub species harvested at three stages

Shrub species	Stages	OM	DM	DDM	DMI	RFV
Calicotome villosa	Before flowering	96.5 ac	28.5	76.1 de	2.9 jk	172.7 hı
	Flowering	96.5 ac	35.9	75.3 fg	2.6 j-l	154.7 ıj
	Bear fruit	96.2 bd	46.1	71.0 k	2.5 kl	136.4 j
	Average	**96.4 A**	**36.8 C**	**74.1 C**	**2.7 G**	**154.6 G**
Quercus coccifera	Before flowering	96.0 be	51.6	75.8 ef	5.6 f	328.0 f
	Flowering	95.8 c-e	57.4	73.1 j	4.7 g	267.7 g
	Bear fruit	95.6 d-f	70.8	58.4 o	2.4 l	107.7 k

	Average	**95.8 B**	**59.9 A**	**69.1 D**	**4.2 E**	**234.5 E**
Rhamnus oleoides ssp. *graecus*	Before flowering	95.4 ef	56.4	75.0 gh	6.3 e	368.9 e
	Flowering	94.5 gh	57.0	74.2 ı	6.2 e	355.7 e
	Bear fruit	96.2 b-d	61.3	73.0 j	5.6 f	318.8 f
	Average	**95.4 B**	**58.3 A**	**74.1 C**	**6.0 C**	**347.8 C**
Pistacia terebinthus	Before flowering	97.1 a	43.7	83.5 a	11.9 a	769.3 a
	Flowering	95.5 d-f	35.6	78.2 c	8.5 b	512.5 b
	Bear fruit	96.7 ab	59.1	76.2 de	6.8 d	402.8 d
	Average	**96.5 A**	**46.1 B**	**79.3 A**	**9.1 A**	**561.5 A**
Leuceana leucocephala	Before flowering	93.2 j	27.8	77.9 c	7.8 c	470.6 c
	Flowering	94.4 g-ı	37.2	76.6 d	6.5 e	383.1 e
	Bear fruit	93.7 ıj	39.6	76.0 de	6.1 ef	357.3 e
	Average	**93.7 D**	**34.9 C**	**76.8 B**	**6.8 B**	**403.7 B**
Paliurus spina-christi	Before flowering	93.9 hı	45.9	78.9 b	6.3 e	384.4 e
	Flowering	95.4 ef	52.3	76.3 de	4.6 g	274.0 g
	Bear fruit	95.0 fg	65.3	74.6 hı	4.1 h	234.6 g
	Average	**94.8 C**	**54.5 A**	**76.6 B**	**5.0 D**	**297.7 D**
Phillyrea latifolia	Before flowering	96.7 ab	51.1	68.8 l	3.5 ı	186.6 h
	Flowering	96.6 ab	56.3	67.9 m	3.2 ıj	167.0 h-j
	Bear fruit	97.0 a	62.6	65.8 n	3.1 ıj	160.1 h-j
	Average	**96.8 A**	**56.7 A**	**67.5 E**	**3.3 F**	**171.2 F**

a-o Means with the same lower latter in a column are not statistically significant different from each other (P ≤0.005).
A-F Means with the same capital latter in a column are not statistically significant different from each other (P ≤0.005



CP: Crude Protein, CT: Condensed Tannin, A: Ash, OM: Organic Matter, DM: Dry Matter, ADF: Acid Detergent Fiber; NDF: Neutral Detergent Fiber, DDM: Digestibility Dry Matter, DMI: Dry Matter Intake, RFV: Relative Feed Value.

Figure 1. The biplot of 7 shrub species for nutritive value.

It is well established that animal production is impaired as the quality of forage is decreased by the proceeding development of the plants during growth period (Castle, 1982; Steen, 1992). Generally, as plant mature, CP decreases, cell wall contents increase, while digestibility, DMI and RFV decline. These responses are relatively well known, and the obvious means to minimize the effects of maturity is to harvest at optimum maturity.

Conclusion: Harvesting stage is an important factor affecting nutritive value of leaves of the some shrub species. The nutritive value of the leaves of the shrub species continually changed as they mature. Leaves of *L. leucocephala, C. villosa* and *P. terbinthus* may be used as protein supplements since their CP contents are high. The digestibility coefficients are similar to other tropical legumes and forages. The shrub species harvested at the proper stage of maturity offers considerable potential as high quality forage for ruminant during critical period in the some semi arid regions of Turkey.

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