Seasonal Variation of the Nutrient Contents of *Sarcopoterium spinosum* (L.) Spach

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The research was conducted to find out the feeding potential of *Sarcopoterium spinosum* (L.) Spach, commonly found in Mediterranean climate dominated areas and also have an important place in rangeland livestock farming as well as in erosion of these areas. The study was carried out in Yıldız Koyu of Gökçeada Island in 2013. The nutrient contents of plant were determined seasonally (winter, summer, spring and fall) as well as in different organs (stalk and leaf) of the plant. Total of 10 plants were taken during each sampling period. Only the crude protein and ADF contents of plant leaf had found statistically important in terms of season, but there were not any significant importance in respect to other characteristics of the plant. The leaf and stalk ratios were changed between 37.57% (fall)–42.38% (winter) and 57.62% (winter)–62.49% (fall), respectively. Highest leaf/stalk ratio (0.74) has been observed in winter while the least (0.60) in fall. Average crude protein (6.39%), ash (9.66%) and fat (6.33–7.60%) of leaves were found more as compared to the crude protein (3.81%), ash (4.95%) and fat (4.37–5.80%) of stalk. On the other hand, NDF (36.19–43.41%), ADF (22.31–27.54%) and ADL (9.50–13.35%) of leaves were found less as compared to stalks. Consequently, *Sarcopoterium spinosum* has an importance in terms of soil protection and shrub formation into the degraded parts of Mediterranean flora, also found as a feed source for animals. However, supplementary feed should be given to the animals grazing in these areas for overcoming their poor performances.

Keywords: *Sarcopoterium spinosum* L., crude protein, crude ash, crude lipid, NDF, ADF, ADL

Introduction

Broad areas of maquis scrubland are found in Marmara, Aegean and Mediterranean regions of Turkey where the Mediterranean climatic conditions are dominant. This situation is due to the long hot and dry summer season of the Mediterranean climatic zone. A portion of Mediterranean shrubby (especially in disrupted areas) is composed of dwarf shrubs called as garrigue. In addition to climatic factors, soil conditions were also found very important for dwarf shrubs (Diamantopoulos et al., 1994). Thus in areas with drought season and particularly shallow soils, woody plants with roots close to the surface become dry quickly. In this situation shrubs with deeper roots become emplaced and preserve their greenery during the drought season. Because of this, the dominant plant vegetation cover in the Mediterranean climatic zone are the shrubby lands (maquis and garrigue). Maquis describes shrubs growing up to 5 meters, while the plant vegetation cover of garrigue describes the plants growing to a height of 1 meter. Maquis and garrigue plant vegetation cover encompasses 100 million hectares of the earth's surface in the world, while around 7 million hectares in Turkey (Baytekin et al., 2005).

Maquis plant cover is distributed in karstic areas, while garrigue plant vegetation cover grows in poor, arid and shallow soils. According to Yılmaz (1993), the most significant species found in maquis plant vegetation cover are: strawberry tree (*Arbutus unedo*), Greek strawberry tree (*Arbutus andrachne*), tree heath (*Erica arborea*), common myrtle (*Myrtus communis*), turpentine tree (*Pistacia terebinthus*), carob tree (*Ceretonia siliqua*), bay laurel (*Laurus nobilis*), evergreen oak (*Quercus ilex*), mock privet (*Phillyrea latifolia*), Judas tree (*Cercis siliquastrum*), juniper (*Juniperus* sp.), Spanish broom (*Spartium junceum*, *Genista* spp.), oleander (*Nerium oleander*), spiny broom (*Calicotome villosa*) and rockrose (pink rockrose) (*Cistus* spp.). In case of garrigue plant cover, kermes oak (*Quercus coccifera*), mock privet (*Phillyrea latifolia*), thyme (*Thymus* spp.), sage (*Salvia* spp.), rockrose (*Cistus* spp.), thorny burnet (*Sarcopoterium spinosum*), lavender (*Lavandula* spp.), rosemary (*Rosmarinum* spp.) and milkvetch (*Astragalus* spp.) are common (Yilmaz, 1996). Garrigue plant cover is commonly found in disrupted maquis areas. Many researchers mentioned that these are the peak plant cover in the Mediterranean climatic zone and they minimize the erosion risk than may occur in these areas (Bakir, 1987; Atalay et al., 2003). The westernmost point of Turkey in Gökçeada (Imbros)

is covered by 27% maquis and 33% thorny burnet (garrigue) stated by Cengiz et al., 2009. Within the garrigue pant cover, the amount of thorny burnet is very high. These areas on Gökçeada represent an important place in terms of pasture animal husbandry. As the characteristic trait of the Mediterranean belt is the short and dry green forage period, in these areas sheep and goat farming has increased. In general, cattle farming increases in areas with a long humid and green forage period (Seligman, 1996). By hiding the grazed portion of the leaves under the thorny portions, in semi-arid Mediterranean shrub pastures plants have become resistant to grazing (Osem et al., 2007). Due to these characteristics of plants, grazing is at very limited levels. That is why, the most favourable grazing periods were the winter and autumn months when the plants become soften (Gökkuş et al., 2009). Some studies showed that in periods when tasty species are not found into the vegetation cover then the animals are compelled to graze on ***Sarcopoterium spinosum*** with low flavor (Kababya et al., 1998; Aharon et al., 2007). ***S. spinosum*** is best consumed by sheep and especially goats. However, there is a reduction observed in goat population in island since 1980. On the other hand, the Gökçeada (Imbros) sheep has adapted well to this plant. The thorny burnet (*Sarcopoterium spinosum* (L.) Spach. syn: *Poterium spinosum* L.) belongs to the Rosaceae family and is within the scrub bush (nanophanerophyte) group (Smirin et al., 2010). Globally, it is spreading between the Mediterranean and Iran-Turanian regions (Lanteri et al., 2012).

In Turkey, it is generally observed in the Aegean, Mediterranean and Marmara regions (Adana, İstanbul, Antalya, Aydın, Çanakkale, İzmir and Sinop) (Davis, 1972; Anonymous, 2014). Its habitat is between 0-1000 meters (Kaya and Aladağ, 2009). ***S. spinosum*** requires shallow soil that is poor in phosphorus, and develops in practiced but abandoned areas and on limestone bedrock (Alphan, 2006; Reisman-Berman et al., 2006; Cengiz et al., 2009; Kaya and Aladağ, 2009; Henkin and Seligman, 2011). Garrigue plant cover develops after the disruption of maquis areas and is generally observed in areas with semi-arid climatic conditions (Atalay, 1994; Sternberg and Shoshany, 2001). The reason for its development and widespread cover in these areas are proposed as its adaptation ability, and high ability for sexual and asexual proliferation (Seligman and Henkin, 2009). It is a perennial plant, and may reach a height of 100-150 cm. Leaves are oppositely set and there are 9-15 leaves. Seeds do not have distribution characteristics that is why it forms an excess amount of seeds. Seeds may only spread up to 50 cm from the main plant. The amount of seeds left under the main plant is about 2000-3000 seeds/m^2. Thus it proliferates in a very rapid fashion. Fruits have 2 carpels and each carpel contains one seed (Mishkinsky, 1965; Osem et al., 2007; Seligman and Henkin, 2007; Metz et al., 2010). Flowers are bisexual, with a flowering duration of 3 months generally (February-March-April). Roots may reach a depth of 40 cm. The competitive power of the plant against other plants in terms of competition and aridity is very weak, especially in their seedling period (Litav et al., 1963; Reisman-Berman, 2007; Seifan et al., 2010). The thorny burnet is used in Middle Eastern countries for diabetes, to solve digestive problems, in cancer treatment and in religious services (Tovit et al., 2010). In Greece, it is used for bio-fuel technology (Margaris and Vokou, 1985). This plant is used in some Middle Eastern countries like Palestine as fencing material (Figure 9). A large proportion of the essential oil acids in the roots is elemol (66.65%) with the remainder α-eudesmol (33.26%) (Hudifa et al., 2013).

The pasture quality is an important factor in estimation of the productivity power of animals (Tatlı Seven and Çerçi, 2006). For this reason, the main aim of this study was to determine nutritional content of the grazable portions of thorny burnet (investigation of seasonal variations) and provide a good description of 33% vegetation covering of the grazing area.

Materials and Methods

The research was conducted in 2013 in the Yıldız Village of Gökçeada in Çanakkale Province. The soils used in the experiments were slightly alkaline (pH: 7.92), with low soluble salt (94.46 ppm) and carbonate (2.32%), moderate organic matter (2.68%), low phosphorus (2.42 ppm), high calcium (42.015 ppm), magnesium (4275 ppm) and potassium (2823 ppm) and low sodium (675 ppm) have been identified. According to the data records obtained from Çanakkale Provincial Directorate of Meteorology, in last 20 years (1982-2012) showed that the average monthly temperature in Gökçeada was 15.3 °C. Whether in the long term or in the experimental year, the highest monthly mean temperatures were in July and August while

the lowest temperatures have been measured in January and February. The 20 year mean annual total precipitation in Gökçeada was recorded as 722.1 mm, with mean total precipitation in 2010, 2012 and 2013 (except December) of 791.8, 792.7 and 869.1 mm with higher precipitation as compared to the long-term records. The year of 2011 was found more arid as compared to previous years (640.8 mm). During the experimental period, drought was generally effective in June-September. The plant materials used in this research work have been collected from a total of 10 plants selected randomly in each time. Plant samples were collected in the months of May, August, November and February to represent the spring, summer, autumn and winter seasons. Plant samples were taken to the laboratory and separated into leaf and stalk, and then necessary analyses have been done. The research determined leaf/stalk ratio, crude oil and ash analyses (AOAC, 2000), crude protein (Bremner, 1960) and NDF-ADF and ADL analyses (Van Soest et al., 1991). Statistical analysis in the research used the mean multiple comparison test with the SAS 9.0 statistical program.

Findings and Discussion

Leaf, stalk (%) and leaf/stalk ratio

There was no statistically significant variation in leaf, stalk and leaf/stalk ratios of thorny burnet according to season (Table 1). The highest leaf percentage was 42.38% in winter with lowest leaf percentage of 37.57% recorded in autumn for thorny burnet. The mean leaf percentages in the spring and summer months were very close to each other i.e., 41.28 and 41.72%, respectively. The mean leaf percentage produced during the year was noted as 40.88%. The stalk percentage within the seasonal mean grazable plant component produced was as 59.12%. The highest stalk percentage (62.43%) was measured in autumn while stalk percentages quite similar in the other months (between 57.62-58.28%). The year-long mean leaf/stalk ratio was identified as 0.69%. Within the year, the highest leaf/stalk ratio was 0.74% in winter, but the lowest has been identified in autumn (0.60). The ratio of leaf was found correlated to the life cycle of plant. As the plant leaves became dry in summer period it enters the autumn with the lowest leaf percentage and begins green again with autumn rains, increasing toward the winter period and reaching its highest point. After winter, the leaf percentages continuously reduced. Thus, the stalk percentage exhibits an inverse conditio

Table 1. Leaf, stalk and leaf/stalk ratio according to seasons

Seasons	Leaf ratio (%)	stalk ratio (%)	Leaf/stalk ratio (%)
Autumn	37,57	62,43	0,60
Winter	42,38	57,62	0,74
Spring	41,84	58,16	0,72
Summer	41,72	58,28	0,72
Mean	**40,88**	**59,12**	**0,69**
Pr>F P_{leaf} ratio=0,7944, $P_{stalk\ ratio}$=0,7944, $P_{leaf/stalk\ ratio}$ = 0,8871			

Ratio of crude protein (%)

In terms of crude protein content of different parts of the plant, the stalk had little difference in the periods (Pstalk=0.6773), while the leaf portion produced completely adverse results ((Pleaf=0.0017). The crude protein percentage in stalk part of the plant was recorded as 3.81%, having highest in spring (4.13%) and lowest (3.71%) in autumn. The mean protein percentage in the leaves was noted as 6.39%. The crude protein content in leaves were observed as 7.46% and 7.10% in winter and spring, respectively; while in autumn (6.38%) and summer (4.63%). The mean crude protein content in case of the whole plant was found highest in spring (5.37%) and lowest in summer (4.10%). As all portions of the plant dry out in the summer season, the crude protein percentage reaches at lowest levels. The mean crude protein content per season and plant part was identified as 4.87% shown in Table 2. For sheep and goat breeders, the protein content in feed for survival should be at least 8.9% (Welch, 1989). Studies have found the crude protein contents of thorny burnet are in between 3.8-5.6% (Özaslan-Parlak et al., 2011), but in case of another study findings, a variation of 6-8% has been mentioned (Kababya et al., 1997). Thus the thorny

burnet does not supply necessary protein requirements for sheep and goat survival in any season within the all parts of the plant.

Table2. Variation in crude protein ratio according to seasons and plant parts

Seasons	Ratio of crude protein (%)		
	stalk	Leaf	Mean
Autumn	3,71	6,38 **a**	4,71
Winter	3,69	7,46 **a**	5,29
Spring	4,13	7,10 **a**	5,37
Summer	3,72	4,63 **b**	4,10
Mean	**3,81**	**6,39**	**4,87**
Pr>F P_{stalk}=0,6773, P_{leaf}=0,0017			

Ratio of crude ash (%)

Differences between crude ash content of plant parts depending on season were not found statistically significant (Pstalk=0.2986, Pleaf=0.3854). The stalk part of thorny burnet had mean crude ash percentage of 4.92% along with the leaf content of 9.66%. However, the crude ash content of stalk part was highest in winter valued by 6.13%, while for leaves, it was observed highest in summer season with 11.35%. The lowest ash contents were recorded in stalk part in autumn with 3.99%, while the lowest was determined in leaves in autumn with a ratio of 8.39%. According to season, the crude ash content of the whole plant (stalks and leaves) was recorded highest in summer (7.63%), but the lowest was found in autumn (6.01%). Seasonal mean crude ash content of thorny burnet was determined as 6.85% shown in Table 3. The crude ash content found in the leaves of taken plant samples during the year was above the mineral requirements of animals. In this way, thorny burnet may be a good inorganic matter source for grazing animals.

Table 3. Variation in crude ash ratio according to seasons and plant parts

Seasons	Ratio of crude ash (%)		
	stalk	Leaf	Mean
Autumn	3,99	9,38	6,01
Winter	6,13	9,53	7,57
Spring	4,61	8,39	6,19
Summer	4,95	11,35	7,63
Mean	**4,92**	**9,66**	**6,85**
Pr>F P_{stalk}=0,2986, P_{leaf}=0,3854			

Ratio of crude oil (%)

Variance analysis found that the crude oil content of thorny burnet had no statistically significant difference according to season. The mean crude oil percentage in stalks was noted as 5.33% and in leaves it was recorded as 7.16%. Depending on season, the crude oil percentage in stalk varied from 4.73-5.80%, while in leaves it varied from 6.33-7.60%. The mean crude oil percentage in stalk and leaves varied from 5.89% (in autumn) and 6.37% (in spring) according to season (Table 4). For grazing animals, the consumed forage should not contain less than 2.70% oil (NRC, 2001). Accordingly, the grazable portions of thorny burnet contain sufficient levels of crude oil for animals throughout the year.

Table 4. Variation in crude oil ratio according to seasons and plant parts

Seasons	Crude fat ratio (%)		
	Stalk	Leaf	Mean
Autumn	5,62	6,33	5,89
Winter	5,18	7,56	6,19
Spring	5,80	7,16	6,37
Summer	4,73	7,60	5,93
Mean	**5,33**	**7,16**	**6,10**
Pr>F P_{stalk}=0,3475, P_{leaf}=0,1622			

Ratio of cell membrane matters (NDF, ADF, ADL)

The NDF ratio in the thorny burnet shrub did not have a statistically significant difference according to season. The stem section of the plant has NDF percentage of 69.52%, with this percentage 40.79% in leaves. Additionally, when season is examined, the highest NDF percentage in the stem was found in the summer season (71.85%) with highest percentage for leaves found in the autumn (43.41%). The lowest NDF percentage in the stem was 66.93% in the autumn and in leaves was 36.19% in the winter period. The NDF percentage for the whole plant varied from 59.81% (summer) to 54.83% (winter) and mean NDF percentage was determined as 57.75% (Table 5). For grazing animals, the daily based consumed forage should not contain NDF content more than 45.80% (NRC, 2001). According to this, the NDF content in stalk of the plant was above this level, but leaves had NDF content below the desired level.

Table 5. Variation in NDF ratio according to seasons and plant parts

Seasons	NDF oranı (%)		
	Stalk	Leaf	Mean
Autumn	66,93	40,60	57,03
Winter	68,53	36,19	54,83
Spring	70,77	43,41	59,32
Summer	71,85	42,98	59,81
Mean	**69,52**	**40,79**	**57,75**
Pr>F P_{stalk}=0,1884, P_{leaf}=0,2339			

The percentage of ADF in thorny burnet only had a statistically significant difference in leaves according to season. Accordingly, the mean ADF percentage in the stalk of the plant was recorded as 52.14%, while in leaves this percentage was gone down less than half (24.17%). The ADF percentage in plant stalks was lowest in autumn (49.21%), increasing by significant levels in spring and summer to 52.88% and 54.74%, respectively. The ADF percentage in leaves was significantly higher in spring as compared to other seasons (27.54%). It varied from 22.31-23.89% in other seasons. The seasonal mean varied from 42.28% (spring) and 39.25% (summer) for the whole plant (stalk + leaves). The mean ADF percentage was recorded as 40.67%, shown in Table 6. For grazing animals, the highest acceptable level of mean ADF is taken as 25%, and accordingly the stalk part of the plant had high ADF percentages throughout the year. However, the leaf ADF content was remained below at acceptable levels.

Table 6. Variation in ADF ratio according to seasons and plant parts

Seasons	ADF ratio (%)		
	stalk	Leaf	Mean
Autumn	49,21	23,98 **b**	39,73
Winter	51,72	22,31 **b**	39,25
Spring	52,88	27,54 **a**	42,28
Summer	54,74	22,83 **b**	41,42
Mean	**52,14**	**24,17**	**40,67**
Pr>F P_{stalk}=0,0582, P_{leaf}=0,0087			

The ADL content of stalk and leaf parts of the thorny burnet did not show any significant importance according to season. The stalk section of the plant had mean ADL as 20.26%, while the leaf portion had a much lower percentage of 11.36%. The ADL percentage in stalk varied from 18.83% (autumn) to 21.27% (summer), while the ADL percentage in leaves varied from 9.50% (spring) to 13.35% (autumn). The seasonal means varied from 17.56% (summer) to 15.98% (spring) for the whole plant (leaf + stem) along with the mean ADL percentage identified as 16.59% (Table 7). The ADL level in forage consumed by rangelands livestocks should not be above 10%. Accordingly, this level remained above into stalk section in all seasons, while the ADL content was slightly kept above the desired level in leaves.

Table 7. Variation in ADL ratio according to seasons and plant parts

Seasons	ADL ratio (%)		
	stalk	Leaf	Mean
Autumn	18.83	13.35	16.78
Winter	20.30	10.25	16.04
Spring	20.65	9.50	15.98
Summer	21.27	12.36	17.56
Mean	**20.26**	**11.36**	**16.59**
Pr>F P_{stalk}=0,6968, P_{leaf}=0,1128			

Conclusions

The research was conducted aim to reveal the nutritional potential of different plant parts (stalk and leaf) of the thorny burnet plant commonly found in shrubland vegetation cover (garrigue) in Mediterranean countries. The leaf percentage mean was found 40.88% with stalk percentage as 59.12% and leaf/stalk ratio as 0.69. The mean crude protein percentage in leaves was determined as 6.39%, but this ratio was found as 3.18% in stalks. The protein content of the leaves reached a maximum of 7.46% in winter, but with the lowest percentage of 4.63% in summer. The mean crude protein content for the whole plant was 4.87%. The mean crude ash percentage in leaves was found as 9.63%, while this value was 4.92% in stalks. The highest crude ash content in leaves was noted in summer (11.35%) with lowest in autumn (8.39%). The mean crude ash content for the whole plant was identified as 6.85%. The mean crude oil content of leaves was obtained as 7.16%, with stalk having mean of 5.33%. The highest oil content in the leaves was found in summer (7.60%) with lowest in autumn (6.33%), and mean oil content for the whole plant noted as 6.10%. The mean ratios of NDF, ADF and ADL found in the leaves were 40.79%, 24.17% and 11.14%, respectively, while this ratio was recorded as 69.52, 52.14 and 20.26% in stalks. According to these results, the nutritional content of the leaves of plant may not be an alternative source of forage for pasture-based animal farming in Mediterranean countries with short green forage period as the nutritional potential of the stalk is below desired levels and is not appropriate for animal nutrition. Thus, animals generally take more benefit from this plant in spring when new leaves start emerging.

References

Alphan, H. 2006. Ekosistem dinamiklerinin izlenmesine bir araç olarak peyzaj değişimlerinin analizi. Ekoloji, 58: 8-15.

Anonim, 2014. Türkiye bitkileri veri serisi. http://turkherb.ibu.edu.tr/index.

AOAC, 2000. Official Methods of Analysis. 17th Edition, Association of Analytical Chemists, Gaithersburg, MD, USA.

Atalay, I. 1994. Türkiye Vejetasyon Coğrafyası. Ege Üni. Basımevi, İzmir, s, 195.

Atalay, I., A. Semenderoğlu, H. Çukur and N. Gümüş, 2003. Driving forces of rangeland degradation in Turkey. The RICAMARE Workshop on Land Use Changes and Cover and Water Resources in the Mediterranean Region, 17 Feb., Toulouse, France, pp 8.

Bakır, Ö. 1987. Çayır Mera Amenajmanı. Ankara Üni. Ziraat Fak. Yay.: 992, Ders Kitabı: 292, 362 s.

Baytekin, H., İ. Y. Yurtman and T. Savaş, 2005. Süt keçiciliğinde kaba yem üretim organizasyonu. Süt Keçiciliği Ulusal Kongresi, 26-27 Mayıs 2005, İzmir.

Bremner, J.M. 1960. Determination of nitrogen in soil by Kjeldahl method. J. Agri. Sci. 55: 11-33.

Cengiz, T., H. Özcan, H. Baytekin, Ü. Altınoluk, A. Kelkit, F. Özkök, C. Akbulak and A.Ç. Kaptan, 2009. Gökçeada Arazi Kullanım Planlaması. TÜBİTAK ÇAYDAĞ Hızlı Destek Projesi (Proje No: 107Y337) Sonuç Raporu, s 146.

Davis, P.H. 1972. Flora of Turkey and the East Aegean Islands. Uni. of Edinburg Press, Vol. 4.

Diamantopulos, J., S.A. Pirintsos, N.S. Margaris and G.P. Stamou, 1994. Variation in Greek phrygana vegetation in relation to soil and climate. J. Vegetation Sci., 5: 355-360.

Gökkuş, A., A. Özaslan Parlak, H. Hakyemez, H. Baytekin and M. Parlak, 2009. Maki örtüsünde yer alan bitki türlerinin botanik özellikleri ile besleme değerlerindeki değişimin belirlenmesi. TÜBİTAK Proje No: 106O458, Sonuç Raporu, 147 s.

Henkin, Z. and N.G. Seligman, 2011. The role of management on the rate of secondary succession in Mediterranean shrubland after fire. Plant Biosystems, 145(3): 708-714.

Kababya, D., A. Perevolotsky, I. Bruckental and S. Landau, 1997. Nutritional potential of woody vegetation for local goats in Israel, In: Recent Advances in Small Ruminant Nutrition (Eds; Lindberg J.E., Gonda H.L., Ledin I.), Options Méditerranéennes: Série A, Séminaires Méditerranéens, n. 34, 47-52.

Kaya, B. and C. Aladağ, 2009. Maki ve garig topluluklarının Türkiye'deki yayılış alanları ve ekolojik özelliklerinin incelenmesi. Selçuk Üni. Sosyal Bil. Enst. Dergisi, 22: 67-80.

Lanteri, A., A. Guglielmo, P. Pavone and C. Salmeri, 2012. Seed germination in *Sarcopoterium spinosum* (L.) Spach from South-Eastern Sicily. Plant Biosystems, 147(1): 60-63.

Litav, M., G. Kupernik and G. Orshan, 1963. The role of competition as a factor in determining the distribution of dwarf shrub communities in the Mediterranean territory of Israel. J. Ecology, 51: 467-480.

Margaris, N. and D. Vokou, 1985. Latex producing plants in Greece. Biomass, 7: 161-170.

Metz, J., P. Liancourt, J. Kigel, D. Harel, M. Sternberg and K. Tielbörger, 2010. Plant survival in relation to seed size along environmental gradients: A long-term study from semi-arid and Mediterranean annual plant communities. J. Ecology, 98: 697-704.

Mishkinsky, J., E. Menczel and F. Sulman, 1965. Hypoglycemic Effect of *Poterium spinosum* L. (Rosaceae). Archives Internationales de Pharmacodynamie ET de Thérapie, 161(2): 306-313.

Nelson, C.J. and L.E. Moser, 1994. Plant factors affecting forage quality. In: Forage Quality, Evaluation and Utilization Fahey, Jr G.C., Ed., ASA, CSSA, SSSA, Wisconsin, 115-154.

NRC, 2001. Nutrient Requirements of Dairy Cattle. 7th Rev. ed. *Natl. Acad. Sci*., Washington, DC.

Osem, Y., I. Konsens, A. Perevelotsky and J. Kigel, 2007. Soil seed bank and seedling emergence of *Sarcopoterium spinosum* as affected by grazing in a patchy semiarid shrubland. Israel J. Plant Sciences, 55(1): 35-43.

Özaslan-Parlak, A., A. Gökkuş, B.H. Hakyemez and H. Baytekin, 2011. Shrub yield, forage quality in Mediterranean shrublands of West Turkey during a year. African J. Agric. Research, 6(7), 1726-1734.

Reisman-Berman, O. 2007. Age-related change in canopy traits shifts conspecific facilitation to interference in a semi-arid shrubland. Ecography, 30: 459-470.

Reisman–Berman, O., R. Kadmon and M. Shachak, 2006. Spatio-temporal scales of dispersal limitation in the recolonization of a semi–arid Mediterranean old–field. Echography, 29: 418-426.

Seifan, M., K. Tielbörger and R. Kadmon, 2010. Direct and indirect interactions among plants explain counterintuitive positive drought effects on an Eastern Mediterranean shrub species. Oikos, 119: 1601-1609.

Seligman, N. and Z. Henkin, 2007. Survival of *Sarcopoterium spinosum* seedlings growing on terra rossa soil. Israel J. Plant Sciences, 55(1): 45-51.

Seligman, N.G. 1996. Management of Mediterranean grasslands. In: The Ecology and Management of Grazing Systems, J. Hudgson, A.W. Illuis (eds.), CAB Int., 359-391.

Seligman, N.G. and Z. Henkin, 2009. Regeneration of a dominant Mediterranean Dwarf–Shrub after Fire. *J.* Vegetation Science, 11(6): 893-902.

Smirin, P., D. Taler, G. Abitbol, T. Brutman-Barazani, Z. Kerem, S. Sampson and T. Rosenzweig, 2010. *Sarcopoterium spinosum* extract as an antidiabetic agent: in vitro and in vivo study. J. Ethnopharmacology, 129: 10-17.

Sternberg, M. and Shoshany, 2001. Influence of slope aspect on Mediterranean woody formations: comparison of a semiarid and an arid site in Israel. Ecological Research, 16: 335-345.

Tatlı Seven, P. and I.H. Çerçi, 2006. Relationship between nutrient composition and feed digestibility determined with enzyme and nylon bag (in situ) techniques in feed sources. Bulg. J. Vet. Med., 9(2), 107−113.

Tovit, R., K. Zohar and D. Dvir, 2010. Pharmaceutical compositions comprising extracts of *Sarcopoterium spinosum*, components thereof and uses thereof. Patent: PCT/IB2010/052551.

Van Soest, P.J., J.D. Robertson and B.A. Lewis, 1991. Methods for dietary fiber, neutral detergent fiber and non-starch polysaccharides in relation to animal nutrition. J. Dairy Science, 74: 3583-3597.

Welch, B.L. 1989. Nutritive Value of Shrubs. In: The Biology and Utilization of Shrubs (Ed. C.M. McKell), Academic Press, Inc., 405-424.

Yılmaz, K.T. 1996. Akdeniz Doğal Bitki Örtüsü. Çukurova Üni. Ziraat Fak. Genel Yayın No: 141, Yardımcı Ders Kitapları Yayın No: 13, s 179.

Yılmaz, O. 1993. Maki Bitkileri. Ankara Üni. Ziraat Fak. Yayın No: 1326, Ders Kitabı: 325, s 60

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