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Determination of Seasonal Changes of Feed Value of Common Grazable Species in Aşağı Gökdere Macquis Shrublands

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A B S T R A C T

This study was conducted in the years of 2018-2020 to determine the feed value of common shrub species that can be grazed in the maquis area around Aşağı Gökdere village of Isparta. Ten species (*Quercus coccifera, Quercus infectoria, Quercus cerris, Phillyrea latifolia, Spartium junceum, Crataegus monogyna, Paliurus spina-christi, Juniperus oxycedrus, Cistus creticus* and *Arbutus andrachne*) were used in the study. Leaf samples were collected from these species in each season. Dry matter content, crude protein content, NDF, ADF, total digestible nutrients, relative feed value and tannin content were determined. According to the analysis of variance, the differences between seasons and shrub species were found to be statistically significant in all traits analyzed.

According to the two-year averages, when the seasons were compared, the highest crude protein content, total digestible nutrients and relative feed value were obtained in spring, decreased as the seasons progressed, and the lowest values were obtained in winter. The lowest dry matter ratios, ADF and NDF values were obtained in spring and they increased in parallel with the progression of the seasons. The lowest condensed tannin ratios were obtained in spring and summer, while the highest values were determined in autumn.

When the species were compared, the lowest dry matter and condensed tannins contents were found in *Spartium junceum*, while NDF and ADF ratios were found in *P. spina-christi*. The highest crude protein content was determined in *Quercus infectoria*, while total digestible nutrients and relative feed value were determined in *P. spina-christi* species. As a result, it was observed that shrubs, shrub-formed trees and shrubs in the maquis have an important potential as high quality feed for ruminants during the critical period in semi-arid and arid regions.

1. Introduction

The areas under the influence of the Mediterranean climate type in the world are around 100 million ha (Le Houerou, 1981). 32 million hectares of these areas are located in countries bordering the Mediterranean Sea. There are approximately 7.5 million hectares of maquis in Turkey and almost all of them are under the influence of the Mediterranean climate. (Baytekin et al., 2005). Maquis vegetation can spread in all kinds of soil conditions from acidic soils to basic soils. Due to their wide adaptability, maquis species have spread from sea level to the mid-alpine zone of high mountains and from arid to semi-arid regions (Tsiouvaras, 1987). In places where the summer dry period is severe, after the herbaceous layer dries up, the grasses lose their fodder quality and are not sufficient to meet the basic needs of animals. Shrubs can retain their greenery during this period and can provide much better-quality nutrients than dried grasses. Changes in plants depending on climate factors also affect

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the grazing habits of animals (Papachristou and Papanastasis, 1994; Temel and Tan, 2013; Gökkuş et al., 2009; Bakoğlu et al., 1999; Koç, 2000). Gutman et al. (1999) stated that herbaceous species are densely present in the vegetation during the early growth periods, they withdraw from the vegetation with maturity, but shrub and tree species are continuous throughout the year. Evergreen and deciduous shrubs and woody species are important sources of food for animals when herbaceous species are not available or are too few to meet the needs of animals (Silva-Pando et al., 1999; Temel and Kır, 2015).

Shrub communities with high fibre content (maquis and garig) are important feed resources for animals. Young shoots and leaves of these species contain more nutrients than herbaceous species in their young stages. Especially in the summer period, their feeding properties are very important (Dzowela et al., 1995; Tolera et al., 1997; Kamalak, 2006; Narvaez et al., 2010; Kökten et al. 2012; Dökülgen and Temel 2015; 2019; 2020). Because shrubs can largely meet the protein needs of grazing animals. In addition, they are important roughage sources at the end of winter and in summer, and especially their seeds are indispensable feed sources for wildlife in winter (Koç, 2000). Due to these characteristics, shrubs contribute to sustainable agriculture and have the potential to do much more. This great potential has found a serious place in the studies of scientists in our country only in the last 20 years, and many more issues related to shrubs are waiting to be studied.

In this study, it was aimed to determine the seasonal changes in the feed values of grazable common shrub species around Aşağı Gökdere village of Isparta.

2. Materials and Methods

This study was conducted in 2018-2020 in the shrubland area around the village of Aşağı Gökdere in Isparta (37° 32' 53.55" N, 30° 46' 18.65" E, 351 m). According to the climate data, annual total precipitation values in Aşağı Gökdere were 770.20 mm in 2018 and 848.80 mm in 2019, lower than the long-term average (856.0 mm). The average temperature was 14.58 ºC in 2018 and 14.05 ºC in 2019, higher than the long-term average (14.03 ºC). Average relative humidity values were 60.78% in 2018 and 60.15% in 2019, higher than the long-term average (58.21%).

The soils in Aşağı Gökdere are sandy-clay texture, salt-free (0.12 dS/m), lime content is below 2.5% and classified as non-lime, pH value is 7.40, slightly alkaline and organic matter content is below 2%.

Preliminary studies on the species included in the study and their locations were carried out in April 2018 and 10 common species with forage potential in the region were identified and their locations were marked with a GPS device (Table 1).

Leaf samples of the identified species were collected from the parts of the plants where animals can graze in each season (spring, summer, autumn and winter) in 2018 and 2019 (Alatürk et al., 2014). During sampling, 5 plants were selected from each species in each season. The locations of all sampled plants were determined with a GPS device, the plants were labelled and the same plants were sampled in each season. Spring samples were collected in April, summer samples in July, autumn samples in October and winter samples in February. Winter samples could not be taken from all plants due to defoliation of some species.

During the sampling periods, sufficient samples were taken for chemical analysis from each plant were dried in a drying oven at 65°C for 48 hours and kept at room humidity for 24 hours, then weighed on a 0.1 g sensitive balance and dry grass weights were determined. Dry matter was calculated as percentage by using the values obtained (Cevheri and Avcioglu, 1998).

Table 1. Species identified in the study

	Turkish Name	Latin Name	Family
1	Kermes Meşesi	*Quercus coccifera* L.	*Fagaceae*
2	Mazı Meşesi	*Quercus infectoria* Olivier	*Fagaceae*
3	Saçlı Meşe	*Quercus cerris* L.	*Fagaceae*
4	Akçakesme	*Phillyrea latifolia* L.	*Oleaceae*
5	Katırtırnağı	*Spartium junceum* L.	*Fabaceae*
6	Adi Alıç	*Crataegus monogyna*. Lindm.	*Rosaceae*
7	Karaçalı	*Paliurus spina-christi* Mill.	*Rhamnaceae*
8	Katran Ardıcı	*Juniperus oxycedrus* L.	*Cupressaceae*
9	Tüylü Laden	*Cistus creticus* L.	*Cistaceae*
10	Sandal	*Arbutus andrachne* L.	*Ericaceae*

After the shrub samples obtained were dried and ground, the amount of nitrogen was determined by Kjeldahl method, the value found was multiplied by 6.25 and crude protein ratios were determined (Helrich, 1990). NDF and ADF analyses were performed with the help of ANKOM 220 Fibre Analyser device according to the principles reported by ANKOM technology (Ankom, 2017). Condensed tannin content was determined according to the butanol-HCl method described by Makkar (2003). Total digestible nutritive value and relative feed value were calculated according to Horrocks and Vallentine (1999) (1, 2, 3, 4).

TDN = (-1.291 x ADF%) + 101.35 (1)
DMI = 120 / NDF% dry matter basis (2)
DDM = 88.9 – (0.779 x ADF dry matter basis) (3)
RFV = DDM% x DMI% x 0.775 (4)

NDF: Neutral Detergent Fiber
ADF: Acid Detergent Fiber
TDN: Total digestible nutrients
DMI: Dry matter intake
DDM: Digestible dry matter
RFV: Relative feed value

The results obtained in the study were subjected to statistical analysis by using SAS computer package programme according to factorial trial design in random blocks. Duncan multiple comparison test was used to compare the differences between means (Düzgüneş et al., 1987).

3. Results and Discussion

According to the variance analysis results of the data obtained from the study, season, species and season x species interaction had a statistically significant effect at the 1% level on all examined traits (Table 2).

In terms of seasonal averages, the highest dry matter ratio was obtained in autumn (60.55%) and the lowest value was obtained in spring (42.42%). The highest dry matter content among shrub species was obtained from *C. monogyna* with 62.06% and the lowest value was obtained from *S. junceum* with 46.20%. When the seasons are evaluated separately, *P. latifolia, C. monogyna, J. oxycedrus, Q. infectoria* and *Q. cerris* (47.43%, 49.85%, 47.33%, 44.23% and 43.95%) in spring, *C. monogyna* (70.90%) in summer, *P. latifolia, C. monogyna, Q. coccifera, J. oxycedrus* and *Q. cerris* (63.22%, 65.43%, 63.04%, 58.14% and 65.88%) in autumn, *Q. coccifera* (67.21%) in winter has a higher dry matter ratio than other species. The lowest values were obtained in *S. junceum* in spring, *S. junceum* and *A. andrachne* in summer, *P. spina-christi, S. junceum, C. creticus* and *A. andrachne* in autumn, *S. junceum* and *C. creticus* in winter. In seasonal averages, dry matter ratios increased until autumn and decreased in winter. However, in some species (*C. monogyna, P. spina-christi*) the highest values were determined in summer and in some species (*Q. coccifera*) in winter, and the differences in the rates of increase and decrease caused the species x season interactions to be significant (Table 3). The dry matter ratios were lowest in spring when the plants were green and juicy and increased to their highest level in the following seasons due to the decrease in air relative humidity and the drying of the plants. Similar results were found in other studies that analysed the seasonal variation of dry matter content in shrub leaves (Lyons et al., 1996; Muruz et al., 2000; Khorchani et al., 2000; Pollock et al., 2007; Gökkuş et al., 2009; Tölü, 2009; Tolunay et al., 2009).

Table 2. Results of variance analysis (Mean Squares)

Sources of Variation	Df		DM Ratio	CP Ratio	ADF Ratio	NDF Ratio	TDN Ratio	RFV	Tannin Content
	1	2							
Block	2	2	1.73	1.31	3.60*	16.98**	6.01*	708.97**	0.07
Year (Y)	-	1	257.28**	8.51**	1.29	1.11	2.15	65.72	1.37
Season (S)	3	3	3676.18**	236.77**	248.62**	759.98**	414.46**	25839.92**	16.63**
Species (Sp)	9	9	519.93**	60.58**	1686.83**	2014.28**	2811.31**	101012.61**	109.90**
S*Y Interaction	-	3	193.03**	2.92*	2.07	2.02	3.47	77.40	0.39
Sp*Y Interaction	-	9	34.64**	0.65	0.50	1.13	0.84	41.96	0.81
S*Sp Interaction	27	27	72.68**	17.09**	16.52**	36.47**	27.52**	1247.41**	2.66**
S*Sp*Y Interaction	-	27	18.88**	1.73**	0.55	0.88	0.91	48.68	0.26
Error	66	158	2.77	0.74	1.02	0.86	1.70	63.08	0.60

*P<0.05,**P<0.01, Df: Degrees of freedom, DM:Dry matter, CP:Crude protein, ADF: Acid detergent fiber, NDF: Neutral detergent fiber, TDN: Total digestible nutrient, RFV: Relative feed value.

Table 3. Two-year average dry matter rates determined in the study (%)

Shrub Species	Spring	Summer	Autumn	Winter	Mean
Phillyrea latifolia	47.43 k-m	58.56 f-j	63.22 b-d	58.99 e-h	**57.05 c**
Spartium junceum	31.03 p	49.14 k	54.41 ij	50.23 k	**46.20 g**
Juniperus oxycedrus	47.33 k-m	58.14 g-j	64.58 b-d	62.53 c-f	**58.15 c**
Cistus creticus	41.75 no	58.69 f-i	55.22 h-j	48.24 kl	**50.97 e**
Arbutus andrachne	40.30 no	47.31 k-m	56.14 h-j	54.17 j	**49.48 f**
Quercus coccifera	40.17 no	65.58 b-d	63.04 b-e	67.21 ab	**59.00 b**
Quercus infectoria	44.23 l-n	55.04 h-j	61.46 d-g	-	**53.57 d**
Quercus cerris	43.95 mn	66.87 bc	65.88 bc	-	**58.90 b**
Paliurus spina-christi	38.20 o	57.12 h-j	56.16 h-j	-	**50.49 ef**
Crataegus monogyna	49.85 k-m	70.90 a	65.43 b-d	-	**62.06 a**
Mean	**42.42 d**	**58.74 b**	**60.55 a**	**56.90 c**	

There is no statistical difference between the averages shown with the same letter.

When the average crude protein ratios are examined, it is seen that there is a significant difference between the seasons and crude protein ratios decreased with the progression of the seasons. The highest value was obtained in spring with 12.68% and the lowest value was obtained in winter with 7.20%. The highest crude protein ratios were obtained from *Q. infectoria* and *Q. cerris* with 12.09% and 11.94%. The lowest value was obtained from *J. oxycedrus* with 6.49%. Especially in the measurements in spring, it is seen that evergreen plant species have lower values in terms of crude protein ratio compared to other species. When the crude protein ratios of the species in Aşağı Gökdere are examined in terms of seasons, it is seen that *Q. infectoria* in spring, *P. spina-christi*, *Q. coccifera*, *Q. coccifera*, *C. creticus*, *Q. infectoria* and *Q. cerris* in summer, *C. monogyna*, *Q. coccifera* and *S. junceum* in autumn, *C. monogyna*, *Q. coccifera* and *S. junceum* in autumn and *S. junceum* in winter have the highest crude protein ratio. The lowest crude protein ratios were obtained from *J. oxycedrus* in spring, *J. oxycedrus* and *A. andrachne* in summer, autumn and winter. When comparing species in spring, it should not be overlooked that all the leaves of plant species that shed their leaves in winter are young in this season, while mature and young leaves are found together in evergreen plant species. When evergreen species were evaluated within themselves, the highest crude protein content was found in *A. andrachne* in spring, *Q. coccifera* and *C. creticus* in summer, *S. junceum* and *Q. coccifera* in autumn, and *S. junceum* in winter. The irregular seasonal variation in crude protein ratios of some species examined caused the species x season interaction to be significant in two-year averages (Table 4).

Table 4. Two-year average crude protein ratios determined in the study (%)

Shrub species	Spring	Summer	Autumn	Winter	Mean
Phillyrea latifolia	11.25 d-f	7.89 k-m	7.11 m-o	6.82 m-p	**8.26 d**
Spartium junceum	10.21 e-i	9.06 h-k	9.84 g-j	9.71 g-j	**9.71 c**
Juniperus oxycedrus	7.01 m-o	6.46 n-p	6.88 m-p	5.60 p	**6.49 e**
Cistus creticus	11.43 de	10.09 f-j	7.89 k-m	7.92 k-m	**9.33 c**
Arbutus andrachne	14.24 c	6.75 m-p	6.04 op	5.59 p	**8.15 d**
Quercus coccifera	12.18 d	10.03 f-j	9.04 h-k	7.57 l-n	**9.70 c**
Quercus infectoria	18.31 a	10.34 e-h	7.61 m-l	-	**12.09 a**
Quercus cerris	16.14 b	10.73 e-g	8.94 i-k	-	**11.94 ab**
Paliurus spina-christi	16.18 b	10.82 e-g	7.23 m-o	-	**11.41 b**
Crataegus monogyna	9.81 g-j	8.81 j-l	9.00 i-k	-	**9.21 c**
Mean	**12.68 a**	**9.09 b**	**7.96 c**	**7.20 d**	

While the highest crude protein ratios in leaves of all species were obtained in spring, crude protein ratios decreased in parallel with the progression of the seasons. As the growth rate slows down with the advancement of maturation in plants, the synthesized assimilates are stored in the form of carbohydrates and the crude protein ratio decreases accordingly (Koç et al., 2000). Similar results were obtained in many studies where changes in crude protein ratios of shrubs were monitored (Pollock et al., 2007; Gökkuş et al., 2009; Muruz et al., 2000; Lyons et al., 1996; Khorchani et al., 2000; Tölü, 2009; Ayhan et al., 2009; Tolunay et al., 2009; Aygün et al., 2018; Dökülgen and Temel, 2020). Considering that the crude protein ratio of forages used in feeding ruminants should be at least

10.60% (NRC, 2001), *P. latifolia*, *P. spina-christi*, *Q. coccifera*, *C. creticus*, *Q. infectoria*, *A. andrachne* and *Q. cerris* in spring and *P. spina-christi* and *Q. cerris* in summer produced forage with sufficient crude protein ratio for animals. In terms of crude protein ratios, *P. spina-christi*, *Q. infectoria* and *Q. cerris* were the prominent species.

The lowest NDF rates were obtained in spring with 33.12%, the NDF rate increased depending on the progression of the seasons and the highest values were obtained in winter with 46.31%. While the lowest NDF rate among the species was obtained from *P. spina-christi* with 22.00%, the highest NDF rate was obtained from *S. junceum* with 63.27%. When the seasons are evaluated separately, it is seen that *S. junceum* has a higher NDF rate compared to other species in all seasons. The lowest NDF rates were detected in *P. spina-christi* in spring, summer and autumn, and in *A. andrachne* in winter. When evergreen species are evaluated among themselves, the lowest NDF rate in all seasons was obtained from *A. andrachne*. The irregular seasonal variation in NDF ratios of some species examined caused the species x season interaction to be significant (Table 5). While the lowest NDF rates were obtained in spring, NDF rates increased as the seasons progressed. Similar findings have been revealed by many researchers (Castle, 1982; Holechek et al., 1989; Huston and Pinchak, 1991; Steen, 1992; Gonzalez–Andres and Ceresuela, 1998; Ventura et al., 1999; Ventura et al., 2004; Pecetti et al., 2007; Frost et al., 2008; Özarslan Parlak et al., 2011a; Özarslan Parlak et al., 2011b, Özarslan Parlak et al., 2011c, Bouazza et al., 2012; Aygün et al., 2018; Yüksel and Arslan Duru, 2019). Kökten et al. (2012) in their study examining the changes in nutritional value of different species, they found that the NDF ratio increased as the ripening period progressed in all species. It is known that at the beginning of growth, the majority of the cell protoplasm content of plants consists of water and cell wall substances are at low levels. Cell wall substances are associated with the presence of mature cells rather than young cells (Lyons et al., 1996). The amount of stem and cell wall substances responsible for the fibrous structure increases as the plant matures (Akyıldız, 1966; Griffin and Jung, 1983; Nelson and Mooser, 1994; Papachristou and Papanastasis, 1994; Koç et al., 2000; Açıkgöz, 2001; Frost et al., 2008). This increase leads to a significant reduction in the digestibility of the plant (Jung and Allen, 1995).

Table 5. Two-year average NDF ratios determined in the study (%)

Shrub species	Spring	Summer	Autumn	Winter	Mean
Phillyrea latifolia	33.57 l	34.85 k	36.44 ij	37.87 h	**35.68 f**
Spartium junceum	54.17 c	64.30 b	67.01 a	67.58 a	**63.27 a**
Juniperus oxycedrus	35.98 jk	41.77 g	46.74 f	52.22 d	**44.18 c**
Cistus creticus	27.95 q	32.37 mn	36.03 jk	38.50 h	**33.71 g**
Arbutus andrachne	26.80 q	27.34 q	27.64 q	29.72 p	**27.87 h**
Quercus coccifera	38.07 h	47.57 f	49.59 e	51.95 d	**46.80 b**
Quercus infectoria	31.83 no	40.84 g	46.72 f	-	**39.80 d**
Quercus cerris	30.96 o	37.86 h	41.35 g	-	**36.73 e**
Paliurus spina-christi	18.76 t	22.42 s	24.81 r	-	**22.00 i**
Crataegus monogyna	33.09 lm	35.92 jk	37.33 hi	-	**35.44 f**
Mean	**33.12 d**	**38.52 c**	**41.37 b**	**46.31 a**	

When the average ADF ratios were analysed, it was observed that there was a significant difference between the seasons and ADF ratio increased as the seasons progressed. The lowest ADF ratio was obtained in spring with 23.70%, the ADF ratio increased with the progression of the seasons and the highest values were obtained in winter with 34.10%. The lowest ADF rate was obtained from *P. spina-christi* with 11.81% and the highest ADF rate was obtained from *S. junceum* with 52.55%. When the seasons are evaluated individually, *P. spina-christi* in spring, summer and autumn, and *C. creticus* and *A. andrachne* in winter had lower ADF rates than other species. The highest ADF rates were detected in *S. junceum* in all four seasons. When evergreen species are evaluated within themselves, the lowest ADF rate in all seasons was obtained from *C. creticus* and *A. andrachne*. ADF rates of the examined species generally increased depending on the progression of the seasons. The lack of this statistical increase in some species (*P. latifolia* and *A. andrachne*) during the transition from spring to summer caused the species x season interaction to be significant. Considering that the NDF content of the grass consumed daily by ruminant animals should be at most 45.80% and the

ADF content should be at most 25% (NRC, 2001); *P. latifolia*, *C. monogyna*, *P. spina-christi*, *C. creticus*, *Q. infectoria*, *A. andrachne* and *Q. cerris* in spring, *C. monogyna*, *P. spina-christi*, *C. creticus*, *A. andrachne* and *Q. cerris* in summer, *C. monogyna*, *P. spina-christi*, *C. creticus* and *A. andrachne* in autumn contained fiber below the specified values. While the lowest ADF rates were obtained in spring, they increased as the seasons progressed (Table 6). Similar findings have been revealed by many researchers (Castle, 1982; Holechek et al., 1989; Huston and Pinchak, 1991; Steen, 1992; Gonzalez–Andres and Ceresuela, 1998; Ventura et al., 1999; Ventura et al., 2004; Pecetti et al., 2007; Frost et al., 2008; Özarslan Parlak et al., 2011b; Bouazza et al., 2012; Yüksel and Arslan Duru, 2019).

Table 6. Two-year average ADF ratios determined in the study (%)

Shrub species	Spring	Summer	Autumn	Winter	Mean
Phillyrea latifolia	24.80 k-n	25.52 j-m	26.54 ij	27.63 hi	**26.12 d**
Spartium junceum	43.93 d	51.58 c	55.31 b	59.37 a	**52.55 a**
Juniperus oxycedrus	28.28 h	33.72 f	32.92 fg	33.60 f	**32.13 c**
Cistus creticus	18.63 t	22.06 pq	22.73 p	24.31 m-o	**21.93 fg**
Arbutus andrachne	19.46 st	20.20 rs	21.30 qr	24.48 l-n	**21.36 g**
Quercus coccifera	28.06 h	33.40 f	32.06 g	35.20 e	**32.18 b**
Quercus infectoria	25.01 k-n	26.43 j	25.73 j-l	-	**25.72 d**
Quercus cerris	18.91 t	23.13 op	25.79 jk	-	**22.61 e**
Paliurus spina-christi	9.67 v	12.55 u	13.21 u	-	**11.81 h**
Crataegus monogyna	20.27 rs	22.30 pq	23.93 no	-	**22.17 ef**
Mean	**23.70 d**	**27.09 c**	**27.95 b**	**34.10 a**	

When the seasons were compared in terms of TDN ratios obtained in the study, it was observed that the highest value was obtained in spring with 70.75% and the lowest value was obtained in winter with 57.33%. In terms of total digestible nutrient ratio, the highest value was obtained from *P. spina-christi* with 86.11% and the lowest value was obtained from *S. junceum* with 33.51%. When we compare the species separately in each season, it is seen that *P. spina-christi* in spring, summer and autumn, *C. creticus* and *A. andrachne* in winter have the highest TDN ratio. The lowest rates were found in *S. junceum* in all seasons. When the species x season interactions were examined, there was no significant difference between summer and autumn averages in most of the species, while there was an increase in some species (*Q. coccifera*) and a decrease in some species (*C. monogyna*, *S. junceum* and *Q. cerris*), which caused the species x season interactions to be significant. While the highest TSBM rates were obtained in spring, TDN ratios decreased in parallel with the progression of the seasons. From spring to winter, TDN ratios decreased from 70.75% to 57.33% (Table 7). Türk et al. (2018) found the highest TDN ratios in the spring months in their study on *Q. coccifera* in Isparta and found that this ratio decreased until autumn.

Table 7. Two-year average TDN ratios determined in the study (%)

Shrub species	Spring	Summer	Autumn	Winter	Mean
Phillyrea latifolia	69.34 i-l	68.40 j-m	67.09 mn	65.68 no	**67.63 e**
Spartium junceum	44.63 s	34.76 t	29.95 u	24.70 v	**33.51 h**
Juniperus oxycedrus	64.84 o	57.82 q	58.85 pq	57.97 q	**59.87 f**
Cistus creticus	77.30 c	72.88 fg	72.00 g	69.97 h-j	**73.04 bc**
Arbutus andrachne	76.22 cd	75.27 de	73.85 ef	69.75 i-k	**73.77 b**
Quercus coccifera	65.12 o	58.23 q	59.96 p	55.91 r	**59.81 g**
Quercus infectoria	69.07 i-l	67.23 m	68.13 k-m	-	**68.14 e**
Quercus cerris	76.94 c	71.49 gh	68.06 lm	-	**72.16 d**
Crataegus monogyna	75.18 de	72.56 fg	70.45 hi	-	**72.73 cd**
Paliurus spina-christi	88.87 a	85.15 b	84.30 b	-	**86.11 a**
Mean	**70.75 a**	**66.38 b**	**65.26 b**	**57.33 c**	

When the relative feed values determined in the study are considered on a seasonal basis, it is seen that the highest value is obtained in spring with 216.1, relative feed values decrease as the seasons progress and the lowest values are obtained in winter with 138.9. While the highest value among the species was obtained from *P. spina-christi* with 342.1, the lowest value was obtained from *S.*

junceum with 71.7. When the relative feed values of the species are considered in terms of seasons, it is seen that *P. spina-christi* in spring, summer and autumn and *A. andrachne* in winter have the highest relative feed values. The lowest values were found in *S. junceum* in all seasons. While the relative feed values decreased in most of the species from spring to summer, there was no statistically significant decrease in *P. latifolia* and *A. andrachne*, which caused the species x season interaction to be significant (Table 8).

Table 8. Two-year average relative feed values determined in the study

Shrub species	Spring	Summer	Autumn	Winter	Mean
Phillyrea latifolia	192.8 h	184.2 h	174.2 ij	165.5 jk	**179.1 e**
Spartium junceum	93.9 r	70.5 s	63.6 st	58.7 t	**71.7 i**
Juniperus oxycedrus	172.9 ij	139.5 n	125.9 o	111.7 pq	**137.5 g**
Cistus creticus	247.5 de	206.1 g	183.7 h	169.0 i-k	**201.6 c**
Arbutus andrachne	255.9 d	248.9 de	243.3 e	218.5 f	**241.7 b**
Quercus coccifera	163.8 kl	122.9 o	119.9 op	110.1 q	**129.2 h**
Quercus infectoria	202.8 g	155.6 lm	137.1 n	-	**165.2 f**
Quercus cerris	222.8 f	174.1 ij	154.8 m	-	**183.9 de**
Paliurus spina-christi	403.3 a	328.3 b	294.7 c	-	**342.1 a**
Crataegus monogyna	205.5 g	185.2 h	175.1 i	-	**188.6 d**
Mean	**216.1 a**	**181.5 b**	**167.2 c**	**138.9 d**	

Relative feed value is a parameter calculated by using ADF and NDF values and used to compare the quality of feeds (Moore and Undersander, 2002). Therefore, the fibre ratio in the plant affects the relative feed value of the feed. Türk et al. (2018) determined the highest relative feed value in the spring months in their study *on Q. coccifera* in Isparta and stated that this ratio decreased until autumn. In this study, a similar decrease was found in terms of relative feed value in *Q. coccifera*. Kökten et al. (2012) from pre-flowering to fruit setting period relative feed values decreased from 328.0 to 107.7 in *Q. coccifera*, from 186.6 to 160.1 in *P. latifolia*, from 384.4 to 234.6 in *P. spina-christi*, from 769.3 to 402.8 in *P. terebinthus*. Temel (2015) stated that the highest relative feed values were obtained in the early vegetative development period in his study conducted in Igdir. These results were in parallel with the results we obtained.

Table 9. Two-year average tannin ratios determined in the study (%)

Shrub species	Spring	Summer	Autumn	Winter	Mean
Phillyrea latifolia	0.61 lm	0.25 m	0.41 lm	0.57 lm	**0.46 f**
Spartium junceum	0.42 lm	0.25 m	0.23 m	0.38 lm	**0.32 f**
Juniperus oxycedrus	6.57 b-d	7.24 b	8.39 a	8.18 a	**7.60 a**
Cistus creticus	4.49 fg	3.76 g-i	6.84 bc	6.07 c-e	**5.29 b**
Arbutus andrachne	3.48 hi	3.17 ij	5.45 e	5.64 de	**4.43 c**
Quercus coccifera	3.54 g-i	2.26 jk	3.13 i-j	2.76 i-j	**2.92 d**
Quercus infectoria	1.05 lm	2.13 j-k	3.12 ij	-	**1.99 e**
Quercus cerris	2.40 j	4.36 f-h	5.22 ef	-	**3.99 c**
Paliurus spina-christi	2.23 jk	1.31 kl	2.33 j	-	**1.96 e**
Crataegus monogyna	6.75 bc	6.04 c-e	8.33 a	-	**7.04 a**
Mean	**3.15 c**	**3.19 c**	**4.23 a**	**3.93b**	

When the seasons were compared in terms of tannin ratios, it was observed that the highest tannin ratio was obtained in autumn with 4.23% and the lowest values were obtained with 3.15% in spring and 3.19% in summer. In terms of tannin content, among the species, the highest values were obtained from *J. oxycedrus* and *C. monogyna* with 7.60% and 7.04%, while the lowest values were obtained from *S. junceum* and *P. latifolia*. When the seasons were evaluated separately, it was determined that *C. monogyna* and *J. oxycedrus* had the highest tannin ratio in spring, summer and autumn seasons, *J. oxycedrus* had the highest tannin ratio in winter season, while the species with the lowest ratios were *P. latifolia* and *S. junceum* in all seasons. When the species x season interactions were examined, it was observed that the tannin ratio increased significantly in *C. monogyna*, *P. spina-christi*, *J. oxycedrus*, *C. creticus* and *A. andrachne* from summer to autumn, while it did not change in *P. latifolia*, *Q. coccifera*, *S. junceum*, *Q. infectoria* and *Q. cerris*. The irregular variation of the tannin ratios of the studied species according to the seasons caused the species x season interactions to be significant (Table 9).

In the study, tannin ratios increased from spring to autumn and decreased in winter. Alatürk et al. (2014) examined 9 shrub species in Çanakkale and reported that the lowest tannin rate was determined in spring with 1.19% and the highest rate was determined in winter with 1.62%. Although the tannin rates we detected are higher, this result is similar to our study in terms of change according to seasons.

It is stated that in addition to ripening, genetic differences and environmental factors also affect the tannin content of plants (Barry and Forss, 1983; Mueller Harvey and Dhanoa, 1991). Tannin content is one of the factors that limit the grazing and digestion in shrub and tree species (Altın et al., 2021). Proanthocyanidins, also known as condensed tannins due to their chemical structure, are the most commonly found tannin group in trees and shrubs used as forage plants (Hagerman, 1987; Gutteridge and Shelton, 1994). Tannin ratios vary in terms of plant species, tissues and vegetation periods, and cattle, which have the lowest tolerance, can tolerate 1-4% tannin in the ration, while sheep can tolerate 6% and goats can tolerate 8-10% tannin in the ration. Although the effect varies according to the structure of the tannin and various factors, the generally acceptable tannin ratefor ruminants is 5% (Piluzza et al., 2014). A tannin content above 5% in the feed consumed by animals can cause toxic effects (Brooker et al., 1994). In the study *P. latifolia, P. spina-christi, Q. coccifera, S. junceum, C. creticus, Q. infectoria, A. andrachne* and *Q. cerris* in spring, *P. latifolia, P. spina-christi, Q. coccifera, S. Junceum* and *Q. infectoria* in autumn, *P. latifolia, Q. coccifera* ve *S. junceum* in winter were found to have tannin content below 5%, which is the threshold value to show a harmful effect for animals.

4. Conclusion

When the species, which are common in the around of Aşağı Gökdere and have feed potential, were evaluated in terms of the quality characteristics that should be present in the feeds of ruminants, it was determined that most of them had sufficient nutritional value. It was determined that these species produce sufficient quality grass for grazing, especially in the spring, and that additional feeding was not required in spring and summer. The maquis species have the highest feeding value in spring, but since this season is the period when meadows and pastures are at maximum value in terms of yield and quality, the need for quality roughage can be met at a much better level in this period compared to other seasons. Therefore, maquis species are of great importance in summer, autumn and winter seasons when it is difficult to provide quality roughage due to the herbaceous species drying up and withdrawing from vegetation, being consumed by grazing or becoming dormant. Because maquis species can maintain their greenness and quality feed value better than herbaceous species during these periods. Evergreen species are a source of feed even in winter. Considering the ratio of evergreen species in vegetation and the quality of forage they produce in autumn and winter, it is thought that additional feeding in this period will be beneficial for the health and productivity of grazing animals.

When the data obtained from the study are analysed in terms of quality parameters, it is seen that most of the maquis species, especially *P. spina-christi*, *Q. infectoria* and *Q. cerris*, produce quality forage for sheep and goats even in the summer period when the pastures are dormant, so it is concluded that it is a necessity to include maquis areas in grazing systems. In this way, the grazing period in pastures can be extended, feed costs which is the biggest input of animal husbandry can be reduced and profitability can be increased.

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