

Influence of time of harvesting on phytochemical composition and antioxidant activity of different organs of *Dittrichia viscosa* (L.) Greuter

Ercan Petekkaya¹, Tuğba İduğ^{2*}

¹Istanbul Medipol University, Graduate School of Health Sciences, Istanbul, Türkiye

²Istanbul Medipol University, School of Pharmacy, Department of Pharmacognosy, Istanbul, Türkiye

ARTICLE HISTORY

Received: Apr. 16, 2025

Accepted: Aug. 26, 2025

KEYWORDS

Dittrichia viscosa,
Antioxidant activity,
DPPH,
LC-MS/MS.

Abstract: Traditionally, the leaves and roots of *Dittrichia viscosa* are used as natural remedies for ailments, serving externally as an antispasmodic, sedative, and antiseptic, for treating wound healing, women's infertility, bronchial disorders, and hemorrhoids. It also exhibits various pharmacological properties, including antioxidant, enzyme inhibition, antibacterial, and anticancer activities. There has been limited comparison research on the ideal harvest time and plant part to extract for human health. This study aims to evaluate in which harvest period, and which part of the plant is rich in phenolic and flavonoid compounds throughout the year. Total phenolic and flavonoid content were quantified, and the DPPH radical scavenging activity test was performed on the methanol extracts. According to the results, the highest amount of phenolic and flavonoid content values was found in July harvest leaves (L07). This extract was analyzed with LC-MS/MS. The results were as follows: quercetin 40.66 mg/kg, rutin 16.41 mg/kg, rosmarinic acid 17.84 mg/kg, caffeic acid 7.98 mg/kg, and chlorogenic acid 3.89 mg/kg. Total phenolic and flavonoid contents and antioxidant activity of extracts obtained from leaves, roots, and flowers provide evidence for the reliability of their traditional use.

INTRODUCTION

The plant formerly known as *Inula viscosa* (L.) Aiton (Asteraceae) has been reclassified and is now referred to as *Dittrichia viscosa* (L.) Greuter (Figure 1). Common names of the plant are sticky fleabane, aromatic inula, and taoon, among others. In Türkiye, the species is locally known as “Sarı ot” and “Yapışkan andız otu”. The genus *Dittrichia* was renamed after the German botanist Manfred Dittrich, while the term “viscosa” is a Latin word that describes the sticky texture of the plant's glandular hairs. *D. viscosa* is an extensively branching, perennial, diminutive shrub that is widespread across the Mediterranean region. The plant possesses elongated and slender leaves characterized by serrated margins and the presence of glandular hairs on the surfaces. The viscous secretion from the glandular trichomes disperses an unpleasant odor. It was determined that the viscous secretion contains volatile oil. During its blooming phase, this plant can produce several yellow flower buds; the yellow capitula are dense and placed in a composite cluster (Figure 1). The canopy is highly compact and can attain a height of 150 cm. The species has high resilience to unfavorable abiotic conditions commonly

*Corresponding Author: Tuğba İDUĞ ✉ tugbaidug@gmail.com

✉ Istanbul Medipol University, School of

Pharmacy, Department of Pharmacognosy, Istanbul, Türkiye

The copyright of the published article belongs to its author under CC BY 4.0 license. To view a copy of this licence, visit <http://creativecommons.org/licenses/by/4.0/>

e-ISSN: 2148-6905

found in degraded conditions, such as repeated cutting, fire, drought, and nutrient-depleted soil. *D. viscosa*, a Mediterranean plant, is found naturally in Morocco, Southern Italy, Palestine, Algeria, Jordan, and other Mediterranean countries, including Türkiye. In many of these countries, the leaves and roots of *D. viscosa* have been commonly used as a traditional and natural treatment for a variety of illnesses and ailments (Bentarhlia *et al.*, 2024; Colak *et al.*, 2022; Grauso *et al.*, 2020; Tuzlacı, 2006). *D. viscosa* is traditionally used externally as antispasmodic, sedative, antiseptic, expectorant, antirheumatic, for wound healing, women's infertility, bronchial disorders, and haemorrhoids. It is also used internally as antipyretic, antispasmodic, antidiabetic, antidiarrheic, anthelmintic, general tonic, for headache and stomach pain (Ali-Shtayeh *et al.*, 1998).



Figure 1. *Dittrichia viscosa*, A: Parts of *Dittrichia viscosa* B: The overall appearance of the plant in natural habitat and its reproductive organs

Studies have found that extracts obtained from *D. viscosa* have various pharmacological properties such as antioxidant, enzyme inhibitor, hemostatic, antiproliferative, antibacterial, antimicrobial, antiameobic, cytotoxic, and anticancer activities (Chekroud *et al.*, 2020; Güçlü *et al.*, 2022; Hepokur *et al.*, 2019; Lounis *et al.*, 2018; Ozkan *et al.*, 2019; Öztürk *et al.*, 2022; Zeouk *et al.*, 2020).

Recently, sophisticated extraction techniques and very sensitive metabolic profiling approaches have been used efficiently to provide new information about the phytochemical profiles of plants. *D. viscosa* is a species that is well known for containing many different phytochemical groups. These phytochemicals are responsible for the bioactivities that are attributed to the plant. The majority of these compounds are sesquiterpenoids, which have different chemical structures and are classified as polar compounds. Flavonoids and caffeic acid derivatives are two groups of polar compounds that were found in the plant and were isolated and described. The plant also included a number of polar compounds that were extracted and characterized from various parts of the plant. These phytochemical investigations have been carried out by employing traditional methods such as chromatographic separations, which were then followed by spectroscopic procedures (Brahmi-Chendouh *et al.*, 2019; Grauso *et al.*, 2020; Ozkan *et al.*, 2019; Ouari & Benzidane, 2024). Compounds such as gallic acid, caffeic acid, rutin, luteolin, kaempferol, rosmarinic acid, myricetin, quercetin, and apigenin have been identified using analytical methods like UHPLC-HRMS, HPLC-DAD-MS, HPLC-DAD/ESI-MS, LC/MS-MS and GC-MS (Aissa *et al.*, 2019; Brahmi-Chendouh *et al.*, 2019; Kheyar-Kraouche *et al.*, 2018; Mahmoudi *et al.*, 2016; Ozkan *et al.*, 2019; Trimech *et al.*, 2014). Furthermore, the essential oil of the plant has a variety of functional groups, including aldehydes, alcohols, and esters, as well

as long-chain fatty acids, and alkyls. Additionally, the plant contains a high concentration of short-chain volatile compounds, primarily monoterpenoids (Grauso *et al.*, 2020).

Radicals with an unpaired valence electron at one nitrogen atom can be reduced by compounds with antioxidant properties. Analysis for antioxidant activity is based on spectrophotometric measurements of unreacted radicals after a certain incubation period. DPPH (2,2-diphenyl-1-picrylhydrazyl) is one of these radicals and is one of the frequently used methods for antioxidant activity (Abramovič *et al.*, 2017). Phenolic compounds and flavonoids exhibit significant free radical scavenging activity due to their hydroxyl groups, identifying them as potential antioxidants. The high polyphenol and flavonoid content found in *D. viscosa* leaves may result in high free radical scavenging and antioxidant activity for its extracts. To verify this, *in vitro* tests, including DPPH, FRAP, and Co(II)/EDTA-induced luminol chemiluminescence method, were used to compare the antioxidant activities of different extracts of various parts of *D. viscosa* (Trimech *et al.*, 2014; Qneibi *et al.*, 2021). In the bioactivity tests conducted, *D. viscosa* extracts showed high antioxidant activity. Additionally, compared to water extract, methanolic extract showed higher antioxidant activity. In a study comparing maceration, hot extraction with methanol or water, and Soxhlet ethanol extraction of leaves and flower buds of *D. viscosa*, the highest antioxidant activity was found in Soxhlet ethanol extraction (Mohti *et al.*, 2020; Mrid *et al.*, 2022). Ethanol and methanol are frequently used as polar solvents in the extraction processes of plants. When compared to nonpolar solvents, it was discovered that these solvents produced better yields in extracts of *D. viscosa*. On the other hand, it is common knowledge that plant extracts prepared with different solvents may show different biological activities (Grauso *et al.*, 2020). Although numerous studies have been conducted on the phenolic compounds, flavonoids, and antioxidant effects of *D. viscosa* extracts, not enough comparative studies have been done on the optimal harvest time (within a one-year vegetation period) and plant part to use for extraction to support human health. In light of the fact that the harvesting procedure is carried out during various vegetative periods of the plant, it is reasonable to assume that the plant will exhibit variations in terms of the active chemicals that it contains.

The objectives of this work were to assess the effects of time of harvesting on phytochemical composition and antioxidant activity of different organs of *Dittrichia viscosa*.

METHOD

Plant Material

Dittrichia viscosa were collected from the Salihli district of Manisa at different times of the plant's vegetation period (June, July, August, September, October, and November 2022) and separated into the different organs: leaves, flowers, roots, lateral roots, stems, and seeds. Even though the plant typically blooms between the months of August and October, it did not bloom until September in the year that it was harvested. Taking into consideration its traditional uses, the flowering branch tips were collected in September, and the mature flowers were collected in October. All plant materials were dried in the shade in the laboratory. The plant material was identified by Assoc. Prof. Gülnur Ekşi Bona (Department of Pharmaceutical Botany Faculty of Pharmacy, Istanbul University–Cerrahpasa, Türkiye). The collected plants were divided into parts and were given codes.

Extraction Procedure

Dried and crushed plant materials were extracted with 80% methanol with a Soxhlet for 8 hours. After extraction, the obtained methanol extracts were filtered. Then, the solvents were evaporated with a rotary evaporator. All extracts were stored in a refrigerator at 4°C until further required. All the parts of the plant were subjected to the same technique for extraction.

DPPH Radical Scavenging Activity

The extract's ability to scavenge DPPH radicals was determined using Özgen's method. Briefly, stock extracts were prepared at a concentration of 10 mg/mL and diluted with methanol to 2.5

mg/mL, 0.625 mg/mL, and 0.156 mg/mL. In a 96-well plate, 10 µL of each dilution was combined with 190 µL of DPPH solution. The mixture was shaken and left for 30 minutes at room temperature in the dark. The absorbance was then measured against methanol using a microplate reader set to 517 nm (Ozgen *et al.*, 2022).

DPPH radical scavenging activity was calculated as follows:

$$\text{Antioxidant activity (\%)} = [(A_0 - A_1) / A_0] \times 100$$

Where A₀ is the absorbance of the control and A₁ is the absorbance of the extracts or standard. The extract concentration with 50% inhibition (IC₅₀) was calculated using a graph plotting inhibition percentage against extraction concentration. Trolox was used as a positive control. The tests were carried out in triplicate.

Total Phenolic Content

A previously developed total phenolic content (TPC) analysis with slight modifications was used in this study (Singleton & Rossi, 1965). Briefly, 5 µL of the test samples (2.5, 1.25, 0.635, and 0.312 mg/mL in MeOH), 25 µL of 0.2 N Folin-Ciocalteu reagent, and 145 µL of distilled water were mixed in 96-well plates and gently shaken. After 6 minutes of incubation in the dark, 75 µL of Na₂CO₃ (7%) solution was added to the mixture and shaken again. The plates were incubated in the dark for two hours at room temperature. Absorbances at 765 nm were measured. Gallic acid was utilized as the standard. The results are given as gallic acid equivalents dry extract. (mg GAE/g). All tests were performed in triplicate.

Total Flavonoid Content

Total flavonoid content (TFC) was determined using AlCl₃ following the method described in the literature (Chang *et al.*, 2002). About 5 mg of each extract was dissolved in 10.0 mL of methanol. 1.0 mL of each solution was combined with 4.0 mL of distilled water, 0.3 mL of 5% NaNO₂, 0.6 mL of 10% AlCl₃, and 2.0 mL of 1 M NaOH, and left to stand for 6 minutes. The absorbance was measured at 510 nm using water as a blank. Standard catechin solutions at concentrations of (10, 20, 30, 50, and 100) mg/mL were used to create a calibration curve, which was then used to calculate TFC as milligrams of catechin equivalents per gram of dry extract (CE/g extract). Unless stated otherwise, all tests were performed in triplicate.

LC-MS/MS Analysis

LC-MS/MS analysis of methanolic extracts of *D. viscosa* were performed on a liquid chromatography system Agilent LC (1290)-MS/MS (6430).

RESULTS

Total phenolic and flavonoid content were quantified, and the DPPH radical scavenging activity test was performed on the obtained methanol extracts. Comprehensive data about the total phenolic content, total flavonoid content, and DPPH radical scavenging activity tests can be found in Table 1. The TPC ranged from 28.87 to 79.94 mg GAE/g extract, and TFC ranged from 21.08 to 69.43 mg CE/g extract. Antioxidant activity also ranged from 0.674 to 4.994 mg/mL extract. When the total phenolic and total flavonoid content values were examined together, it was seen that the highest amount of phenolic and flavonoid compounds was in the July harvest, so this harvest was chosen for the quantity determination of the selected phenolic compounds. The highest results were found in the July harvest's leaves (L07), while the lowest results were obtained in the October flower (F10) harvest and November seed (Se11) harvest, respectively. An LC-MS/MS analysis was performed on L07, which is one of the groups that has the highest content of phenolic and flavonoid compounds among the extracts. As a result of these analyses, five compounds, two of which were flavonoids and three were phenolic acid compounds, were identified, and their amounts were determined. The results were as follows: quercetin 40.66 mg/kg, rutin 16.41 mg/kg, rosmarinic acid 17.84 mg/kg, caffeic acid 7.98 mg/kg, and chlorogenic acid 3.89 mg/kg.

The highest amount of phenolic content was found in the leaf extract of the July (L07) harvest with a value of 87.86 mg GAE/g. The highest amount of flavonoid content was found in the leaf extract of the June (L06) harvest, with a value of 69.43 mg CE/g. According to the DPPH test result, the highest antioxidant activity was found as 0.674 IC₅₀ (mg/mL) in the flower extract of the September harvest (F10). According to the findings of the investigation that was carried out, it was discovered that extracts of leaves and flowers produced better outcomes. The traditional use of the plant is supported by the findings of phenolic and flavonoid content determinations, as well as antioxidant activity results.

Table 1. Antioxidant activity, total phenolic and total flavonoid contents of *D. viscosa* extracts

Harvest time	Plant Part	Codes	Total Phenolic Content (TPC) mg GAE/g	Total Flavonoid Content (TFC) mg CE/g	DPPH Radical Scavenging Activity IC ₅₀ (mg/mL)
June2022	Leaves	L06	79.74	69.43	1.448
	Stems	St06	32.97	25.63	3.551
	Lateral Roots	Lr06	34.42	26.71	2.938
	Roots	R06	48.06	36.57	0.884
July2022	Leaves	L07	87.86	67.65	1.528
	Stems	St07	28.87	30.55	4.994
	Lateral Roots	Lr07	42.68	32.34	2.421
	Roots	R07	42.94	29.9	1.196
August2022	Leaves	L08	77.59	67.68	1.523
	Stems	St08	32.24	21.08	2.789
	Lateral Roots	Lr08	54.32	41.66	2.305
	Roots	R08	36.63	28.81	1.198
September2022	Flowering branch tips	L09	61.87	59.03	2.022
	Stems	St09	29.61	24.82	5.019
	Lateral Roots	Lr09	57.35	44.51	1.724
	Roots	R09	60.63	43.15	0.682
October2022	Flowers	F10	43.02	37.36	0.674
November2022	Seed	Se10	35.53	22.75	3.983
	Trolox				3.44 (µg/mL)

In the ethanolic extract obtained from leaves and flower buds of *D. viscosa*, antioxidant activity evaluated by DPPH radical scavenging ability method, and the result showed an IC₅₀ value of 54.24 ± 0.21 µg/mL (Mohti *et al.*, 2020). In the methanolic extract from the aerial parts of *D. viscosa*, total flavonoid content was found as 86.274 ± 2.13 mg quercetin equivalents (QE)/g dry weight. Also, antioxidant activity was evaluated by DPPH radical scavenging ability method, and the result showed significant antioxidant activity with an IC₅₀ value of 1.36 mg/L (Ounaissia, 2021). The antioxidant activity of ointments containing ethanolic extracts of the plant at several concentrations (2.5%, 5%) was assessed using various methods (TAC, ABTS, FRAP, DPPH). A notable level of activity was detected in comparison to the control. The observed impact was attributed to the polyphenolic compounds in the plant, particularly the dicaffeoylquinic acid derivatives (Rhim *et al.*, 2019). A different study revealed that compounds extracted from the leaves of the plant, specifically dicaffeoylquinic acid derivatives, had greater antioxidant activity when compared to trolox and caffeic acid (Danino *et al.*, 2009). Hydroalcoholic extract of the leaves showed antioxidant activity with an IC₅₀ value (13.5 ± 0.44 µg/mL) compared to Trolox (3.23 ± 0.92 µg/mL). TFC value in the sample was found as 594.9 ± 12.2 mg rutin equivalents (RE)/g extract, and TPC value was found as 93.07 ± 9.1 mg GAE/g extract. This TPC value is similar to those results (140-274 GAE/g) (177 mg GAE/g) obtained

from Moroccan and Turkish plants, respectively (Chahmi *et al.*, 2015; Gökbulut *et al.*, 2013; Qneibi *et al.*, 2021). In another study, various techniques were used to extract bioactive compounds from the aerial parts of the plant, including 80% methanol decoction, 70% ethanol maceration, 50% ethanol and 99% ethanol Soxhlet extraction. All the extracts exhibited the TPC ranging from 12.354 to 22.184 µg GAE/mg, while the TFC ranged from 4.442 to 17.263 µg QE/g. The aqueous ethanol extract exhibited the maximum antioxidant activity, as determined by the DPPH method, with an IC₅₀ value of 21.00 µg/mL (Sevgi *et al.*, 2021).

In another study where various extracts (diethyl ether, ethyl acetate and methanol extracts) of its roots, stems, leaves and flowers were studied, total phenolic contents for diethyl ether extract was 0.86±0.47 mg GAE/g in the roots, 3.84±0.53 mg GAE/g in the stems, 5.78±0.57 mg GAE/g in the leaves, 6.95±0.59 mg GAE/g in the flowers; for ethyl acetate extract was 0.42±0.03 mg GAE/g in the roots, 24.18±2.07 mg GAE/g in the stems, 8.48±1.04 mg GAE/g in the leaves, 16.36±3.08 mg GAE/g in the flowers; for methanol extract was 14.50±2.55 mg GAE/g in the roots, 14.00±1.77 mg GAE/g in the stems, 2.57±0.68 mg GAE/g in the leaves, 10.42±0.58 mg GAE/g in the flowers were found. Moreover, when the DPPH radical scavenging activity results are compared, for the roots ethyl acetate extract, for the flowers stems and leaves, diethyl ether possessed the highest activity. The best activity was found in the diethyl ether extract obtained from the flowers (0.03 mg Ferulic acid equivalent (FAEs)/mL). However, methanol extracts also have remarkable results ranging from 0.20-0.25 FAEs/mL. The extracts also included quercetin, diacetyl quinic acid derivatives, chlorogenic acid, luteolin derivatives, and coumaric acid derivatives (Trimech *et al.*, 2014). In research, it has been highlighted that larger quantities of antioxidant compounds can be extracted with polar solvents such as water and methanol instead of extraction methods using organic solvents. However, when water and methanol extracts were examined, it was observed that methanol extracts had better yields (Ozkan *et al.*, 2019; Amrouche *et al.*, 2019). For this reason, in our study, 80% methanol was used as the extraction solvent.

A study conducted in Türkiye revealed that the methanol extract of the plant exhibited superior antiproliferative properties compared to the aqueous extract. Additionally, the methanol extract included higher levels of flavonoid and phenolic compounds. The HPLC-DAD study revealed the presence of several phenolic compounds including gallic acid, caffeic acid, chlorogenic acid, rosmarinic acid, rutin, luteolin, myricetin, quercetin especially notable source of kaempferol (Ozkan *et al.*, 2019). Methanolic extract of *D. viscosa* leaves contained compounds such as luteolin, isorhamnetin, chlorogenic acid, caffeic acid, taxifolin (Mahmoudi *et al.*, 2016).

A further investigation that was carried out in Türkiye showed that the methanol extract from the aerial parts of the plant had a significant antioxidant activity. The LC-MS/MS study revealed that it contained a high concentration of phenolic compounds, including acacetin, quercetin, chlorogenic acid, and protocatechuic acid, among others (Eruygur *et al.*, 2024). In a study that was carried out with *Inula graveolens*, it was found that alcoholic and aqueous extracts of the leaves of *I. graveolens* had powerful antioxidant activity. This activity was attributed to the fact that the extract contained a high concentration of phenolic compounds, including chlorogenic acid, quinic acid, hyperoside, protocatechuic acid, and quercetin (Silinsin & Bursal, 2018). In a different investigation that was carried out in Manisa/Türkiye, a comparison was made between the aqueous and methanolic extracts of the aerial parts of *D. viscosa*. In the aqueous extract, the total phenolic content was 59.2 mg GAE/g and the flavonoid content was 68.5 mg CE/g; in the methanol extract, the phenolic content was 107 mg GAE/g and the flavonoid content was 158.35 mg CE/g. The analysis of antioxidant activity was performed using the DPPH method. The IC₅₀ value was found to be 23.2 µg/mL in the aqueous extract, while the IC₅₀ value for the methanol extract was found to be 20.4 µg/mL (Ozkan *et al.*, 2019).

DISCUSSION and CONCLUSION

This study assesses the antioxidant activity and variations in the chemical profile of *D. viscosa* in Türkiye, focusing on different vegetative periods. Each part of the plant, including the leaves, roots, and other sections, was evaluated separately, considering their respective traditional uses. This study highlights the influence of the duration of plant collection on the chemical composition of the plant. The obtained findings are supported by the current collection of literature. The importance of our study lies in its capacity to reveal the comprehensive phytochemical composition of the plant and facilitate further research into its biological activity. Further research is necessary to make a thorough analysis of the chemical compounds found in the species.

Acknowledgments

The authors of this article declare that they have no financial, professional, or personal conflicts of interest that could have inappropriately influenced this work. This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Declaration of Conflicting Interests and Ethics

The authors declare no conflict of interest. This research study complies with research and publishing ethics. The scientific and legal responsibility for manuscripts published in IJSM belongs to the author.

Data Availability Statement

Research data is available and can be sent with e-mail upon request.

Authorship Contribution Statement

Ercan Petekkaya: Investigation, Methodology, Software. **Tuğba İduğ:** Investigation, Supervision, Conceptualization, Methodology, Writing-review & editing.

Orcid

Ercan Petekkaya  <https://orcid.org/0009-0002-9784-7277>

Tuğba İduğ  <https://orcid.org/0000-0001-8241-647X>

REFERENCES

- Abramovič, H., Grobin, B., Ulrih, N.P., & Cigić, B. (2017). The methodology applied in DPPH, ABTS and Folin-Ciocalteu assays has a large influence on the determined antioxidant potential. *Acta Chimica Slovenica*, 64(2), 491-499. <https://doi.org/10.17344/acs.2017.3408>
- Aissa, I., Znati, M., Zardi-Bergaoui, A., Flamini, G., Ascrizzi, R., & Jannet, H.B. (2019). GC and GC-MS integrated analyses and *in vitro* antibacterial, anticholinesterase, anti-tyrosinase, and anti-5-lipoxygenase potential of *Inula viscosa* root fractionated essential oil. *South African Journal of Botany*, 125, 386-392. <https://doi.org/10.1016/j.sajb.2019.08.019>
- Ali-Shtayeh, M.S., Yaghmour, R.M.R., Faïdi, Y.R., Salem, K., & Al-Nuri, M.A. (1998). Antimicrobial activity of 20 plants used in folkloric medicine in the Palestinian area. *Journal of Ethnopharmacology*, 60(3), 265-271. [https://doi.org/10.1016/S0378-8741\(97\)00153-0](https://doi.org/10.1016/S0378-8741(97)00153-0)
- Amrouche, S., Mohellebi, F., & Derriche, R. (2019). Extraction of antioxidant phenolic compounds from Algerian *Inula viscosa* leaves: influence of the harvest period and optimization. *Journal of Fundamental and Applied Sciences*, 11(3), 1212-1227. <http://dx.doi.org/10.4314/jfas.v11i3.11>
- Bentarhlia, N., Kartah, B.E., Fadil, M., El Harkaoui, S., Matthäus, B., Abboussi, O., Abdelmoumen, H., Bouhnik, O., & El Monfalouti, H. (2024). Exploring the wound-healing and antimicrobial potential of *Dittrichia viscosa* L lipidic extract: Chemical composition and *in vivo* evaluation. *Fitoterapia*, 172, 105707. <https://doi.org/10.1016/j.fitote.2023.105707>
- Brahmi-Chendouh, N., Piccolella, S., Crescente, G., Pacifico, F., Boulekbache, L., Hamri-Zeghichi, S., Akkal, S., Madani, K., & Pacifico, S. (2019). A nutraceutical extract from *Inula viscosa* leaves: UHPLC-HR-MS/MS based polyphenol profile, and antioxidant and cytotoxic activities. *Journal of Food and Drug Analysis*, 27(3), 692-702. <https://doi.org/10.1016/j.jfda.2018.11.006>
- Chahmi, N., Anissi, J., Jennan, S., Farah, A., Sendide, K., & El Hassouni, M. (2015). Antioxidant activities and total phenol content of *Inula viscosa* extracts selected from three regions of Morocco. *Asian Pacific Journal of Tropical Biomedicine*, 5(3), 228-233. [https://doi.org/10.1016/S2221-1691\(15\)30010-1](https://doi.org/10.1016/S2221-1691(15)30010-1)

- Chang, C.C., Yang, M.H., Wen, H.M., & Chern, J.C. (2002). Estimation of total flavonoid content in propolis by two complementary colometric methods. *Journal of Food and Drug Analysis*, 10(3), 178-182. <https://doi.org/10.38212/2224-6614.2748>
- Chekroud, Z., Kheffif, A., & Bassout, R. (2020). Valorisation of Algerian medicinal plants: *Inula viscosa* L. a future source of antibacterial drugs. *Asian Journal of Scientific Research*, 13(1), 58-66. <https://doi.org/10.3923/ajsr.2020.58.66>
- Colak, D.K., Egili, U., Eryilmaz, I.E., Aybastier, O., Malyer, H., Cecener, G., & Tunca, B. (2022). The anticancer effect of *Inula viscosa* methanol extract by miRNAs' re-regulation: an *in vitro* study on human malignant melanoma cells. *Nutrition and Cancer*, 74(1), 211-224. <https://doi.org/10.1080/01635581.2020.1869791>
- Danino, O., Gottlieb, H.E., Grossman, S., & Bergman, M. (2009). Antioxidant activity of 1, 3-dicaffeoylquinic acid isolated from *Inula viscosa*. *Food Research International*, 42(9), 1273-1280. <https://doi.org/10.1016/j.foodres.2009.03.023>
- Eruygur, N., Tuzcu, N., Tugay, O., Yilmaz, M.A., & Cakir, O. (2024). Phytochemical characterization and biological activities of *Inula viscosa* L. Aiton: A promising plant from Turkey. *International Journal of Environmental Health Research*, 34(9), 1-14. <https://doi.org/10.1080/09603123.2024.2305215>
- Gökbulut, A., Özhana, O., Satılmış, B., Batçioğlu, K., Günal, S., & Şarer, E. (2013). Antioxidant and antimicrobial activities, and phenolic compounds of selected *Inula* species from Turkey. *Natural Product Communications*, 8(4), 475-478 <https://doi.org/10.1177/1934578X1300800417>
- Grauso, L., Cesarano, G., Zotti, M., Ranesi, M., Sun, W., Bonanomi, G., & Lanzotti, V. (2020). Exploring *Dittrichia viscosa* (L.) Greuter phytochemical diversity to explain its antimicrobial, nematocidal and insecticidal activity. *Phytochemistry Reviews*, 19, 659-689. <https://doi.org/10.1007/s11101-019-09607-1>
- Güçlü, G., Ergül, M., Uçar, E., Eruygur, N., Ataş, M., & Akpulat, H.A. (2022). Anticancer, antioxidant, antimicrobial and enzyme inhibitory activities of *Inula aucheriana*. *Journal Of Agriculture and Nature*, 25(5), 946-954. <https://doi.org/10.18016/ksutarimdogu.vi.985837>
- Hepokur, C., Budak, Y., Karayel, H.B., Selvi, B., & Yaylım, İ. (2019). Investigation of cytotoxic effects of *Inula viscosa* extract. *Cumhuriyet Science Journal*, 40(3), 578-582. <https://doi.org/10.17776/csj.437993>
- Khayar-Kraouche, N., da Silva, A.B., Serra, A.T., Bedjou, F., & Bronze, M.R. (2018). Characterization by liquid chromatography-mass spectrometry and antioxidant activity of an ethanolic extract of *Inula viscosa* leaves. *Journal of Pharmaceutical and Biomedical Analysis*, 156, 297-306. <https://doi.org/10.1016/j.jpba.2018.04.047>
- Lounis, H., Bergheim, I., Bouhaimi, A., Guignonis, J.M., & Belhamel, K. (2018). Anti-inflammatory and antioxidant activities of *Inula viscosa* and *Senecio anteuphorbium*. *Oriental Pharmacy and Experimental Medicine*, 18, 225-236. <https://doi.org/10.1007/s13596-018-0307-0>
- Mahmoudi, H., Hosni, K., Zaouali, W., Amri, I., Zargouni, H., Hamida, N.B., Kaddour, R., Hamrouni, L., Nasri, M.B., & Ouerghi, Z. (2016). Comprehensive phytochemical analysis, antioxidant and antifungal activities of *Inula viscosa* Aiton leaves. *Journal of Food Safety*, 36(1), 77-88. <https://doi.org/10.1111/jfs.12215>
- Mohti, H., Taviano, M.F., Cacciola, F., Dugo, P., Mondello, L., Marino, A., Crisafi, G., Benameur, Q., Zaid, A., & Miceli, N. (2020). *Inula viscosa* (L.) Aiton leaves and flower buds: Effect of extraction solvent/technique on their antioxidant ability, antimicrobial properties and phenolic profile. *Natural Product Research*, 34(1), 46-52. <https://doi.org/10.1080/14786419.2019.1569659>
- Mrid, R.B., Bouchmaa, N., Kabach, I., Zouaoui, Z., Chtibi, H., Maadoudi, M.E., Kounnoun, A., Cacciola, F., El Majdoub, Y.O., Mondello, L., Zyad, A., & Nhiri, M. (2022). *Dittrichia viscosa* L. leaves: A valuable source of bioactive compounds with multiple pharmacological effects. *Molecules*, 27(7), 2108. <https://doi.org/10.3390/molecules27072108>
- Ouari, S., & Benzidane, N. (2024). Chemical composition, biological activities, and molecular mechanism of *Inula viscosa* (L.) bioactive compounds: A review. *Naunyn-Schmiedeberg's Archives of Pharmacology*, 397, 3857-3865. <https://doi.org/10.1007/s00210-023-02930-7>
- Ounaissia, K. (2021). Total phenol content, antioxidant and anti-inflammatory activities of *Inula viscosa* from Guelma-Algeria. *International Journal of Agricultural and Natural Sciences*, 14(3), 186-193. Retrieved from <https://www.ijans.org/index.php/ijans/article/view/544>

- Omurtag Ozgen, P.S., Biltekin, S.N., Idug, T., Macit, C., Ayran, I., Celik, S.A., Kultur, Ş., Kan, Y., & Omurtag, G.Z. (2022). Chemical composition and *in vitro* mutagenic, antioxidant and anti-inflammatory activities of *Lavandula angustifolia* Mill. essential oil from Turkey. *Journal of Research in Pharmacy*, 26(4), 781–789. <https://doi.org/10.29228/jrp.175>
- Ozkan, E., Karakas, F.P., Yildirim, A.B., Tas, I., Eker, I., Yavuz, M.Z., & Turker, A.U. (2019). Promising medicinal plant *Inula viscosa* L.: Antiproliferative, antioxidant, antibacterial and phenolic profiles. *Progress in Nutrition*, 21(3), 652–661. <https://doi.org/10.23751/pn.v21i3.7186>
- Qneibi, M., Hanania, M., Jaradat, N., Emwas, N., & Radwan, S. (2021). *Inula viscosa* (L.) Greuter, phytochemical composition, antioxidant, total phenolic content, total flavonoids content and neuroprotective effects. *European Journal of Integrative Medicine*, 42, 101291. <https://doi.org/10.1016/j.eujim.2021.101291>
- Öztürk, O.U., Uğur, M., Güzel, Y., Öztürk, M.A., Gürsoy, D., Doğan, S., & Temiz, M. (2022). Hemostatic effects of traditional *Inula viscosa* and *Capsella bursa-pastoris* plant mixture extract on rat liver parenchymal bleeding model. *Turkish Journal of Trauma and Emergency Surgery*, 28, 1059-1065. <https://doi.org/10.14744/tjtes.2022.90838>
- Rhimi, W., Hlel, R., Ben Salem, I., Boulila, A., Rejeb, A., & Saidi, M. (2019). *Dittrichia viscosa* L. ethanolic extract based ointment with antiradical, antioxidant, and healing wound activities. *BioMed Research International*, 4081253. <https://doi.org/10.1155/2019/4081253>
- Sevgi, E., Dag, A., Kızıllarslan-Hançer, Ç., Atasoy, S., Kurt, B. Z., & Aksakal, Ö. (2021). Evaluation of cytotoxic and antioxidant potential of *Dittrichia viscosa* (L.) Greuter used in traditional medicine. *Journal of Ethnopharmacology*, 276, 114211. <https://doi.org/10.1016/j.jep.2021.114211>
- Silinsin, M., & Bursal, E. (2018). UHPLC-MS/MS phenolic profiling and *in vitro* antioxidant activities of *Inula graveolens* (L.) Desf. *Natural Product Research*, 32(12), 1467-1471. <https://doi.org/10.1080/14786419.2017.1350673>
- Singleton, V.L., & Rossi, J.A. (1965). Colorimetry of total phenolics with phosphomolybdic-phosphotungstic acid reagents. *American Journal of Enology and Viticulture*, 16(3), 144-158. <https://doi.org/10.5344/ajev.1965.16.3.144>
- Trimech, I., Weiss, E.K., Chedea, V.S., Marin, D., Detsi, A., Ioannou, E., & Kefalas, P. (2014). Evaluation of anti-oxidant and acetylcholinesterase activity and identification of polyphenolics of the invasive weed *Dittrichia viscosa*. *Phytochemical Analysis*, 25(5), 421-428. <https://doi.org/10.1002/pca.2510>
- Tuzlacı, E. (2006). *Türkiye Bitkileri Sözlüğü* [A Dictionary of Turkish Plants] Alfa Yayınları (In Turkish).
- Zeouk, I., Sifaoui, I., Rizo-Liendo, A., Arberas-Jimenez, I., Reyes-Batlle, M., Bazzocchi, L., Bekhti, K., Piñero, J.E., Jiménez, I.A., & Lorenzo-Morales, J. (2020). Exploring the anti-infective value of inuloxin A isolated from *Inula viscosa* against the brain-eating amoeba (*Naegleria fowleri*) by activation of programmed cell death. *ACS Chemical Neuroscience*, 12(1), 195-202. <https://doi.org/10.1021/acscchemneuro.0c00685>