Turkish Journal of Agricultural and Natural Sciences 12 (2): 390–396, 2025

https://doi.org/10.30910/turkjans.1609310

TÜRK TARIM ve DOĞA BİLİMLERİ DERGİSİ

TTDB

TURKISH JOURNAL of AGRICULTURAL and NATURAL SCIENCES

www.dergipark.gov.tr/turkjans

Original Article

Influence of Various Drying Methods on the Antioxidant and Essential Oil Content of *Salvia fruticosa* Plant

Uğur Tan[1]✉, Hatice Kübra Gören[1]

[1]Aydin Adnan Menderes University, Faculty of Agriculture, Department of Field Crops, 09100, Aydin, Türkiye

[1]https://orcid.org/0000-0002-9592-2790, [2]https://orcid.org/0000-0001-7654-1450

✉:ugur.tan@adu.edu.tr

ABSTRACT

Salvia fruticosa (Anatolian sage) contains significant amounts of secondary metabolites, which are essential for the plant's anti-inflammatory, antimicrobial, and antioxidant effects. The drying methods applied post-harvest directly impact the plant's essential oil content, antioxidant activity (ABTS, DPPH), total phenol, and flavonoid levels. In particular, drying temperature and method are critical factors in determining the degradation rate of these compounds, playing an important role in preserving the plant's medicinal and aromatic value. This study aims to investigate the effects of different post-harvest drying methods on the bioactive properties of the Salvia fruticosa to identify the most effective drying method. In this study, *Salvia fruticosa* plant subjected to various drying methods: sun drying, shade drying, and oven drying at 100°C, 70°C, and 40°C. According to results, drying in shade yielded the highest values of DPPH radical scavenging activity (61.71 mg TEAC/g DW) and ABTS activity (91.39 mg TEAC/g DW), alongside essential oil content (1.60%) and phenolic content (31.41 mg GAE/g DW). In contrast, D100 (drying at 100 °C) showed the lowest values for DPPH, ABTS, essential oil, phenol, and flavonoid as 19.16 mg TEAC/g DW, 43.95 mg TEAC/g DW, 0.06%, 13.02 mg GAE/g DW, and 35.29 mg rutin/g DW, respectively, highlighting the detrimental effects of thermal degradation. These findings suggest that lower temperature drying methods, specifically shade and sun drying, are more effective in preserving the integrity of beneficial compounds, thus maximizing the antioxidant capacity and essential oil value of sage.

Key words: *Drying methods, DPPH, Essential oil, Phenolic content, Antioxidant activity, Sage*

Farklı Kurutma Yöntemlerinin *Salvia fruticosa* Bitkisinin Antioksidan ve Uçucu Yağ İçeriği Üzerine Etkisi

ÖZ

Salvia fruticosa (Anadolu adaçayı), bitkisi yüksek oranda sekonder metabolit içermekte olup, anti-enflamatuvar, antimikrobiyal ve antioksidan etkilere sahip bir bitkidir. Hasat sonrası uygulanan kurutma yöntemleri, bitkinin uçucu yağ içeriği, antioksidan aktivitesi (ABTS, DPPH), toplam fenol ve flavonoid seviyelerini doğrudan etkilemektedir. Özellikle kurutma sıcaklığı ve yöntemi, bu bileşiklerin bozulma hızını belirleyerek bitkinin tıbbi ve aromatik değerini koruma açısından kritik bir rol oynar. Bu çalışma, farklı hasat sonrası kurutma yöntemlerinin bitkinin biyoaktif özelliklerine etkilerini araştırarak en etkili kurutma yöntemini belirlemeyi amaçlamaktadır. *Salvia fruticosa* bitkisi, güneşte kurutma, gölgede kurutma ve etüvde 100°C, 70°C ve 40°C'de kurutma gibi farklı yöntemlere tabi tutulmuştur. Kurutma işlemi tamamlandıktan (kuru ağırlık sabitlenince) sonra analizler yapılmıştır. Sonuçlara göre, gölgede kurutma en yüksek DPPH radikal süpürme aktivitesi (61,71 mg TEAC/g KM) ve ABTS aktivitesi (91,39 mg TEAC/g KM), uçucu yağ içeriği (1,60%) ve fenolik içeriği (31,41 mg GAE/g KM) elde edilmiştir. Buna karşılık, 100°C'de kurutma (D100), DPPH, ABTS, uçucu yağ, fenol ve flavonoid için en düşük değerler sırasıyla 19.16 mg TEAC/g KM, 43.95 mg TEAC/g KM, %0.06, 13.02 mg GAE/g KM ve 35.29 mg rutin/g KM olarak kaydedilmiş olup, termal bozulmanın olumsuz etkileri ortaya koyulmuştur. Bu bulgular, daha düşük sıcaklıklarda kurutma yöntemlerinin, özellikle gölgede ve güneşte kurutmanın, faydalı bileşiklerin

bütünlüğünü koruma açısından daha etkili olduğunu ve adaçayının antioksidan kapasitesi ile uçucu yağ değerini maksimize ettiğini göstermektedir.

Anahtar kelimeler: *Salvia fruticosa, Kurutma yöntemleri, DPPH, uçucu yağ, Fenolik içerik, Antioksidan aktivite*

INTRODUCTION

Sage is a part of the *Salvia* genus and encompasses over 900 species found on each continent in the world. These plants have been known to be used from time immemorial as remedies against a large number of diseases. Their primary indications relate to ailments such as pain, epilepsy, colds, bronchitis, tuberculosis, hemorrhages, and menstrual disorders. These plants have traditionally been utilized in curing over sixty ailments (Hamidpour et al., 2014; Topçu et al., 2017; Ghorbani and Esmaeilizadeh 2017). However, even if there are immense diversity in taxa, only a few *Salvia* species have major commercial importance. According to Demirci et al. (2002), *Salvia fruticosa* Miller, also known as *Salvia triloba* L., is one of the species that are of high commercial value, particularly in Turkey. *Salvia fruticosa* is native to the Mediterranean, including Türkiye, both in the wild and under cultivation. Şenol et al. (2010) reported that *Salvia fruticosa* has been consumed traditionally as herbal tea in winter periods. This species has restorative and curative properties of high value. *S. fruticosa* contains large amounts of secondary metabolites, including phenolics and terpenoids, which enrich its pharmacological properties. In fact, these compounds account for the plant's anti-inflammatory (El-Sayed et al., 2006), antibacterial (Delamare et al., 2007), and antioxidant (Tepe et al., 2006) activities. Phenolic constituents that present in *S. fruticosa*, rosmarinic acid is especially renowned for its high antioxidant activity (Lu and Foo, 2002; Papageorgiou et. al., 2008). Besides rosmarinic acid, there were many reports about *Salvia* species containing a large number of phenolic acids and flavonoids, such as vanillic acid, ferulic acid, caffeic acid, apigenin, quercetin, and luteolin (Askun et al., 2009; Papageorgiou et al., 2008).

Drying is an essential preservation technique in food processing. The major aim is to diminish the water activity of food goods, so limiting microbial proliferation and decreasing chemical reactions to prolong shelf life at ambient temperature. Moreover, drying diminishes the necessary storage space and enhances transit efficiency by decreasing weight. Drying methods encompass ancient procedures, such as sun or shade drying, and contemporary ones, such microwave or oven drying (Sathishkumar et al., 2009). Enzymatic and non-enzymatic processes during the drying of young plant tissues can substantially modify the phytochemical composition (Capecka et al., 2005). The retention of the essential oils and phenolic compounds into the plant materials occurs differently depending on the drying techniques. While high-temperature drying leads to severe loss of essential chemicals, different drying metods has demonstrated the ability for retaining higher quantities of bioactive ingredients due to reduced exposure time and lower temperatures (Figuérédo et al., 2011; Dinçer et al., 2012).

This study aims to evaluate the effects of different post-harvest drying methods on the bioactive properties of *Salvia fruticosa*. Specifically, it examines the impact on essential oil content, antioxidant capacity, total phenolic content, and flavonoid levels. The goal is to determine which drying method (sun drying, shade drying, or oven drying at varying temperatures) is most effective in preserving these valuable bioactive compounds. By identifying the optimal drying technique, this research aims to contribute to improving the quality and potential health benefits of dried *S. fruticosa*, supporting its use in herbal and medicinal applications.

.

MATERIALS AND METHODS

The plant material used in this study was *Salvia fruticosa* (Anatolian sage), cultivated at the Faculty of Agriculture, Aydin Adnan Menderes University. The plants are eight years old, were harvested during the flowering stage in 2024. The harvested material was divided into three replicates and subjected to different drying methods to evaluate their effects on bioactive compounds. The drying methods included sun drying, shade drying, and oven drying at temperatures of 100°C, 70°C, and 40°C. The drying process continued until a stable dry weight was achieved for each sample, ensuring consistency across treatments. Once the drying was complete, the plant materials were analyzed to determine their chemical composition, focusing on parameters such as essential oil content, phenolic content, flavonoid content, and antioxidant activity, to assess the impact of different drying techniques on the preservation of beneficial compounds.

Determination of Essential Oil Content

The content of the essential oil within the dried plant material was determined by using the hydro-distillation technique (Wichtl, 1971). For this 10 g of dried plant material was combined with 100 mL of distilled water and subjected to hydro-distillation in a Clevenger-type apparatus. The distillations were performed at

180°C for one hour. The mixture of distillate was cooled for five minutes after distillation. The separated essential oil was collected and measured. Results were expressed as the percentage, showing the amount of the essential oil obtained from weight of the dried plant material used.

Extraction of Samples

Dried plant samples have been crushed with a grinder and then sieved for homogeneity during extraction. A 500 mg aliquot of the powdered sample was extracted by combining it with 50 ml of 80% methanol in a shaking incubator maintained at 40°C for 2 hours. The extract was utilized immediately following its preparation for subsequent measurements.

DPPH (2,2-diphenyl-1-picrylhydrazyl) Assay

The antioxidant capacity was assessed utilizing the DPPH test, in accordance with the Gadow et al. (1999) and Maisuthisakul et al. (2007). A 100 µL aliquot of the extract was diluted to create four distinct concentrations, which were subsequently combined with 3.9 mL of freshly made 0.1 mM DPPH solution. The mixture was agitated and incubated in the absence of light at ambient temperature for 30 minutes. Following incubation, the absorbance was measured at 516 nm with a microplate reader. The antioxidant activity was quantified as Trolox equivalent antioxidant capacity (mg TEAC/g DW). The calibration equation for DPPH was y=1032.8x+93.5, (R^2=0.9967) as absorbance/mg TEAC ml^{-1}, absorbance calculated as total absorbance change (control absorbance – sample absorbance) to obtain linearly increasing value.

ABTS (2,2'-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid) Assay

The ABTS assay adhered to the methodology established by Re et al. (1999). To generate the ABTS radical cation (ABTS•+), a 7 mM ABTS solution was mixed with 2.45 mM potassium persulfate in a 1:1 ratio and allowed to react in the dark for 16 hours. The ABTS•+ solution was diluted with methanol to achieve an absorbance of 0.700 at 734 nm. A 5 µL aliquot of the plant extract was thereafter combined with 3.995 mL of the diluted ABTS•+ solution and incubated in the dark for 30 minutes. The absorbance was quantified, and the antioxidant capacity was represented as Trolox equivalent antioxidant capacity (mg TEAC/g DW). The calibration equation for ABTS was y=234.4x+69, (R^2=0.9995) as absorbance/mg TEAC ml^{-1}, absorbance calculated as total absorbance change (control absorbance – sample absorbance) to obtain linearly increasing value.

Determination of Total Flavonoid Content

To determine the flavonoid concentration, 0.5 mL of the extract was combined with 2.5 mL of distilled water and 150 µL of 5% sodium nitrite ($NaNO_2$). Following gentle mixing, the solution was permitted to react for 5 minutes, after which 300 µL of 10% aluminum chloride ($AlCl_3$) was introduced. Subsequent to an additional 5 minutes, 1 mL of 1 M sodium hydroxide (NaOH) was introduced, and the total volume was adjusted to 5 mL with distilled water. The solution was incubated for 30 minutes, and absorbance was measured at 510 nm using a microplate reader. The flavonoid content was quantified as Rutin trihydrate equivalents (MW: 664.56), in accordance with the methodology of Cheng et al. (2006). The calibration equation for flavonoid content was y=123x+7.5, (R^2 = 0.9816).

Determination of Total Phenolic Content

The total phenolic content was assessed utilizing the methodology outlined by Skerget et al. (2005). An aliquot of 0.5 mL of the extract was combined with 2.5 mL of 0.1 N Folin-Ciocalteu reagent and 2 mL of sodium carbonate (Na_2CO_3, 75 g/L). The amalgamation was incubated at 50°C for 5 minutes and subsequently cooled. Absorbance was quantified at 760 nm utilizing a microplate reader, and the phenolic content was articulated as gallic acid equivalents (mg GAE/g DW). The calibration equation for phenolic content was y=2240x+80.5, (R^2 = 0.9959).

Statistical Analyses

The one-way ANOVA approach was employed to compare the differences among the treatment groups. When ANOVA displayed significance, Tukey's HSD was employed as the post hoc test relative to the control to address multiple comparisons. All statistical analyses were conducted using JMP Pro 16 software (SAS Institute, Cary, NC, USA).

RESULTS AND DISCUSSION

The results of the ANOVA for the analyzed parameters have been presented in Table 1. According to this table, drying methods exhibited highly significant effects ($P < 0.01$) on all the studied parameters. These findings

show the importance of drying methods for the preservation or degradation of the bioactive compounds present in *S. fruticosa.*

Table 1. Analysis of Variance of Drying Methods on Bioactive Compounds in Salvia fruticosa: Essential Oil, Phenolic Content, DPPH, ABTS, and Flavonoid Levels

Source	df	EO (%)	Fenol (mg GAE/ g DW)	DPPH (mg TAEC/ g DW)	ABTS (mg TAEC/ g DW)	Flavonoid (mg rutin/ g DW)
		Mean Square				
Drying	4	1.084**	187.514**	829.911**	1218.360**	4568.260**

***:p-value of less than 0.01,*: p-value of less than 0.05.*

Figure 1 shows the effect of different drying methods on various parameters of the samples, including antioxidant activity (DPPH and ABTS), essential oil content, phenolic content, and flavonoid content. The results shows consistent trends across five parameters: DPPH radical scavenging activity, essential oil content, ABTS radical scavenging activity, phenolic content, and flavonoid content. Shade drying (DShd) and sun drying (DSun) consistently exhibited higher values across all five parameters compared to higher temperature drying methods, such as drying at 70°C (D70) and 100°C (D100).

A consistent pattern is seen where antioxidant activity, essential oil content, phenolic content, and flavonoid content decrease as drying temperature increases. Shade drying (DShd) and sun drying (DSun) demonstrate significantly higher values, indicating better preservation of beneficial compounds and antioxidant properties. The DPPH radical scavenging activity has highest in DShd (61.71 mg TEAC/g DW) and DSun (56.24 mg TEAC/g DW), however values decreasing as drying temperature rises, and D100 displaying the lowest activity (19.16 mg TEAC/g DW) (Figure 1A). Similarly, ABTS radical scavenging activity follows the same trend, with DShd showing the highest activity (91.39 mg TEAC/g DW) and D100 the lowest (43.95 mg TEAC/g DW) (Figure 1C). Essential oil content is also significantly higher in DShd (1.60%) and DSun (1.12%), while higher temperature drying methods shows a decrease, with D100 having the lowest value (0.06%) (Figure 1B). Phenolic content is highest in DShd (31.41 mg GAE/g DW) and DSun (28.12 mg GAE/g DW), while D100 shows the lowest value (13.02 mg GAE/g DW) (Figure 1D). Flavonoid content follows a similar trend, with DShd showing the highest value (125.39 mg rutin/g DW) and D100 having the lowest (35.29 mg rutin/g DW) (Figure 1E).

Higher temperature-drying treatments, in particular D70 and D100, produce high losses of all the parameters considered, and therefore are confirmed to have thermal degradation playing a key role in their reduction. Essential oil, phenolic content,, and flavonoids loss indicate how these compounds are susceptible to high temperatures and thus undergo degradation upon drying. Results showed that drying conditions using low temperatures better preserved the quality of the samples. Low-temperature drying methods, such as shade drying, is more effective in preserving essential oil yields, phenolic content, and antioxidant capacity compared to other techniques. In contrast, high-temperature oven drying, while reducing drying time, significantly compromised these properties due to the thermal degradation of essential oils and the breakdown of heat-sensitive compounds like polyphenols and flavonoids (Ayyobi et al., 2014). Also degrading thermolabile compounds like chlorophyll and bioactive components, impacting color and quality (Tellez et al., 2018). Therefore, with regards to maximum retention of antioxidant capacity, essential oil, and phenolic and flavonoid compounds, shade drying or sun drying is recommended as the most favorable approach. Shade and sun drying methods, by preserving these valuable compounds, allow the samples to retain their bioactive properties to a greater extent compared to high-temperature drying.

Other studies have also indicated the same tendency for DPPH radical scavenging activity, essential oil content, ABTS radical scavenging activity, phenolic content, and flavonoid content. More specifically, lower-temperature drying methods protect these compounds better than higher-temperature drying (Kwaśniewska-Karolak & Mostowski, 2021; Dudek et al., 2022; Sadowska et al., 2017; Stanisavljević et al., 2012). The studies carried out on *Salvia* species showed that antioxidant capacities have decreased with the increase of drying temperatures, due to the degradation of sensitive phytochemicals (Tohma et al., 2016). Therefore, other plant species have also shown the exact same trend, confirming that an increase in drying temperatures has an adverse effect on the antioxidant activities. Moreover heat-sensitive phytochemicals such as phenolics and flavonoids progressively degrade, resulting in a loss of their antioxidant properties in high temperatures. (Kwaśniewska-Karolak & Mostowski, 2021; Dudek et al., 2022). These degrations is happen primarily through evaporation,

oxidation, and structural breakdown. Mechanisms such as hydroperoxide formation and subsequent breakdown into inactive byproducts (Hamama & Nawar, 1991; Mahanta et al., 2021).

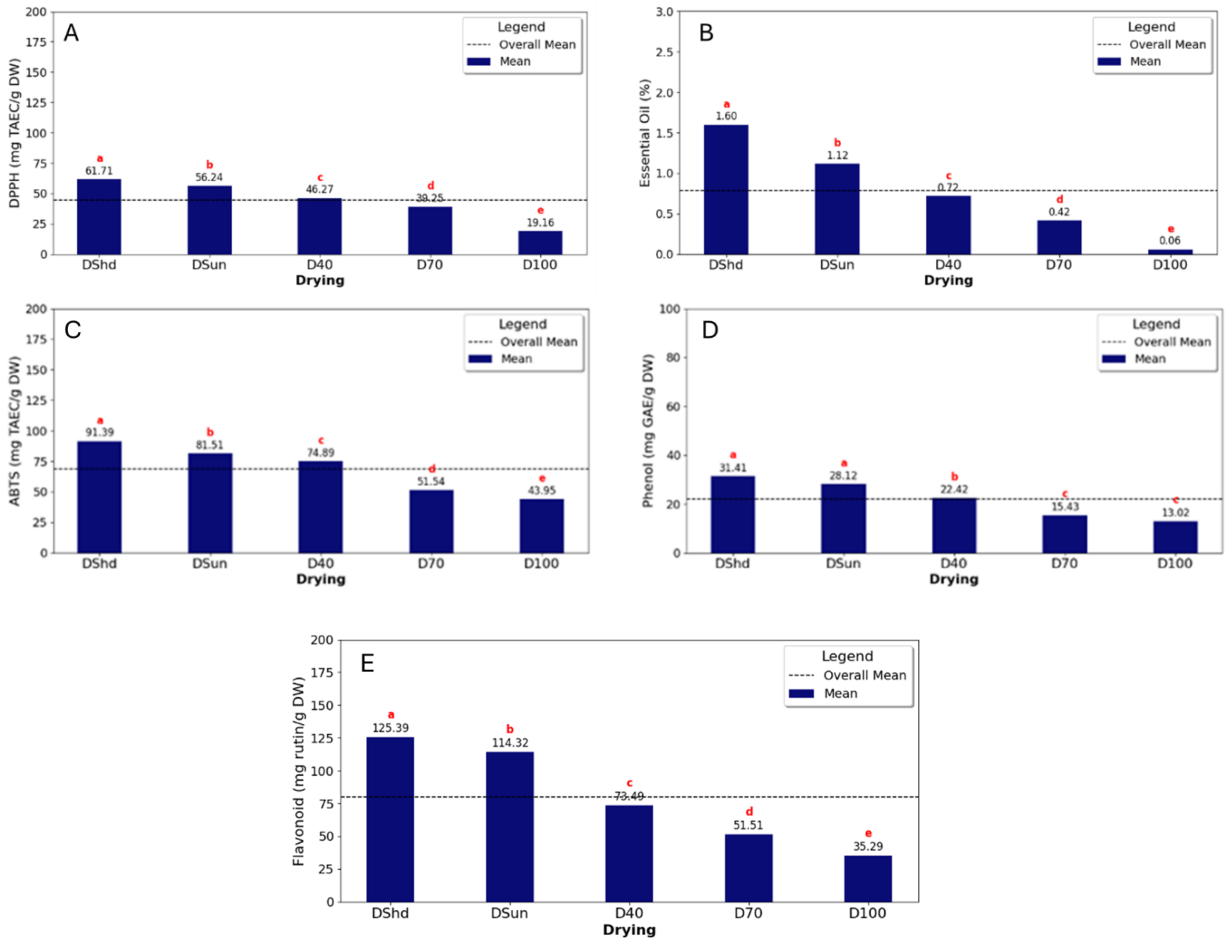

Figure 1. Effects of Drying Methods on Bioactive Compound Concentrations in *Salvia fruticosa*: DPPH(A), Essential Oil (B), DPPH (C), ABTS (C), Phenolic Content (D) and Flavonoid Content (E). Letter Groups Indicating Statistical Significance at $p \leq 0.01$.

Shade drying stands out for its ability to better preserve the bioactive compounds in plants. It minimizes the degradation of thermolabile (heat-sensitive) components such as phenolic compounds, flavonoids, and essential oils. Since this method operates at low temperatures, it helps retain color, aroma, and quality attributes. A study on *Ocimum basilicum* reported that samples dried in the shade exhibited higher antioxidant capacity compared to those dried in the sun (Tepe et al., 2006). However, shade drying often requires an extended duration; the drying process needs to be fast to prevent mold development due to humidity. Extended drying duration can cause quality loss (Babu et al., 2018). On the other hand, sun drying is a more economical and faster method. However, exposure to UV radiation and high temperatures during sun drying can lead to the degradation of bioactive compounds in plants. For example, structural degradation of essential oils has been observed at high temperatures (Paşa et al., 2021). In regions with high humidity, the drying time may be prolonged, which can result in a decline in plant quality (Chua et al., 2019). Shade drying is also ideal for maintaining the color, aroma, and structural integrity of herbs compared to in locations have high UV radiation (Thamkaew et al., 2021).

CONCLUSION

This study showed that drying temperature significantly influences the retention of bioactive compounds in *Salvia fruticosa*, with much higher temperatures drastically reducing such retention. Essential oils, antioxidants, phenolics, and flavonoids have decreased considerably with an increase in the drying temperature mainly because these compounds are heat-sensitive and degrade or evaporate upon exposure to higher temperatures. The results showed that either shade drying or sun drying was best suited for retaining these valuable bioactive components. However, selecting the appropriate method depends on specific conditions. Each

method has its own advantages and disadvantages. Shade drying excels in preserving bioactive compounds and quality but requires longer durations and proper ventilation. Sun drying is faster and more economical but may result in quality losses due to prolonged drying times in high-humidity conditions. Therefore, the choice of method should be choosed to the product and environmental conditions to optimize drying efficiently.

Acknowledgements
The analyses of the study were conducted at the Agricultural Biotechnology and Food Safety Application and Research Center, ADÜ-TARBİYOMER. We extend our sincere gratitude to the institution for its support.

Declaration of Interests
The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper

Author Contributions
Uğur TAN : Conceptualization; data curation; formal analysis; investigation; methodology; project administration; software; writing— original draft; writing—review and editing.
Hatice Kübra GÖREN : Conceptualization; investigation; methodology.

ORCID
Uğur TAN https://orcid.org/0000-0002-9592-2790
Hatice Kübra GÖREN https://orcid.org/0000-0001-7654-1450

Article History	
Submission received:	29.12.2024
Revised:	10.02.2025
Accepted:	13.02.2025

REFERENCES
Askun, T., Tumen, G., Satil, F., Ates, M. 2009. Characterization of the phenolic composition and antimicrobial activities of Turkish medicinal plants. *Pharm. Biol.* 47, 563–571.

Ayyobi, H., Peyvast, G., Olfati, J. 2014. Effect of drying methods on essential oil yield, total phenol content and antioxidant capacity of peppermint and dill. Ratarstvo i Povrtarstvo 51, 18-22. https://doi.org/10.5937/RATPOV51-5077.

Babu, A.K., Kumaresan, G., Raj, V.A.A. ve Velraj, R. 2018. Review of leaf drying: Mechanism and influencing parameters, drying methods, nutrient preservation, and mathematical models. Renewable and Sustainable Energy Reviews, 90: 536-556.

Capecka, E., Marecczek, A., Leja, M. 2005. Antioxidant activity of fresh and dry herbs of some *Lamiaceae* species. *Food Chem.* 93, 223–226.

Chua, L.Y., Chong, C.H., Chua, B.L. ve Figiel, A. 2019. Influence of drying methods on the antibacterial, antioxidant and essential oil volatile composition of herbs: a review. Food and Bioprocess Technology, 12: 450-476.

Delamare, A.P.L., Moschen-Pistorello, I.T., Artico, L., Atti-Serafini, L., Echeverrigaray, S. 2007. Antibacterial activity of the essential oils of *Salvia officinalis* L and *Salvia triloba* L cultivated in South Brazil. *Food Chem.* 100, 603–608.

Demirci, B., Tabanca, N., Başer, K.H.C. 2002. Enantiomeric distribution of some monoterpenes in the essential oils of some *Salvia* species. *Flavour Fragr. J.* 17, 54–58.

Dudek, K., Pietryja, M.J., Kurkiewicz, S., Kurkiewicz, M., Błońska-Fajfrowska, B., Wilczyński, S., Dzierżęga-Lęcznar, A. 2022. Influence of the drying method on the volatile component profile of *Hypericum perforatum* herb: a HS-SPME-GC/MS study. *Processes*, 10(12), 2593. https://doi.org/10.3390/pr10122593

El-Sayed, N.H., El-Eraky, W., Ibrahim, M.T., Mabry, T.J. 2006. Antiinflammatory and ulcerogenic activities of *Salvia triloba* extracts. *Fitoterapia* 77, 333–335.

Ghorbani, A., Esmaeilizadeh, M. 2017. Pharmacological properties of Salvia officinalis and its components. Journal of Traditional and Complementary Medicine 7, 433-440. https://doi.org/10.1016/j.jtcme.2016.12.014.

Hamama, A., Nawar, W. 1991. Thermal decomposition of some phenolic antioxidants. Journal of Agricultural and Food Chemistry 39, 1063-1069. https://doi.org/10.1021/JF00006A012.

Hamidpour, M., Hamidpour, R., Hamidpour, S., Shahlari, M. 2014. Chemistry, Pharmacology, and Medicinal Property of Sage (Salvia) to Prevent and Cure Illnesses such as Obesity, Diabetes, Depression, Dementia, Lupus, Autism, Heart Disease, and Cancer. Journal of Traditional and Complementary Medicine 4, 82-88. https://doi.org/10.4103/2225-4110.130373.

İzli, N., Yıldız, G., Ünal, H., Işık, E., Uylaşer, V. 2013. Effect of different drying methods on drying characteristics, colour, total phenolic content and antioxidant capacity of goldenberry (*Physalis peruviana* L.). *International Journal of Food Science & Technology*, 49(1), 9-17. https://doi.org/10.1111/ijfs.12266

Kwaśniewska-Karolak, I., Mostowski, R. 2021. Effect of different drying processes on an antioxidant potential of three species of *Lamiaceae* family. *Herba Polonica*, 67(1), 8-17. https://doi.org/10.2478/hepo-2021-0004

Lu, Y.R., Foo, L.Y. 2002. Polyphenolics of *Salvia* – a review. *Phytochemistry* 59, 117–140.

Mahanta, B., Bora, P., Kemprai, P., Borah, G., Lal, M., Haldar, S. 2021. Thermolabile essential oils, aromas and flavours: Degradation pathways, effect of thermal processing and alteration of sensory quality. Food Research International 145, 110404. https://doi.org/10.1016/j.foodres.2021.110404.

Papageorgiou, V., Gardeli, C., Mallouchos, A., Papaioannou, M., Komaitis, M. 2008. Variation of the chemical profile and antioxidant behavior of *Rosmarinus officinalis* L and *Salvia fruticosa* Miller grown in Greece. *J. Agric. Food Chem.* 56, 7254–7264.

Paşa, C., Kılıç, T., Selvi, S. ve Sağır, Z.Ö. 2019. Satureja cuneifolia Ten. (Lamiaceae) türünün farklı kurutma yöntemleri uygulanarak uçucu yağ oranlarının ve uçucu yağ bileşenlerinin tespit edilmesi. Journal of the Institute of Science and Technology, 9 (4): 2330-2335.

Phong, N.T., Duc, L.A., Khuyen, N.D. 2023. Effects of drying methods and drying temperature on product quality of *Phyllanthus amarus* (*P. amarus*). *IOP Conference Series: Earth and Environmental Science*, 1155(1), 012013. https://doi.org/10.1088/1755-1315/1155/1/012013

Sadowska, U., Kopeć, A., Kouřimská, L., Zarubova, L., Klouček, P. 2017. The effect of drying methods on the concentration of compounds in sage and thyme. *Journal of Food Processing and Preservation*, 41(6), e13286. https://doi.org/10.1111/jfpp.13286

Sathishkumar, R., Lakshmi, P.T.V., Annamalai, A. 2009. Effect of drying treatment on the content of antioxidants in *Enicostemma littorale* Blume. *Research Journal of Medicinal Plant*, 3(3), 93–101.

Stanisavljević, D., Stojičević, S.S., Đorđević, S., Zlatković, B., Veličković, D.T., Karabegović, I., Lazić, M.L. 2012. Antioxidant activity, the content of total phenols and flavonoids in the ethanol extracts of *Mentha longifolia* (L.) Hudson dried by the use of different techniques. *Chemical Industry and Chemical Engineering Quarterly*, 18(3), 411-420. https://doi.org/10.2298/ciceq110919017s

Şenol, F.S., Orhan, I., Celep, F., Kahraman, A., Doğan, M., Yilmaz, G., Şener, B. 2010. Survey of 55 Turkish *Salvia* taxa for their acetylcholinesterase inhibitory and antioxidant activities. *Food Chem.* 120, 34–43.

Tellez, M.C., Figueroa, I.P., Téllez, B.C., Vidaña, E.C.L. ve Ortiz, A.L. 2018. Solar drying of Stevia (Rebaudiana Bertoni) leaves using direct and indirect technologies. Solar Energy, 159: 898-907.

Tepe, B., Sokmen, M., Akpulat, H.A., Sokmen, A. 2006. Screening of the antioxidant potentials of six *Salvia* species from Turkey. *Food Chem.* 95, 200–204.

Thamkaew, G., Sjöholm, I. ve Galindo, F.G. 2021. A review of drying methods for improving the quality of dried herbs. Critical Reviews in Food Science and Nutrition, 61 (11): 1763-1786.

Tohma, H., Köksal, E., Kılıç, Ö., Alan, Y., Yılmaz, M.A., Gülçin, İ., Alwasel, S. 2016. RP-HPLC/MS/MS analysis of the phenolic compounds, antioxidant and antimicrobial activities of *Salvia* L. species. *Antioxidants*, 5(4), 38. https://doi.org/10.3390/antiox5040038

Topcu, G. 2006. Bioactive triterpenoids from *Salvia* species. *J. Nat. Prod.* 69, 482–487.

Topçu, G., Yücer, R., Şenol, H. 2017. Bioactive constituents of Anatolian Salvia species. Salvia Biotechnology, 31-132.