International Journal of
Agriculture, Environment and Food Sciences
e-ISSN: 2618-5946 https://dergipark.org.tr/jaefs

DOI: https://doi.org/10.31015/jaefs.2024.3.25 Int. J. Agric. Environ. Food Sci. 2024; 8(3): 710-728

# The volatile compounds of some edible wild plants consumed in the Mediterranean region

**Aslıhan Cesur Turgut**[1]

[1]Burdur Food Agriculture and Livestock Vocational School, Burdur Mehmet Akif Ersoy University, Burdur, Türkiye

**Article History**
**Received:** August 1, 2024
**Revised:** September 22, 2024
**Accepted:** September 25, 2024
**Published Online:** September 27, 2024
**Final Version:** September 29, 2024

**Article Info**
**Article Type:** Research Article
**Article Subject:** Plant Physiology

**Corresponding Author**
Aslıhan Cesur Turgut
✉ acesur@mehmetakif.edu.tr

**Available at**
https://dergipark.org.tr/jaefs/issue/86361/1526562

DergiPark AKADEMİK

## Abstract

In this study, 13 different edible weed species [*Centaurea depressa* Bieb., *Cichorium intybus* L., *Lactuca serriola* L., *Malva neglecta* Wallr., *Papaver dubium* L., *Polygonum cognatum* Meissn., *Rumex patientia* L., *Scorzonera cana* (C.A.Mey.Hoffm.), *Silene alba* (Mill.) Krause, *Stellaria media* L., *Sonchus oleraceus* L., *Taraxacum officinale*, *Tragopogon longirostris* Bisch] were collected from the same location in the Mediterranean region. Then, the leaves of all species were analyzed by the SPME-GC/MS method for the detection of volatile compounds. The compounds were grouped according to their structures as alcohols, aldehydes, alkanes, ester, furans, hydrocarbons, ketones, sulfur compounds, and terpenes. The percentages of the terpenes, aldehydes and alcoholic compounds were found to have the highest ratios of volatile compounds, respectively. The species found with the highest total terpene percentage was *Sonchus oleraceus* L. (78.84%), while the lowest one was *Stellaria media* L. (51.03%). Similarly, the highest total aldehydes percentage was found in *Stellaria media* L. (38.41%), and the lowest was in *Centaurea depressa* Bieb. (4.62%). Lastly, the highest total alcohol percentage was observed in *Centaurea depressa* Bieb. (9.92%) and the lowest was in *Malva neglecta* Wallr. (1.11%). The limonene, which is an important monoterpene, among 63 components, was found to be the major component in all species with a range of approximately 51-79%. Among them, *Sonchus oleraceus* L. had the highest limonene content (78.84%).

**Keywords:** Volatile compounds, Terpene, Limonene, SPME GC/MS, Wild species

**Cite this article as:** Cesur Turgut, A. (2024). The volatile compounds of some edible wild plants consumed in the Mediterranean region International Journal of Agriculture, Environment and Food Sciences, 8(3), 710-728. https://doi.org/10.31015/jaefs.2024.3.25

## INTRODUCTION

Vegetables play a crucial role in the human diet due to their rich nutritional content and health benefits. They are essential components of a balanced diet as they provide a wide range of essential nutrients, including dietary fiber, phytochemicals, vitamins, and minerals (Dias & Imai, 2017; Amao, 2018), while their regular consumption contributes to improve the overall health (Leyo et al., 2022). In addition, consumption of vegetables is also associated with various health benefits, including improved gastrointestinal health, enhanced vision, reduced risk of heart disease, stroke, chronic diseases like diabetes, and certain forms of cancer (Dias, 2012). Vegetables are also known to be rich in phytonutrients such as phenolics, flavonoids, and carotenoids, which have antioxidant properties and contribute to overall well-being (Liu, 2013). Additionally, vegetables provide a diverse range of tastes, aromas, textures, and colors, as well as enhanced the variety in food choices and satisfying personal preferences (Hong & Gruda, 2020). Furthermore, vegetables are a significant source of vitamins and minerals like vitamin C, folate, potassium, and beta-carotene, which are essential for various bodily functions and overall health (Power et al., 2011). World Health Organization recommends the consumption of at least five portions of fruits and vegetables per day to promote health and prevent chronic conditions (Fulton et al., 2011). Increasing vegetable intake and reducing the consumption of energy-dense foods are important targets for nutrition interventions to maintain good health and prevent diseases (Pearson et al., 2010).

Thirteen species were chosen among the mostly used plants by residents of Bahtiyar village and served as the base of this study. One of them is *Taraxacum officinale*, commonly known as dandelion, a perennial herbaceous plant belonging to the Asteraceae family. The primary bioactive components found in *T. officinale* include phenolic compounds, flavonoids, triterpenes, polysaccharides, and inulin. Among them, phenolic compounds are one of the most significant groups found in *T. officinale*. Some of compounds, like caffeic acid and chlorogenic acid, are known to be strong antioxidants that help the body to fight free radicals and reduced the oxidative stress (García-Carrasco et al., 2015; Khan et al., 2018). Flavonoids are another important class of bioactive compounds found in *T. officinale*, include quercetin and kaempferol. These flavonoids are known for their anti-inflammatory, antimicrobial and anticancer activities (Dongare et al., 2021). The presence of these compounds contributes to the overall health benefits of dandelion, making it a valuable addition to dietary and medicinal applications (Epure et al., 2023). Triterpenes, such as taraxasterol and taraxerol, are also prominent in extract of *T. officinale*, particularly in its roots. These compounds have been associated with various pharmacological activities, including anti-inflammatory and anticancer effects. Researchers have found that taraxasterol can control immune responses and fight against tumors, which makes *T. officinale* even more useful as a medicine (Ren et al., 2022). The presence of volatile compounds in *T. officinale* have been linked to its antimicrobial properties generally. Research has shown that extracts from dandelion roots exhibit significant antimicrobial activity against various bacterial strains, including methicillin-resistant *Staphylococcus* aureus and *Bacillus cereus* (Kenny et al., 2015). This antimicrobial action is attributed to the presence of specific volatile compounds that disrupt bacterial cell membranes and inhibit growth (Jerković et al., 2015). The identification of nitriles as dominant volatile molecule in dandelion honey further underscores the plant's potential as a source of natural antimicrobial agents (Jerković et al., 2015; Siegmund et al., 2017).

*Centaurea depressa* Bieb. (Asteraceae), is consumed for its nutritional value and potential health benefits. Piperitone, elemol, β-eudesmol, and spathulenol are some of the important chemicals that have been studied and found to have medicinal and nutritional value (Carev et al., 2022). The presence of fatty acids like hexadecenoic acid and dodecanoic acid further enhances its profile, suggesting potential applications in dietary practices (Erdoğan et al., 2014). Moreover, *C. depressa* is in a broader trend towards utilizing wild leafy vegetables, which are often underappreciated in modern diets. People are increasingly recognizing these plants on their potential to improve food security and enhance nutritional diversity. Consuming such wild plants not only supports dietary variety, but also contributes to sustainable agricultural practices by promoting the use of native flora (Baydoun et al., 2023). The role of volatile components in the consumption of *Centaurea depressa* Bieb. is multifaceted, encompassing aspects of flavor, aroma, and ecological interactions. In the case of *C. depressa*, the presence of specific volatile organic compounds (VOCs) can improve the sensory experience of consuming the plant, making it more attractive to consumers (Xu et al., 2023).

People consume *Cichorium intybus* L., (Asteraceae), is commonly known as chicory, for its nutritional value, medicinal properties, and culinary versatility, among other reasons. This plant is rich in bioactive compounds, including inulin, flavonoids, and phenolic acids, which contribute in health benefits and make it a valuable addition to the diet. Various cultures have traditionally use of *Cichorium intybus* for its medicinal properties, in addition to its nutritional benefits. Studies have reported that chicory exhibits hepatoprotective effects, reducing enzyme levels in lever and improve its function in toxicity models (Maletha et al., 2022; Andalib et al., 2021). Moreover, the antimicrobial properties of *C. intybus* are noteworthy, with research indicating that its extracts possess activity against various pathogenic microorganisms. The volatile compounds in chicory have been shown to exhibit antibacterial effects against strains such as *Escherichia coli* and *Staphylococcus aureus*, suggesting their potential use as natural preservatives in food products (Ghaderi et al., 2012; Bezerra et al., 2022). This antimicrobial activity is particularly relevant in the context of increasing resistance to conventional antibiotics, positioning *C. intybus* as a valuable resource in the search for alternative antimicrobial agents.

*Lactuca serriola* L. (Asteraceae), commonly known as prickly lettuce, is consumed for its nutritional benefits, medicinal properties, and culinary versatility. This wild relative of cultivated lettuce (*Lactuca sativa*) is rich in various phytochemicals, including flavonoids, phenolic acids, and lactones, which contribute to its health-promoting effects. For instance, the presence of compounds such as lactucin and lactucopicrin has been linked to gastrointestinal relief and respiratory benefits, making it a valuable addition to traditional medicine. Furthermore, studies have shown that *L. serriola* can inhibit α-glucosidase activity, which may aid in regulation of blood sugar, thus providing potential benefits for individuals with diabetes. In addition to its health benefits, the volatile components of *L. serriola* play a significant role in its consumption. Traditional uses of *L. serriola* include its application as a sedative, diuretic, and antispasmodic agent, which have been corroborated by scientific studies. For instance, extracts from *L. serriola* have demonstrated significant sedative effects in experimental models, suggesting that its volatile constituents may play a crucial role in modulating the central nervous system (Aziz et al., 2016; İlgün et al., 2020). The presence of compounds such as lactucin and lactucopicrin in the volatile profile has been linked to these sedative effects, indicating their potential utility in treating anxiety and sleep disorders (Kim et al., 2022). These volatile compounds also contribute in development of plant's aroma and flavor, enhancing its appeal as a food source. The unique profile of volatile organic compounds (VOCs) in *L. serriola* not only influences its sensory characteristics but also affects consumer preferences (Abdul-Jalil, 2020; Kim et al., 2022).

*Malva neglecta* Wallr. (Malvaceae), commonly known as low mallow or common mallow. Its leaves, flowers, and roots are edible, and it can be consumed raw in salads or as cooked in various dishes. They are known to have a mild flavor, which makes them suitable for incorporation into a variety of culinary preparations (Yeşil et al., 2019; Akbulut & Zengin, 2023). The plant is rich in mucilage, flavonoids, and phenolic compounds, which contribute to its health benefits, including anti-inflammatory and antioxidant properties (Jędrzejczyk & Rewers, 2020; Saleem et al., 2020). These attributes make *M. neglecta* a popular choice among foragers and those interested in wild edible plants, as it is often regarded as a nutraceutical or functional food that promotes health (Yeşil et al., 2019). In addition to its antioxidant properties, *M. neglecta* exhibits notable antimicrobial activity. Research has shown that extracts from the leaves and flowers of *M. neglecta* possess significant antibacterial effects against various pathogenic bacteria, including *Escherichia coli* and *Staphylococcus aureus* (Bushra et al., 2012; Al-Qurashy, 2023). This antimicrobial action is attributed to the presence of specific volatile compounds that can disrupt bacterial cell membranes and inhibit growth, making *M. neglecta* a potential candidate for natural preservatives in food products (Keyrouz et al., 2017).

People consume *Papaver dubium* L. (Papaveraceae), also known as blind poppy or horned poppy, for its nutritional value, medicinal properties, and its role in traditional practices. The leaves of the plant are rich in vitamins and minerals, making them a valuable addition to salads and cooked dishes Honěk & Martinková (2010). Traditional medicine has utilized *P. dubium* for its therapeutic properties. Like other species in the *Papaver* genus, it contains alkaloids that may have health benefits. While *P. dubium* is less studied than its more famous relative, *Papaver somniferum*, and it is believed that *P. somniferum* possess same type of beneficial properties, such as anti-inflammatory and analgesic effects (Butnariu et al., 2022). Folk medicine has used plant to treat various ailments, including respiratory issues and digestive problems (Casado-Hidalgo et al., 2021). The presence of specific volatile compounds, phenolic compounds and alkaloids are believed to play a crucial role in antimicrobial action, making *P. dubium* a candidate for natural preservatives in food products. Moreover, the antimicrobial properties of *P. dubium* align with its traditional uses in folk medicine for treating infections and wounds (Mohammed, 2023).

*Polygonum cognatum* Meissn. (Polygonaceae), commonly known as "madimak" in Türkiye. One of the primary reasons for consuming *P. cognatum* is its nutritional profile. The plant is rich in vitamins A and C, minerals, and dietary fiber, which contribute to its health benefits (Demirgül et al., 2022; Akpınar, 2023). The presence of phenolic compounds and other bioactive substances contributes to its therapeutic potential, making it a valuable resource in herbal medicine (Kaplan & Gökşen Tosun, 2023; Yıldırım et al., 2002). Research indicates that essential oils and extracts from various parts of the plant possess significant antibacterial properties against a wide range of pathogenic bacteria. This antimicrobial action is attributed to specific volatile compounds that can disrupt bacterial cell membranes and inhibit their growth, making *P. cognatum* a best candidate for natural preservatives in food products. Its traditional use in folk medicine for treating infections further supports its relevance in modern therapeutic applications (Kaplan & Gökşen Tosun, 2023; Eruygur et al., 2020). Moreover, the volatile composition of *P. cognatum* has been linked to its antidiabetic properties. The plant has been reported to exhibit hypoglycemic effects, which may be associated with its ability to enhance insulin sensitivity and reduce blood glucose levels (Gözcü, 2023).

*Rumex patientia* L., also referred to as patience dock or garden patience, is a perennial herb. This perennial herb's leaves, belonging to the Polygonaceae family, are high in vitamins A and C, as well as minerals such as calcium and iron, making them a valuable addition to diets (Kaya et al., 2020). Research has indicated that extracts from this plant exhibit anti-inflammatory and antioxidant activities, which can be beneficial for managing various health conditions (Jovin et al., 2011). Furthermore, it is used in folk medicine to treat ailments such as respiratory issues and digestive disorders (Küpeli et al., 2007). *R. patientia* has been recognized for its anti-inflammatory effects. The plant has shown potential in reducing inflammation in various models, which may be beneficial for conditions such as arthritis and other inflammatory diseases (Gürbüz et al., 2005). The presence of bioactive compounds such as flavonoids and phenolic acids in the volatile profile is believed to contribute to these anti-inflammatory effects, highlighting the potential of *R. patientia* in managing inflammatory conditions.

*Scorzonera cana* (C.A. Mey. Hoffman), is a member of Asteraceae, commonly known as gray scorzonera. The bioactive compounds found in *S. cana* include flavonoids, phenolic acids, triterpenes, and other phytochemicals that are responsible for its health benefits. *S. cana*'s rich content of flavonoids and phenolic acids contributes to its antioxidant properties. These antioxidants help neutralize free radicals in the body, reducing oxidative damage and lowering the risk of chronic diseases such as heart disease and cancer (Deveci, 2022; Monteiro et al., 2018). In addition to its antioxidant properties, *S. cana* has demonstrated notable antimicrobial activity. This antimicrobial action is attributed to specific volatile compounds that can disrupt bacterial cell membranes. The traditional use of *S. cana* in folk medicine for treating infections further supports its relevance in modern therapeutic applications (Sakul et al., 2021).

*Silene alba* (Mill.) Krause (Caryophyllaceae), has several bioactive components that makes it nutritious and therapeutic. In addition to flavonoids, it contains saponins and glycosides, which have been reported to exhibit antimicrobial properties (Akgöz, 2014). These chemicals have antioxidant, anti-inflammatory, and antibacterial activities. In addition, they can inhibit the growth of various pathogens, thus contributing to the plant's traditional use in folk medicine for treating infections (Ullah et al., 2019). They reduce oxidative stress by scavenging free radicals. Preventing cardiovascular disease and cancer requires antioxidant capacity. *S. alba* also contains quinic and malic acids, which boost its nutrition value. These acids improve food flavor, preservation activity and aid metabolism. Hesperidin, a flavonoid glycoside, improves vascular health and lowers blood pressure, making the plant healthier (Zengin et al., 2018). Research has shown that the floral scent of *S. alba* is specifically adapted to attract nocturnal pollinators, such as moths, which are critical for its reproductive success. The composition of these volatile compound can vary based on environmental conditions and the plant's phenological state, even influenced by effectiveness of pollination (Barthelmess et al., 2005). Moreover, its volatile profile is also indicative of its defense strategies against herbivores. The presence of certain terpenoids and other secondary metabolites in the essential oils has been correlated with antifungal and antibacterial properties, which may protect the plant from pathogens and pests (Hussein et al., 2019). Additionally, the ecological significance of *S. alba* extends to its role in community dynamics. The interactions facilitated by its volatile compounds can influence the composition and structure of plant communities. This suggests that the volatile composition of *S. alba* not only serves its immediate ecological functions but also contributes to broader ecological processes (Ramseier et al., 2005).

*Stellaria media* L. (commonly known as chickweed) is a member of the Caryophyllaceae family. One of the most prominent groups of bioactive compounds is polyphenols, which are known for their strong antioxidant properties. Flavonoids are another important class of compounds, have been extensively studied for their health benefits. The flavonoid content in *S. media* has been quantified, revealing levels of at least 1.2% in raw plant material, while different extraction process showed extraction of higher concentrations (Demján et al., 2022). Research has shown that extracts from *S. media* can inhibit enzymes such as xanthine oxidase, which is involved in the production of uric acid, thus suggesting potential benefits for conditions like gout (Taskin & Bitis, 2013). The volatile profile of *S. media* has implications for its use in traditional medicine. The plant has been utilized for its anti-inflammatory and antiviral properties, with extracts demonstrating efficacy against various pathogens (Ma et al., 2012). The presence of specific volatile compounds may enhance these therapeutic effects, making *S. media* a valuable candidate for further pharmacological research and development. Additionally, the plant's essential oils have been studied for their potential applications in food preservation and as natural antimicrobial agents, highlighting the versatility of its volatile composition (Chak et al., 2021).

The phytochemical profile of *Sonchus oleraceus* L. (Asteraceae), includes flavonoids, phenolic acids, sesquiterpene lactones, and various vitamins and minerals, which collectively offer a range of health benefits. These compounds are well-known for their antioxidant properties, which help in neutralizing free radicals and reducing oxidative stress in the body. The presence of flavonoids such as quercetin and kaempferol has been documented, and these compounds are associated with anti-inflammatory, antimicrobial, and anticancer activities (Hussein & Gobba, 2014; Nouidha, 2023; Li & Yang, 2018). Additionally, phenolic compounds, including hydroxycinnamic acids like caffeic acid, contribute significantly to the plant's antioxidant capacity (Nouidha, 2023; Chen et al., 2019). Understanding the volatile composition of *S. oleraceus* can aid in developing integrated weed management strategies. For instance, the allelopathic effects of its extracts on the germination and growth of other plants can be harnessed to suppress weed populations in agricultural settings (Gomaa et al., 2014). Additionally, the identification of specific VOCs that inhibit the growth of competing species can inform practices aimed at reducing the impact of this weed on crop yields (Ibrahim et al., 2022).

*Tragopogon longirostris* Bisch, a member of the Asteraceae family, exhibits a range of botanical and biochemical properties that are significant for both ecological and medicinal contexts. Biochemically, it is notable for its phytochemical composition, which includes various phenolic compounds and flavonoids known for their antioxidant properties. Similar species, like *Tragopogon porrifolius*, have been studied and found to have high levels of antioxidants like caffeic acid and flavonoids. These antioxidants help the plant's to possess the medicinal potential (Al-Rimawi et al., 2016; Abdalla & Zidorn, 2020). These compounds are associated with various health benefits, including anti-inflammatory and anticancer activities, as evidenced by studies on other *Tragopogon* species (Unver, 2023; Suleimen et al., 2019). In addition to their ecological significance, the volatile compounds of *T. longirostris* may possess medicinal properties. Research on related species within the *Tragopogon* genus has indicated that they contain bioactive compounds with antioxidant and anti-inflammatory activities. For example, a study on *T. graminifolius* found that its essential oil exhibited antioxidant and antimicrobial properties (Farzaei et al., 2014). These properties are often attributed to the presence of phenolic compounds and other secondary metabolites found in the essential oils of these plants.

The relationship between taste and volatile compounds in vegetables is a complex interplay that significantly contributes to the overall sensory experience of consuming vegetables. Volatile compounds are key contributors to the aroma and flavor of vegetables, working in conjunction with non-volatile compounds to create a holistic taste profile (Alasalvar et al., 2012). Non-volatile compounds such as organic acids, sugars, and free amino acids primarily influence taste perception, while, volatile compounds like aldehydes, alcohols, ketones, and aromatic compounds play a crucial role in providing the characteristic aroma of vegetables. The characteristic taste and aroma of vegetables are often determined by specific volatile compounds present in them. For example, the cabbage-like flavor of certain vegetables is attributed to key volatile compounds, many of which contain sulfur

(Meinert et al., 2011; Alasalvar et al., 2012). These volatile compounds not only contribute to the aroma but also influence the overall taste perception of vegetables. In the case of vegetable soybeans, a variety of volatile compounds have been identified, with specific compounds like 1-octen-3-ol, hexanal, and nonanal playing significant roles in defining the flavor profile (Guo et al., 2022). Moreover, the sensory flavor of vegetables is a combination of taste and smell, with both non-volatile and volatile compounds, which play essential roles in shaping the overall taste experience (Fan et al., 2022). While, non-volatile compounds stimulate taste receptors, in the same way, volatile compounds stimulate olfactory receptors, hence, both collectively contribute in the perception of taste and aroma in vegetables (Caporaso & Sacchi, 2021).

Terpenes, the major components of essential oil, are produced by many plant species and have many roles, including herbivore, pathogen protection and plant development. The terpene basic chemical structure is isoprene (Mewalal et al., 2017). Many types of specialized plant cells generate terpenes via metabolic processes (Zulak & Bohlmann, 2010; Cho et al., 2017). In prevention from illness and its treatment, terpenes have shown antibacterial, anti-allergenic, antioxidant, anti-inflammatory, and immunomodulatory activities (Theis & Lerdau, 2003). Their lipophilicity and low molecular weight lend the terpenes widespread usage in medicine (Miguel, 2010; Rufino et al., 2015). Limonene is one of the most common terpenes in nature as a colorless liquid which exists in two optical isomeric forms of d- or l-limonene, and as a racemic mixture (Zulaikha, 2015). This volatile compound found in various fruits and vegetables, contributes significantly to the flavor profile of vegetables. Limonene imparts a fruity aroma and is recognized as a key flavor compound that influences the odor of vegetables Xu et al. (2023). In the food industry, limonene is utilized as a flavoring agent in a wide range of food products, including vegetables, herbs, citrus juices, candies, beverages, and ice creams (Tang et al., 2022). The presence of limonene in vegetables enhances their sensory appeal by providing a distinct citrus-like flavor and aroma. Furthermore, limonene plays a crucial role in defining the taste and aroma of vegetables due to its characteristic properties. In plants, limonene is involved in biosynthetic pathways that lead to the production of various volatile compounds responsible for flavor and aroma. For instance, the 6-hydroxylation of limonene by specific enzymes is a crucial step in the biosynthesis of volatile compounds like carvone, which contributes to the flavor of spices such as caraway fruit (Dudareva et al., 2004). Limonene's citrus-like flavor makes it a popular choice as a flavoring agent in perfumes, creams, soaps, household cleaning products, and various food products, including fruit beverages and ice creams (Espina et al., 2013).

The aim of this study was to determine the volatile compounds content of some uncultivated weed species consumed as vegetables. The increasing interest in using various plants as human food for a healthy life, shaped this objective.

## MATERIALS AND METHODS

### Plant Materials

Thirteen different species (*Taraxacum officinale*, *Centaurea depressa* Bieb., *Cichorium intybus* L., *Lactuca serriola* L., *Malva neglecta* Wallr., *Papaver dubium* L., *Polygonum cognatum* Meissn., *Rumex patientia* L., *Scorzonera cana* (C.A. Mey. Hoffm.), *Silene alba* (Mill.) Krause, *Stellaria media* L., *Sonchus oleraceus* L., *Tragopogon longirostris* Bisch.), used in various ways as vegetables are naturally cultivated in the Akdeniz region of Türkiye.

All plants were collected from Bahtiyar village, Yalvaç distinct in Isparta (Latitude: 38.190574, Longitude: 31.163447), during the vegetation period in May-June, 2021. At least 10 individuals per species were collected in the early hours of the day randomly. Then they brought to the Suleyman Demirel University, Innovative Technologies Application and Research Center under controlled conditions. Fresh plant samples transported to the laboratory with a cold chain were stored at -20 degrees until SPME analysis. In SPME analysis, homogenized leaves were studied in triplicate.

### Determination of Volatile Compounds by Solid-Phase Micro Extraction Gas Chromatography/ Mass Spectrometry

A 2-g sample was weighed in a 15-mL vial closed by a silicone septum. The sample was placed on a heating block at 60°C and held for 15 minutes to achieve temperature equilibrium. A Carboxen/polydimethylsiloxane manual solid-phase microextraction (SPME) fiber (75-µm Fused Silica, Supelco Ltd., Bellefonte, PA, USA) was inserted into the vial and kept for 30 minutes at 60°C to absorb volatile compounds from leaves. The fiber was then inserted into the injection port of gas chromatograph for 5 minutes at 250°C for the desorption of aroma compounds. Gas extraction/mass spectrometry (GC/MS) analyses were performed using a Shimadzu GC-2010 gas chromatograph equipped with an MS-QP2010 plus a mass spectrometer (Shimadzu Corporation, Kyoto, Japan). The analyses conditions are as follows: column, Rxi-5Sil MS (30 m × 0.25 mm i.d. × 0.25 µm film thickness; Restek, Bellefonte, PA, USA); temperature program, from 40°C (2 minutes) to 250°C (5 minutes) at 4°C/min; injection temperature, 250°C; inlet pressure, 83.5 kPa; carrier gas, He [linear velocity (ū): 44.2 cm/s]; injection mode, split (10:1); MS interface temperature, 250°C; MS mode, electron ionization; detector voltage, 1.5 kV; mass range, 35–450 m/z; scan speed, 1428 u/s; interval, 0.30 seconds (2 Hz). Data handling was made through GCMS solution 2.5 (Shimadzu). GC/MS analysis was accomplished in the scan mode in the 40–300 amu mass range (Yılmazer et al., 2016).

### Statistical Analysis

All the experiments were performed in triplicate and their statistical significance of differences between the averages in the obtained data was analyzed with the ANOVA and Duncan (P<0.05) multiple comparison test in SPSS software (IBM-SPSS Inc., Armonk, NY, USA) version 25.0, and the values are given as mean ± SD (standard deviation) (Zhang et al., 2022).

## RESULTS AND DISCUSSION

A total of 63 volatile compounds belonging to 13 species were identified with SPME-GC and presented (Sample chromatogram is shown in Fig. 2). These compounds were grouped according to their structures as alcohols, aldehydes, alkanes, ester, furans, hydrocarbons, ketones, sulfur compounds, and terpenes (Table 1-2). These groups were calculated for each plant species. When the total percentages were analyzed, terpene was in highest concentration compare to other volatile compound contents in all plants following terpenes, aldehydes and alcohols in the groups (Figure 1).

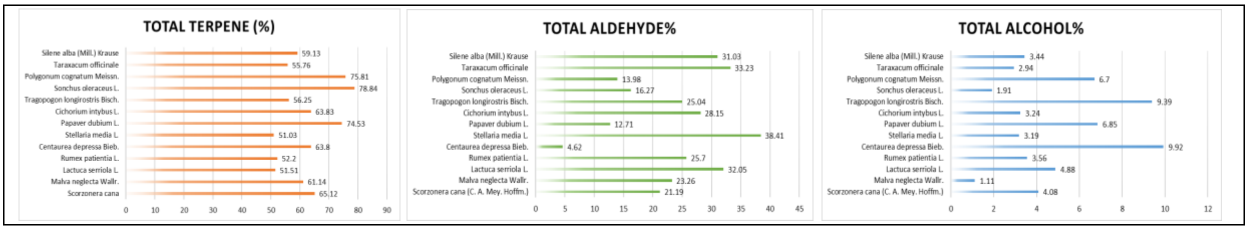

Figure 1. Total Terpene, Aldehyde and Alcohol Ratios (%) of Plant Volatile Compound Contents

In this study volatile component content of *Silene alba* consists of 59.13% terpene, 31.03% aldehyde and 3.44% alcohol (Figure 1). In headspace studies with different *Silene* species, high levels of monoterpenes (myrcene 23% in *Silene chlorantha*, trans-β-ocimene 27.2% in *S. nutans* and 34.9% in *S. sericea*, fenchyl acetate 12.7% in *S. chlorantha*, β-linalool 40.5% in *S. chlorantha* and 14.5% in *S. italica*) were found in all *Silene* species (Jürgens et al., 2002). The genus *Silene* comprises over 700 species, each exhibiting distinct volatile profiles that play critical roles in pollinator attraction and ecological interactions. The volatile components of different *Silene* species vary significantly, influenced by factors such as species-specific adaptations and environmental conditions. In their comparative study, Page et al. noted that the floral scent of *Silene species*, including *S. latifolia*, contains common volatile compounds that influence the preferences of pollinators like *Hadena bicruris* (Page et al., 2014). Moreover, Vivaldo et al. emphasized that the chemical composition of volatiles is often species-specific, with terpenes and nitrogen-containing compounds being prevalent in some *Silene* species, while others may emit sulfur-containing volatiles. This chemical diversity is further supported by the findings of Mamadalieva et al., who documented over 450 different secondary metabolites in *Silene*, indicating a rich array of volatile compounds that may serve various ecological functions (Mamadalieva et al., 2014; Vivaldo et al., 2017; Unlu et al., 2017).

The presence of volatile component content of *Taraxacum officinale* consists of 55.76% terpene, 33.23% aldehyde and 2.94% alcohol. A study on volatile compound was carried out on leaves and roots of *Taraxacum officinale* by HS-SPME/GC-MS. As terpene compounds, it was mentioned that caryophyllene, farnesene, -elemene, neofitadiene detected in the leaves of some varieties of dandelion have anti-inflammatory, antioxidant and anti-tumour like biological activities (Kiyama, 2017; Zhang et al., 2022). It was found that the most intense volatile compound group was dominated by esters and ketones. It was thought that those results, which are not very compatible with our findings, may be due to the difference in habitat condition of the plants.

The volatile component content of *Polygonum cognatum* consists of 75.81% terpene, 13.98% aldehyde and 6.7% alcohol. In another study, essential oils of different *Polygonum* species were extracted by hydro-distillation and analyzed by GC. Their results were found quite similar to our findings and presence of terpene groups were found to be dominant among the volatile compounds. Moreover, it was also observed that essential oil contains 33 different components, among them more than half identified groups were belonging to terpenes (Demirpolat, 2022).

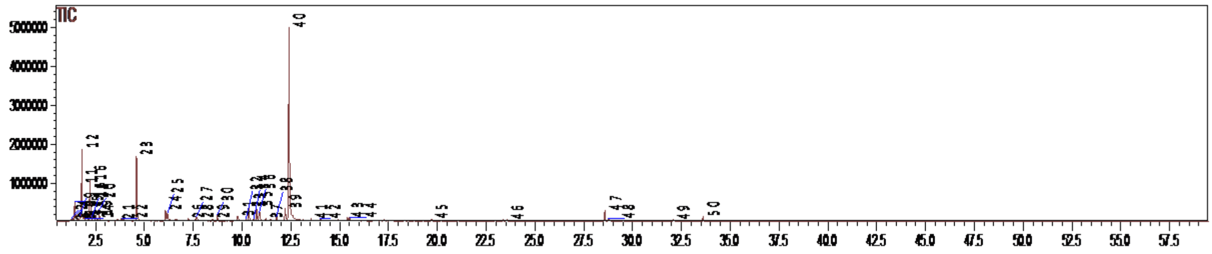

Figure 2. SPME/GC-MS chromatogram of *R. patientia*

The presence of volatile component content in *Sonchus oleraceus* consists of 78.84% terpene, 16.27% aldehyde and 1.91% alcohol. In already published study, gas chromatography mass spectrometry (GC-MS) data showed the identification of ten volatile compounds in hexane fraction of the Sonchus oleraceus, among them two were found to be the major components (40.92% 9 Octadecenamide (CAS) and 21.01% 1 Hexacosanol). Moreover, other thirty-six compounds isolated from different parts of S. oleraceus have also been reported. Among them flavonoids and terpene lactones have been the most reported secondary metabolites in these species (Sánchez-Aguirre et al., 2024). Hence, this information also supports our findings.

The volatile component content of *Tragopogon longirostris* consists of 56.25% terpene, 25.04% aldehyde and 9.39% alcohol. Riu-Aumatell et al. (2011) analyzed *Tragopogon porrifolius'* volatile composition using HS-SPME and SDE, connected to GLC/MS. There were around 80 volatile components from different chemical classes. They found that the SDE approach can identify sesquiterpenes such as β-elemene, α-humulene, α-cadinol, and farnesol.

The volatile component content of *Cichorium intybus* consists of 56.25% terpene, 25.04% aldehyde and 9.39% alcohol. It has been reported in the literature that Cichorium intybus is a rich source of terpenoid and phenolic compounds (Nasimi Doost Azgomi et al., 2021).

The presence of volatile component content ration in *Papaver dubium* consists of 74.53% terpene, 12.71% aldehyde and 6.85% alcohol. Direct information on the terpene content in *Papaver dubium* is limited in the literature. However, related studies on Papaver species like *Papaver somniferum* shed light on the presence of terpenes in poppies (Muthukumaran et al., 2019). Research on *Papaver somniferum* has highlighted the role of tyrosine aminotransferase in benzylisoquinoline alkaloid biosynthesis, indicating the involvement of various compounds, including terpenes, in the metabolic pathways of poppies. Additionally, a study on the phytochemical analysis of *Papaver somniferum* identified the presence of terpenoids among other secondary metabolites (Karioti et al., 2014).

The volatile component content of *Stellaria media* consists of 51.03% terpene, 38.41% aldehyde and 3.19 % alcohol. The results of phytochemical analysis of *Stellaria media,* revealed the presence of various secondary metabolites including terpenoids, flavonoids, phenols, alkaloids, tannins, glycosides and saponin (Chak et al., 2021).

In this study volatile component content of *Centaura depressa* consists of 63.8% total terpene (Figure 1), 4.62% aldehyde and 9.92% alcohol (Figure 1). In another study, the oil of *C. depressa* consisted of four oxygenated monoterpenes (36.5%), six sesquiterpene hydrocarbons (5.9%), 10 oxygenated sesquiterpens (39.7%), five aliphatichydrocarbons (4.4%) and one aliphatic acid (4.0%) (Esmaeili et al., 2005). The chemical composition of *Centaurea scabiosa* hydro-distilled volatile oil was determined using the GC/MS chromatographic technique and 32 volatile oil or chemical compounds were detected, which represent 90.21% of volatile oils. The chemical compounds are grouped in terpenes (43.73%) (Carev et al., 2022). Similar to our findings, the highest volatile compound group was reported in literature appears to be terpenes. However, differences in the percentage of volatile compounds may be due to differences in the species, the method of analysis or the place of cultivation.

The volatile component content of *Rumex patientia* consists of 52.2% terpene, 25.7% aldehyde and 3.56 % alcohol. Data on the presence of volatile component contents of the same species were not found in the literature. However, the contents of a different species belonging to the same genus were found and compared with our findings. According to this study, presence of volatile constituents prepared from *Rumex visicarius* by hydro-distillation was viscous, with yellow in color and unpleasant nauseating odor; results of GC-FID and GC/MS analysis of the essential oil revealed the identification of 26 compounds representing 90.66% of the total sample. Thirteen terpenoid compounds were found (47.23%), of which 3 monoterpenes (7.71%) and sesquiterpenes (39.52%); 5 oxygenated terpenes (28.96%); and 5 esters were identified representing 14.99% (El-Hawary et al., 2011). These results are consistent with our findings.

The volatile component content of *Lactuca serriola* consists of 51.51% terpene, 32.05% aldehyde and 4.88% alcohol. In already published data, *L. serriola* essential oil was obtained by hydro-distillation of plant leaves and analyzed by Gas Chromatography-Mass Spectrometry (GC-MS). As a result of the GS-MS analysis, hexadecanoic acid, oleic acid, myristic acid, hexahydrofarnesyl acetone, β-ionone, and n-tetradecyl butanoate were found as dominant components in the plant essential oil with the rate of 6.61%, 4.84%, 2.05, 1.55%, 1.3%, and 1.09% (v/v), respectively. The difference between the ratios may be due to a different methodology. One was analyzed by SPME directly from the leaf, while the other was analyzed by GC after extracting the essential oil. In addition, seven terpene compounds were isolated from the above-ground parts of *Lactuca indica* L. by column chromatographic separation of MeOH extract (Kim et al., 2008).

Table 1. The Volatile Compounds of *S. cana*, *M. neglecta*, *L. serriola*, *R. patientia*, *C. depressa*, *S. media*, *P. dubium*

| COMPOUNDS | RT | *Scorzonera cana* (C. A. Mey. Hoffm.) | *Malva neglecta* Wallr. | *Lactuca serriola* L. | *Rumex patientia* L. | *Centaurea depressa* Bieb. | *Stellaria media* L. | *Papaver dubium* L. |
|---|---|---|---|---|---|---|---|---|
| ALCOHOLS | | | | | | | | |
| 3-Methyl-1-butanol | 3.296 | - | - | - | - | - | 0.04±0.00 a | - |
| Pentanol | 3.889 | 0.14±0.01 ab | 0.14±0.00 ab | 0.15±0.01 ab | 0.25±0.08 a | - | 0.17±0.02 ab | 0.16±0.04 ab |
| E-2-Penten-1-ol | 3.931 | 0.35±0.01 cd | 0.33±0.06 cd | 0.73±0.14 b | 0.33±0.05 cd | - | 0.15±0.00 de | 0.51±0.12 bc |
| Z-3-Hexen-1-ol | 6.166 | 2.59±0.03 bc | - | 2.90±0.05 b | 2.06±0.08 bc | 5.77±0.14 a | - | 3.04±0.78 b |
| E-2-Hexen-1-ol | 6.539 | - | - | - | - | 0.33±0.09 c | - | 0.19±0.04 c |
| Hexanol | 6.631 | 0.73±0.01 cd | 0.43±0.01 de | 0.90±0.02 bc | 0.29±0.02 e | 2.20±0.00 a | 2.38±0.15 a | 0.72±0.19 cd |
| 1-Octen-3-ol | 10.583 | - | - | - | 0.30±0.03 b | - | 0.22±0.01 b | 1.83±0.40 a |
| Octan-3-ol | 11.263 | - | - | - | - | 0.33±0.03 a | - | - |
| Benzyl alcohol | 12.650 | - | - | - | - | 0.55±0.06 a | - | - |
| Phenethyl alcohol | 15.655 | - | - | - | - | 0.18±0.00 a | - | - |
| 2-Ethylhexanol | 32.100 | 0.27±0.00 de | 0.21±0.01 de | 0.20±0.01 e | 0.33±0.01 cde | 0.56±0.02 b | 0.23±0.03 de | 0.40±0.07 bcd |
| ALDEHYDE | | | | | | | | |
| Isobutanal | 1.625 | 0.06±0.01 cd | - | 0.30±0.02 a | - | - | 0.06±0.01 cd | 0.23±0.08 ab |
| 3-Methylbutanal | 2.224 | 0.49±0.00 cde | 0.26±0.01 de | 1.76±0.26 b | 4.55±0.10 a | - | 0.21±0.01 de | 1.02±0.36 c |
| 2-Methylbutanal | 2.313 | 0.35±0.01 cdef | 0.18±0.01 def | 1.21±0.11 a | 0.59±0.05 bc | - | 0.15±0.02 ef | 0.65±0.21 bc |
| Pentanal | 2.677 | 0.71±0.03 cd | - | 1.15±0.07 b | 2.01±0.08 a | - | 0.46±0.01 de | 0.42±0.12 e |
| 2-Methyl-2- butenal | 3.388 | - | - | - | - | - | 0.14±0.00 a | - |
| E-2-Pentenal | 3.601 | 1.07±0.01 bc | 1.54±0.00 a | 0.83±0.05 cd | 0.37±0.06 ef | 0.14±0.04 fg | 0.96±0.00 bcd | 0.42±0.11 e |
| Hexanal | 4.588 | 3.15±0.23 ef | 4.56±0.00 e | 6.83±0.07 cd | 12.81±0.89 b | 0.16±0.01 g | 15.29±1.08 a | 0.46±0.10 g |
| Furfural | 4.992 | - | - | - | - | - | 0.12±0.02 a | - |
| E-2-Hexenal | 6.070 | 8.69±0.13 d | 11.57± bcd | 14.45±0.78 ab | 2.41±0.25 e | 2.74±0.57 e | 15.20±0.01 ab | 7.99±2.05 d |
| Heptanal | 7.657 | 1.44±0.05 a | 1.14±0.00 b | 1.32±0.01 a | 0.72±0.02 d | 0.23±0.01 f | 1.39±0.06 a | 0.41±0.00 e |
| Z-2-Heptenal | 9.657 | 0.11±0.01 cd | - | - | - | - | 0.43±0.00 a | - |
| Benzaldehyde | 9.770 | 1.09±0.14 b | 1.75±0.00 a | 0.87±0.09 b | 1.13±0.06 b | - | 0.97±0.06 b | - |
| E,E-2,4-Heptadienal | 11.164 | 1.80±0.16 b | 0.65±0.00 d | 1.25±0.22 c | - | - | 0.64±0.01 d | - |
| Octanal | 11.433 | 0.49±0.01 bc | 0.54±0.00 b | 0.41±0.02 cd | 0.25±0.01 e | - | 0.38±0.01 d | - |
| E,Z-2,4-Heptadienal | 11.766 | - | - | - | - | - | 0.66±0.06 b | - |
| Benzeneacetaldehyde | 12.925 | 0.32±0.01 b | 0.18±0.00 b | 0.41±0.08 ab | - | 1.35±0.67 a | - | 0.34±0.06 b |
| Nonanal | 15.385 | 1.26±0.02 cd | 0.81±0.00 def | 1.16±0.21 cde | 0.86±0.03 def | - | 1.24±0.04 cd | 0.67±0.08 ef |
| Decanal | 19.275 | 0.16±0.01 bc | 0.08±0.00 d | 0.10±0.01 cd | - | - | 0.11±0.00 cd | 0.10±0.02 cd |
| ALKANE | | | | | | | | |
| 2,2-Dimethyltetradecane | 23.370 | 0.22±0.03 d | 0.35±0.00 c | 0.11±0.00 ef | - | - | 0.09±0.00 f | 0.19±0.02 de |
| 2,2,11,11-Tetramethyldodecane | 23.562 | 0.25±0.02 de | 0.38±0.00 c | 0.15±0.00 fg | 0.25±0.00 d | - | 0.11±0.02 gh | 0.25±0.00 de |
| ESTER | | | | | | | | |
| 2-Propenoic acid, 2-methyl-, methyl ester | 2.859 | - | - | -- | - | 0.30±0.02 a | - | - |

Table 1. Continued

| COMPOUNDS | RT | *Scorzonera cana* (C. A. Mey. Hoffm.) | *Malva neglecta* Wallr. | *Lactuca serriola* L. | *Rumex patientia* L. | *Centaurea depressa* Bieb. | *Stellaria media* L. | *Papaver dubium* L. |
|---|---|---|---|---|---|---|---|---|
| FURAN | | | | | | | | |
| 2-ethyl- Furan | 2.691 | - | 0.51±0.00 a | - | - | - | - | - |
| HYDROCARBONS | | | | | | | | |
| *o*-Xylene | 6.540 | 0.55±0.00 a | 0.32±0.05 b | 0.21±0.01 c | - | - | - | - |
| Styrene | 7.249 | 0.61±0.00 a | 0.66±0.05 a | 0.42±0.02 b | 0.48±0.03 b | - | 0.17±0.02 d | - |
| 1,2,3-Trimethylbenzene | 10.995 | 0.33±0.00 a | - | - | - | - | - | - |
| *p*-Dichlorobenzene | 11.755 | 1.47±0.00 a | 1.28±0.10 a | 1.45±0.15 a | 0.72±0.04 b | - | - | 0.30±0.07 c |
| γ-Cadinene | 29.908 | - | - | - | - | 1.30±0.07 a | - | - |
| δ -Cadinene | 30.079 | - | - | - | - | 1.97±0.09 a | - | - |
| KETONES | | | | | | | | |
| 1-Penten-3-one | 2.518 | 0.85±0.06 bcdefg | 1.56±0.08 ab | 1.66±0.12 a | 1.30±0.16 abcd | 0.19±0.00 g | 0.29±0.01 fg | 1.35±0.46 abc |
| 2,3-Pentanedione | 2.655 | - | 0.39±0.05 a | - | - | - | | 0.52±0.16 a |
| 3-Pentanone | 2.666 | - | - | - | - | 0.26±0.00 a | - | - |
| 2-Heptanone | 7.278 | - | - | - | - | 0.14±0.00 a | - | - |
| 6-Methyl-5-hepten-2-one | 10.730 | 1.93±0.02 bc | 1.78±0.09 bc | 2.20±0.04 b | 3.41±0.29 a | - | 0.58±0.04 def | 1.81±0.49 bc |
| 3-Octanone | 10.772 | - | - | - | - | 1.32±0.12 a | - | - |
| 3,5-Octadien-2-one | 14.005 | 0.32±0.01 de | 0.51±0.02 abc | 0.48±0.03 bcd | 0.57±0.04 ab | - | 0.65±0.06 a | 0.27±0.06 ef |
| E- β -Ionone | 28.763 | 0.06±0.03 cd | 0.12±0.01 cd | 0.16±0.01 c | 0.60±0.07 a | - | 0.41±0.06 b | 0.14±0.03 c |
| SULFUR COMPOUNDS | | | | | | | | |
| Dimethyl sulfide | 1.496 | 1.13±0.02 c | 4.20±0.51 a | 2.55±0.24 b | - | - | - | - |
| Carbon disulfide | 1.559 | 0.52±0.01 b | 0.61±0.01 a | - | - | - | - | - |
| TERPENE | | | | | | | | |
| α-Thujene | 8.486 | - | 0.08±0.01 cde | 0.13±0.00 cd | 0.32±0.03 b | - | - | 0.10±0.01 cd |
| α-Pinene | 8.727 | - | 0.08±0.02 de | 0.49±0.06 b | 0.94±0.05 a | 0.92±0.14 a | 0.15±0.01 cde | 0.36±0.09 bc |
| Sabinene | 10.223 | - | - | 0.13±0.02 b | 0.31±0.04 a | - | - | 0.10±0.01 bcd |
| β-Pinene | 10.362 | - | 0.17±0.03 ef | 0.98±0.15 bc | 2.29±0.12 a | - | 0.46±0.02 de | 1.16± 0.18 b |
| β-Myrcene | 10.903 | 3.49±0.06 a | 3.53±0.13 a | 1.98±0.01 bcd | 1.03±0.02 f | 2.20±0.19 bc | 1.06±0.05 f | 1.68±0.30 cde |
| δ-3-Carene | 11.212 | - | - | - | 0.30±0.01 a | - | - | - |
| β -Ocimene | 11.594 | - | - | - | - | - | - | - |
| p- Cymene | 12.213 | 4.88±0.00 a | 4.43±0.08 ab | 3.35±0.12 cde | 2.52±0.10 f | 2.59±0.04 f | 2.84±0.03 ef | 3.15±0.32 def |
| Limonene | 12.447 | 56.16±0.16 b | 52.35±0.54 bc | 44.08±2.42 c | 44.13±0.81 c | 53.82±1.57 bc | 45.68±0.77 c | 67.39±5.80 a |
| γ- Terpinene | 13.535 | 0.59±0.00 abc | 0.50±0.01 bc | 0.37±0.02 c | 0.36±0.00 c | 0.80±0.04 a | 0.84±0.03 a | 0.59±0.14 abc |
| Linalool | 15.237 | - | - | - | - | 0.22±0.03 a | - | - |
| α -Cedrol | 29.259 | - | - | - | - | 1.22±0.11 a | - | - |
| Bicyclogermacrene | 29.355 | - | - | - | - | 1.55±0.08 a | - | - |
| α -Muurolene | 29.451 | - | - | - | - | 0.48±0.04 a | - | - |
| OTHERS | | 1.40±0.03 ef | 1.84±0.03 def | 2.18±0.06 def | 11.20±0.76 b | 16.19±0.83 a | 5.07±0.16 c | 1.08±0.19 ef |

* Shows values with insignificant difference ($p < 0.05$) for each column shown with same letters (± standard deviation)

Table 2. The Volatile Compounds of *C. intybus*, *T. longirostris*, *S. oleraceus*, *P. cognatum*, *T. officinale*. *S. alba*

| COMPOUNDS | RT | *Cichorium intybus* L. | *Tragopogon longirostris* Bisch. | *Sonchus oleraceus* L. | *Polygonum cognatum* Meissn. | *Taraxacum officinale* | *Silene alba* (Mill.) Krause |
|---|---|---|---|---|---|---|---|
| ALCOHOLS | | | | | | | |
| 3-Methyl-1-butanol | 3.296 | - | - | - | - | - | - |
| Pentanol | 3.889 | - | 0.16±0.00 ab | 0.05±0.00 bc | 0.23±0.02 a | - | 0.09±0.01 bc |
| E-2-Penten-1-ol | 3.931 | 0.11±0.01 de | 0.46±0.03 bc | 0.09±0.00 de | 1.49±0.09 a | 0.07±0.01 de | 0.28±0.01 cde |
| Z-3-Hexen-1-ol | 6.166 | 2.43±0.21 bc | 3.05±0.06 b | 1.50±0.03 c | 1.99±0.04 bc | 1.90±0.10 bc | 2.25±0.07 bc |
| E-2-Hexen-1-ol | 6.539 | - | 2.40±0.15 a | - | 1.58±0.27 b | - | - |
| Hexanol | 6.631 | 0.28±0.02 e | 2.39±0.10 a | 0.27±0.00 e | 1.15±0.06 b | 0.37±0.05 de | 0.45±0.03 de |
| 1-Octen-3-ol | 10.583 | 0.11±0.00 b | 0.07±0.01 b | - | 0.11±0.00 b | 0.13±0.01 b | 0.10±0.00 b |
| Octan-3-ol | 11.263 | - | - | - | - | - | - |
| Benzyl alcohol | 12.650 | - | - | - | - | - | - |
| Phenethyl alcohol | 15.655 | - | - | - | - | - | - |
| 2-Ethylhexanol | 32.100 | 0.31±0.02 cde | 0.86±0.05 a | - | 0.15±0.02 ef | 0.47±0.09 bc | 0.27±0.02 de |
| ALDEHYDE | | | | | | | |
| Isobutanal | 1.625 | - | 0.15±0.00 bc | - | - | 0.11±0.01 bcd | 0.10±0.01 cd |
| 3-Methylbutanal | 2.224 | 0.33±0.01 de | 0.84±0.03 cd | 0.37±0.04 cde | - | 0.38±0.00 cde | 0.63±0.00 cde |
| 2-Methylbutanal | 2.313 | 0.44±0.00 bcde | 0.52±0.04 bcd | 0.16±0.00 def | - | 0.56±0.04 bc | 0.70±0.03 b |
| Pentanal | 2.677 | 0.49±0.01 de | 0.86±0.00 c | - | - | 0.73±0.08 cd | 0.79±0.06 c |
| 2-Methyl-2- butenal | 3.388 | - | - | - | - | - | - |
| E-2-Pentenal | 3.601 | - | 0.77±0.00 d | 0.46±0.01 | 0.34±0.05 ef | 1.19±0.02 b | 0.89±0.11 cd |
| Hexanal | 4.588 | 4.05±0.18 e | 3.82±0.16 e | 1.14±0.02 fg | 1.15±0.19 fg | 5.08±0.47 de | 7.63±0.27 c |
| Furfural | 4.992 | - | - | - | - | - | - |
| E-2-Hexenal | 6.070 | 16.44±0.06 a | 14.26±1.34 abc | 11.66±0.12 bcd | 11.55±0.41 bcd | 14.72±0.56 ab | 10.12±1.05 cd |
| Heptanal | 7.657 | 1.18±0.03 b | 0.94±0.00 c | 0.61±0.02 d | 0.27±0.00 f | - | 1.45±0.04 a |
| Z-2-Heptenal | 9.657 | 0.09±0.00 d | - | 0.05±0.00 e | - | 0.24±0.00 b | 0.12±0.02 c |
| Benzaldehyde | 9.770 | 0.46±0.06 c | 0.20±0.01 cd | 0.36±0.01 cd | 0.08±0.02 d | 1.95±0.03 a | 1.11±0.15 b |
| E,E-2,4-Heptadienal | 11.164 | 1.36±0.08 c | 1.14±0.07 c | 0.36±0.00 de | 0.22±0.03 de | 1.98±0.02 ab | 2.41±0.02 a |
| Octanal | 11.433 | 0.55±0.02 b | - | 0.13±0.00 f | - | 0.75±0.07 a | 0.70±0.01 a |
| E,Z-2,4-Heptadienal | 11.766 | 0.71±0.06 b | - | - | - | 1.88±0.23 a | 1.76±0.02 a |
| Benzeneacetaldehyde | 12.925 | 0.22±0.01 b | 0.25±0.03 b | 0.17±0.00 b | - | 0.37±0.03 ab | 0.25±0.00 b |
| Nonanal | 15.385 | 1.64±0.06 c | 1.19±0.18 cde | 0.80±0.01 def | 0.37±0.01 fg | 2.94±0.19 a | 2.21±0.08 b |
| Decanal | 19.275 | 0.19±0.00 b | 0.10±0.01 cd | - | - | 0.35±0.04 a | 0.16±0.01 bc |
| ALKANE | | | | | | | |
| 2,2-Dimethyltetradecane | 23.370 | - | 0.92±0.01 a | 0.09±0.00 f | 0.15±0.02 def | 0.78±0.03 b | 0.31±0.00 c |
| 2,2,11,11-Tetramethyldodecane | 23.562 | - | 1.04±0.02 a | 0.08±0.01 h | 0.19±0.02 ef | 0.83±0.02 b | 0.36±0.00 c |

Table 2. Continued

| COMPOUNDS | RT | *Cichorium intybus* L. | *Tragopogon longirostris* Bisch. | *Sonchus oleraceus* L. | *Polygonum cognatum* Meissn. | *Taraxacum officinale* | *Silene alba* (Mill.) Krause |
|---|---|---|---|---|---|---|---|
| ESTER | | | | | | | |
| 2-Propenoic acid, 2-methyl-, methyl ester | 2.859 | - | - | - | - | - | - |
| FURAN | | | | | | | |
| 2-ethyl- Furan | 2.691 | - | - | - | 0.52±0.05 a | - | - |
| HYDROCARBONS | | | | | | | |
| *o*-Xylene | 6.540 | 0.12±0.01 d | - | - | - | 0.20±0.01 cd | - |
| Styrene | 7.249 | 0.17±0.02 d | 0.30±0.03 c | - | 0.12±0.00 d | 0.12±0.02 d | 0.10±0.01 de |
| 1,2,3-Trimethylbenzene | 10.995 | - | - | - | 0.14±0.00 c | 0.30±0.00 a | 0.22±0.03 b |
| *p*-Dichlorobenzene | 11.755 | - | 0.71±0.03 b | 0.34±0.02 c | 0.21±0.03 cd | - | - |
| γ-Cadinene | 29.908 | - | - | - | - | - | - |
| δ -Cadinene | 30.079 | - | - | - | - | - | - |
| KETONES | | | | | | | |
| 1-Penten-3-one | 2.518 | 0.42±0.03 efg | 1.13±0.02 abcde | 0.42±0.00 efg | 0.94±0.06 abcdef | 0.58±0.07 defg | 0.73±0.06 cdefg |
| 2,3-Pentanedione | 2.655 | 0.49±0.01 a | - | 0.56±0.02 a | - | - | - |
| 3-Pentanone | 2.666 | - | - | - | - | - | - |
| 2-Heptanone | 7.278 | - | - | - | - | - | - |
| 6-Methyl-5-hepten-2-one | 10.730 | 1.38±0.06 bcd | 1.59±0.04 bc | 0.63±0.02 def | 0.53±0.04 ef | 1.15±0.06 cde | 1.09±0.04 cde |
| 3-Octanone | 10.772 | - | - | - | - | - | - |
| 3,5-Octadien-2-one | 14.005 | - | 0.36±0.03 cde | 0.13±0.01 fgh | 0.09±0.02 gh | 0.32±0.02 e | 0.23±0.01 efg |
| E- β -Ionone | 28.763 | - | - | 0.09±0.00 cd | - | 0.12±0.01 cd | 0.10±0.00 cd |
| SULFUR COMPOUNDS | | | | | | | |
| Dimethyl sulfide | 1.496 | - | - | 0.76±0.03 cd | | 0.51±0.03 cd | 0.84±0.14 c |
| Carbon disulfide | 1.559 | - | - | - | - | - | - |
| TERPENE | | | | | | | |
| α-Thujene | 8.486 | 0.15±0.02 c | 0.07±0.01 cde | - | 0.05±0.01 de | 1.33±0.05 a | - |
| α-Pinene | 8.727 | 0.35±0.03 bcd | 0.15±0.00 cde | 0.09±0.00 cde | 0.13±0.03 cde | 0.11±0.00 cde | 0.26±0.01 bcde |
| Sabinene | 10.223 | 0.12±0.01 bc | 0.12±0.00 bc | 0.05±0.00 cde | 0.03±0.01 de | - | 0.08±0.00 bcd |
| β-Pinene | 10.362 | 0.92±0.12 bc | 0.32±0.00 def | 0.31±0.00 def | 0.37±0.04 def | 0.28±0.04 def | 0.62±0.01 cd |
| β-Myrcene | 10.903 | 1.80±0.10 cde | - | 1.25±0.01 ef | 1.43± 0.05 def | 2.48±0.04 b | 1.89±0.01 cd |
| δ-3-Carene | 11.212 | - | 0.30±0.03 a | - | - | - | - |
| β -Ocimene | 11.594 | - | 0.09±0.01 a | - | - | - | 0.10±0.01 a |
| p- Cymene | 12.213 | 2.78±0.06 ef | 2.96±0.05 def | 3.55±0.13 cd | 2.65±0.05 f | 4.01±0.09 bc | 3.90±0.23 bc |
| Limonene | 12.447 | 57.27±0.76 b | 51.79±1.04 bc | 72.92±0.61 a | 70.17±0.87 a | 47.42±0.58 bc | 51.82±1.11 bc |
| γ- Terpinene | 13.535 | 0.44±0.03 c | 0.34±0.02 c | 0.60±0.01 abc | 0.74±0.10 ab | - | 0.46±0.02 c |
| Linalool | 15.237 | - | 0.11±0.01 bc | 0.07±0.00 c | 0.24±0.02 a | 0.13±0.01 b | - |
| α -Cedrol | 29.259 | - | - | - | - | - | - |
| Bicyclogermacrene | 29.355 | - | - | - | - | - | - |
| α -Muurolene | 29.451 | - | - | - | - | - | - |
| OTHERS | | 2.21±0.16 def | 3.26±0.16 d | 0.97±0.01 ef | 0.58±0.06 f | 3.15±0.06 d | 2.42±0.15 de |

* Shows values with insignificant difference ($p < 0.05$) for each column shown with same letters (± standard deviation)

The presence of volatile component content in *Malva neglecta* consists of 61.14% terpene, 23.26% aldehyde and 1.11 % alcohol. SPME analysis of *M. neglecta* was not found in the literature. However, *M. neglecta* crude methanolic extract (Mn.Cme) was chemically characterized using GCMS analysis. In GC-MS analysis, oleic acid (19.67%), taurine (17.60%), ethylene dimercaptan (14.67%), isoeugenol (14.61%), patchoulane (10.36%), methyl 12-methyltetradecanoate (8.47%) and isopropyl myristate (7.02%) were highly abundant compounds. In another study, the efficacy of solvent-free microwave extraction (SFME) was investigated for the extraction of essential oils from the above-ground parts of *Malva neglecta* Wallr. The essential oils were then injected onto the HP-5MS column of a commercially available GC/MS (Hewlett-Packard 5973), resulting in a chromatogram of 24 compounds, accounting for 99.9% of the oil composition. In terms of general categories, non-terpene hydrocarbons and sesquiterpene hydrocarbons were found to be the main fractions of the chemical profiles (Mohammadhosseini, 2021.

The volatile component content of *Scorzonera cana* consists of 65.12% terpene, 21.19% aldehyde and 4.08 % alcohol. In another study published by Lendzion et al. (2021), presence of many bioactive compounds like triterpenoids, sesquiterpenoids, flavonoids, or caffeic acid and quinic acid derivatives were found in extracts obtained from aerial and subaerial parts of *Scorzonera* species. On the other hand, *Scorzonera* species are found to be highly rich in terpenes compounds: such as monoterpenes, sesquiterpene lactones, and triterpenes (Acikara et al., 2013; Yang et al., 2016). These studies also support our results.

As mentioned above, terpenes were the dominant group of volatile compounds in all plants and limonene was the major component among them. The interaction of abiotic factors such as soil characteristics and climate can influence the volatile profiles of all species. For instance, environmental conditions can affect the emission rates and types of volatiles produced, leading to variations in the chemical cues available to pollinators and herbivores. Some of the different results we obtained in our study compared to the literature are probably due to this interaction of abiotic factors. The volatile components may play a role in enhancing the sensory attributes of the plant, making it more appealing for culinary uses. The aroma and flavor profile of volatile compounds can significantly affect consumer preferences. For example, terpenes, which are prevalent in many plants, contribute to the characteristic scents and flavors that can enhance the palatability of foods (Fukuda et al., 2013). This sensory enhancement can encourage the consumption of vegetables that contain terpene aromas, thereby increasing their nutritional intake. In conclusion, the high terpene content species serves crucial ecological functions such as pollinator attraction, defense against herbivores, and potential allelopathy. Nutritionally, terpenes contribute to the health benefits, flavor, and potential medicinal properties of these plants, enhancing their value as food sources. The interplay between ecological roles and nutritional benefits highlights the importance of terpenes in these species' survival and utility.

Limonene is frequently identified as one of the most highly volatile compounds found in plants, and this prominence can be attributed to several factors related to its chemical properties, ecological roles, and biosynthetic pathways. Limonene is a monoterpene, characterized by its low molecular weight and relatively simple structure, which contributes to its high volatility. The volatility of a compound is influenced by its molecular weight, boiling point, and vapor pressure; limonene has a low boiling point (approximately 177°C) and high vapor pressure, making it readily evaporate at room temperature. This property allows limonene to be emitted in significant quantities into the atmosphere, where it can serve various ecological functions (Erasto & Viljoen, 2008). Limonene plays a crucial role in attracting pollinators. Its pleasant citrus aroma is appealing to many insects, including bees and butterflies, which are essential for the pollination of many flowering plants. The ability to attract these pollinators enhances the reproductive success of plants that produce limonene, thereby promoting genetic diversity and plant population stability (Zhao & Kang, 2002). Limonene also serves as a defense compound against herbivores and pathogens. Its insecticidal properties have been documented, with studies showing that limonene can deter certain insect pests, thereby reducing herbivory (Lackus et al., 2018). Additionally, limonene has antifungal properties, which can help protect plants from fungal infections. This dual role as both an attractant and a deterrent underscore the ecological significance of limonene in plant survival (Quintana-Rodríguez et al., 2014). The emission of limonene and other volatile compounds can trigger induced resistance in neighboring plants. When a plant is damaged by herbivores, it may release limonene, which can signal nearby plants to bolster their own defenses against potential threats (Erasto & Viljoen, 2008). This phenomenon enhances community resilience against herbivory and disease. Limonene is biosynthesized from geranyl pyrophosphate (GPP) through the action of limonene synthase, an enzyme that catalyzes the conversion of GPP into limonene in a single step. This pathway is common among many plant species, contributing to the widespread occurrence of limonene in various plant genera, particularly in citrus fruits and aromatic herbs. The ability of plants to produce limonene from a common precursor facilitates its prevalence in the plant kingdom (Maruyama et al., 2001; Chen, 2024). The highest limonene content in all species was found in *Sonchus oleraceus* L. with approximately 73%, while the lowest content was found in *Lactuca serriola* L., and *Rumex patientia* L. with 44%. In the food sector, limonene can be utilized as a flavoring agent to mask bitter tastes, and it also possesses antioxidant, antimicrobial, anti-carcinogenic, chemo-preventive, and antidiabetic properties that are beneficial for pharmaceutical purposes (Hidajat et al., 2020). The limonene aroma likely contributes to the local people's preference for collecting and consuming these 13 species. For this reason, limonene can have a positive effect on consumers' vegetable consumption rates.

## CONCLUSION

This study provides important data for determining plants' volatile compound profiles. The volatile components play a significant role in the sensory attributes of food, influencing both aroma and flavor. They are produced by plants in response to various stimuli, including biotic and abiotic stresses, and are crucial for attracting pollinators, deterring herbivores, and facilitating seed dispersal. The complexity of these compounds contributes to the overall sensory experience of food, as they can evoke specific flavors and aromas that enhance consumer appeal. They are integral to the sensory characteristics of food, influencing aroma, flavor, and even food safety. The findings from this study will contribute to obtaining more information about plants potential biological activities and applied areas. Future studies should compare the volatile compound profiles of the same species growing in different habitats or different species growing in the same habitat to better understand the effects of environmental factors. Furthermore, conducting similar analyses on various plant species may increase the general results' validity. These studies will be plants complex interactions and biosynthetic pathways present opportunities for enhancing food quality through agricultural and processing innovations.

### Compliance with Ethical Standards

### Peer-review

Externally peer-reviewed.

### Conflict of interest

The author declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

### Author contribution

ACT: design, writing and laboratory studies. The author verifies that the Text, Figures, and Tables are original and that they have not been published before.

## REFERENCES

Abdalla, M. A. and Zidorn, C. (2020). The genus *Tragopogon* (Asteraceae): a review of its traditional uses, phytochemistry, and pharmacological properties. *Journal of Ethnopharmacology*, *250*, 112466. https://doi.org/10.1016/j.jep.2019.112466

Abdul-Jalil, T. Z. (2020). *Lactuca serriola*: short review of its phytochemical and pharmacological profiles. *International Journal of Drug Delivery Technology*, 10(03), 505-508. https://doi.org/10.25258/ijddt.10.3.34

Acikara, O. B., Çitoğlu, G. S., & Çoban, T. (2013). Phytochemical Screening and Antioxidant Activities of Selected *Scorzonera* Species. *Turkish Journal of Pharmaceutical Sciences*, *10*(3), 453-462.

Akbulut, S. and Zengin, Z. (2023). Ethnobotanical survey of wild plants used in Gümüşhane province (Turkey). *Boletin Latinoamericano Y Del Caribe De Plantas Medicinales Y Aromaticas*, *22*(2), 237-254. https://doi.org/10.37360/blacpma.23.22.2.18

Akgöz, Y. (2014). Biological and antioxidant activities of *Silene* sp.. *International Research Journal of Pharmacy*, *5*(11), 810-813. https://doi.org/10.7897/2230-8407.0511166

Akpınar, R., Yıldırım Baştemur, G., Bıçak, B., Sanli, N. O., Mertoğlu Kamalı, E., Pekmez, M., Kecel Gündüz, S., & Perçin Özkorucuklu, S. (2023). Phytochemical profiling, in vitro biological activities, and in silico (molecular docking and absorption, distribution, metabolism, excretion, toxicity) studies of *Polygonum cognatum* Meissn. *Journal of Separation Science*, *47*(1). https://doi.org/10.1002/jssc.202300750

Al-Rimawi, F., Rishmawi, S., Ariqat, S. H., Khalid, M., Warad, I., & Salah, Z. (2016). Anticancer activity, antioxidant activity, and phenolic and flavonoids content of wild *Tragopogon porrifolius* plant extracts. *Evidence-Based Complementary and Alternative Medicine*, *2016*(1). https://doi.org/10.1155/2016/9612490

Al-Qurashy, N. N. A. (2023). Antibacterial and antifungal activity of the extract of medicinal plant *Malva neglecta* Wallr. *Journal of Wasit for Science and Medicine, 10*(1), 1-6. https://doi.org/10.31185/jwsm.407

Alasalvar, C., Topal, B., Serpen, A., Bahar, B., Pelvan, E., & Gökmen, V. (2012). Flavor characteristics of seven grades of black tea produced in Turkey. *Journal of Agricultural and Food Chemistry, 60*(25), 6323-6332. https://doi.org/10.1021/jf301498p

Amao, I. (2018). Health benefits of fruits and vegetables: Review from Sub-Saharan Africa. *Vegetables: importance of quality vegetables to human health*, *22*, 33-53. https://doi.org/10.5772/intechopen.74472

Andalib, F., Moosavian, H., Khazraeinia, P., Mohajerani, S., & Pourakbari, S. (2021). Comparison of hepatoprotective activity of *Cichorium intybus* and *Cynara scolymus* extracts against paracetamol induced hepatotoxicity in broiler chicken. *Egyptian Journal of Veterinary Sciences*, *52*(2), 251-256. https://doi.org/10.21608/ejvs.2021.48017.1200

Aziz, M. A., Adnan, M., Khan, A., Rehman, A. U., Jan, R., & Khan, J. (2016). Ethno-medicinal survey of important plants practiced by indigenous community at ladha subdivision, south waziristan agency, Pakistan. *Journal of Ethnobiology and Ethnomedicine, 12*(1). https://doi.org/10.1186/s13002-016-0126-7

Barthelmess, E. L., Richards, C. M., & McCauley, D. E. (2005). Relative effects of nocturnal vs diurnal pollinators and distance on gene flow in small *Silene alba* populations. *New Phytologist, 169*(4), 689-698. https://doi.org/10.1111/j.1469-8137.2005.01580.x

Baydoun, S., Hani, N., Nasser, H., Ulian, T., & Arnold-Apostolides, N. (2023). Wild leafy vegetables: a potential source for a traditional mediterranean food from Lebanon. *Frontiers in Sustainable Food Systems*, *6*. https://doi.org/10.3389/fsufs.2022.991979

Bezerra, M. S., Zeferino, K. S., Menezes, L. D., Bezerra, A. S., Lopes, L. Q. S., & Marquezan, F. K. (2022). Antimicrobial and antibiofilm activities of *Cichorium intybus*: a review. *Research, Society and Development, 11*(2), e10911225384. https://doi.org/10.33448/rsd-v11i2.25384

Bushra, I., Fozia, F., Waheed, A., Rehman, A., Ullah, H., Iqbal, H., Wahap, A., Almas, M., & Ahmad, I. (2012). Antimicrobial activity of *Malva neglecta* and *Nasturtium microphyllum*. *International Journal of Research in Ayurveda and Pharmacy, 3*(6), 808-810. https://doi.org/10.7897/2277-4343.03624

Butnariu, M., Quispe, C., Herrera-Bravo, J., Pentea, M., Sărac, I., Küşümler, A. S., Özçelik, B., Painuli, S., Semwal, P., Imran, M., Gondal, T.A., Emamzadeh-Yazdi, S., Lapava, N., Yousaf, Z., Kumar, M., Eid, A.H., Al-Dhaheri, Y., Suleria, H.A.R., Contreras, M.M., Sharifi-Rad, J., & Cho, W. C. (2022). Papaver plants: current insights on phytochemical and nutritional composition along with biotechnological applications. *Oxidative Medicine and Cellular Longevity*, *2022*, 1-23. https://doi.org/10.1155/2022/2041769

Caporaso, N. & Sacchi, R. (2021). Flavor chemistry of virgin olive oil: an overview. *Applied Sciences, 11*(4), 1639. https://doi.org/10.3390/app11041639

Carev, I., Golemac, A., Siljak-Yakovlev, S., Pellay, F. X., & Politeo, O. (2022). Volatile Oil Chemical Composition of Wild, Edible *Centaurea scabiosa* L. and Its Cytotoxic Activity. *Plants, 11*(23), 3267. https://doi.org/10.3390/plants11233267

Casado-Hidalgo, G., Pérez-Quintanilla, D., Morante-Zarcero, S., & Sierra, I. (2021). Mesostructured silica-coated magnetic nanoparticles to extract six opium alkaloids in poppy seeds prior to ultra-high-performance liquid chromatography-tandem mass spectrometry analysis. *Foods, 10*(7), 1587. https://doi.org/10.3390/foods10071587

Chak, P. O. O. J. A., Chaudhary, D., Jain, S. O. N. I. K. A., Soni, P., Jain, P. K., Dwivedi, J. A. Y. A., & Sharma, S. (2021). Phytochemical and gas chromatography-mass spectrometry analysis of *Chenopodium album* and *Stellaria media*. *Indian Journal of Pharmaceutical Sciences, 83*(6), 1261-72. https://doi.org/10.36468/pharmaceutical-sciences.881

Chak, P., Chaudhary, D., Jain, S., Soni, P., Jain, P., Dwivedi, J., & Sharma, S. (2021). Phytochemical and gas chromatography-mass spectrometry analysis of *Chenopodium album* and *Stellaria media*. *Indian Journal of Pharmaceutical Sciences, 83*(6). https://doi.org/10.36468/pharmaceutical-sciences.881

Chen, L., Xia, F., Lin, X., Liu, Q., Zengin, G., Delmas, D., Paoli, P., Teng H. & Xiao, J. (2019). Phenolic extract from *Sonchus oleraceus* L. protects diabetes-related liver injury in rats through TLR4/NF-KB signaling pathway. *eFood, 1*(1), 77-84. https://doi.org/10.2991/efood.k.191018.002

Chen, X., Ding, Y., Guan, H., Zhou, C., He, X., Shao, Y., Wang, Y.-B., Wang, N., Li, B., Lv, G.-Y. & Chen, S. (2024). The pharmacological effects and potential applications of limonene from citrus plants: a review. *Natural Product Communications, 19*(5). https://doi.org/10.1177/1934578x241254229

Cho, K. S., Lim, Y. R., Lee, K., Lee, J., Lee, J. H., & Lee, I. S. (2017). Terpenes from forests and human health. *Toxicological Research, 33,* 97-106. https://doi.org/10.5487/TR.2017.33.2.097

Demirpolat, A. (2022). Chemical composition of essential oils of seven polygonum species from Turkey: A chemotaxonomic approach. *Molecules, 27*(24), 9053. https://doi.org/10.3390/molecules27249053

Demirgül, F., Divriklioğlu-Kundak, M., & Sağdıç, O. (2022). Bioactive properties, antibacterial activity, and color features of polygonum cognatum: the effects of frozen storage and cooking process. *Food Science and Technology, 42*. https://doi.org/10.1590/fst.00322

Demján, V., Sója, A., Kiss, T., Fejes, A., Gausz, F. D., Szűcs, G., Siska, A., Földesi I., Tengölics, R., Darula Z., Csupor, D., Pipicz, M. & Csont, T. (2022). *Stellaria media* tea protects against diabetes-induced cardiac dysfunction in rats without affecting glucose tolerance. *Journal of Traditional and Complementary Medicine, 12*(3), 250-259. https://doi.org/10.1016/j.jtcme.2021.08.003

Deveci, E. (2022). LC-ESI-MS/MS-based phytochemicals and cytotoxic, antioxidant, and enzyme inhibitory activities of *Scorzonera mollis* subsp. Szowitzii: a new reserve of bioactive compounds. *Journal of Food Processing and Preservation, 46*(4). https://doi.org/10.1111/jfpp.16478

Dias, J. S. (2012). Major classes of phytonutriceuticals in vegetables and health benefits: a review. *Journal of Nutritional Therapeutics, 1*(1), 31-62. https://doi.org/10.6000/1929-5634.2012.01.01.5

Dias, J.S. & Imai, S. (2017). Vegetables consumption and its benefits on diabetes. *Journal of Nutritional Therapeutics, 6*(1), 1-10. https://doi.org/10.6000/1929-5634.2017.06.01.1

Dongare, P. N., Kadu, T. B., Pohane, A. L., Dighade, S. J., & Patil, P. G. (2021). Review on pharmacognosy, phytochemistry and pharmacological activity of *Taraxacum officinale* (dandelion plant). *World Journal of Advanced Research and Reviews, 12*(2), 212-118. https://doi.org/10.30574/wjarr.2021.12.2.0570

Dudareva, N., Pichersky, E., & Gershenzon, J. (2004). Biochemistry of plant volatiles. *Plant Physiology, 135*(4), 1893-1902. https://doi.org/10.1104/pp.104.049981

El-Hawary, S. A., Sokkar, N. M., Ali, Z. Y., & Yehia, M. M. (2011). A profile of bioactive compounds of *Rumex vesicarius* L. *Journal of Food Science, 76*(8), C1195-C1202. https://doi.org/10.1111/j.1750-3841.2011.02370.x

Epure, A., Pârvu, A., Vlase, L., Benedec, D., Hanganu, D., Oniga, O., Vlase, A.-M., Ielciu, I., Toiu, A., & Oniga, I. (2023). New approaches on the anti-inflammatory and cardioprotective properties of *Taraxacum officinale* tincture. *Pharmaceuticals, 16*(3), 358. https://doi.org/10.3390/ph16030358

Erasto, P. and Viljoen, A. (2008). Limonene - a review: biosynthetic, ecological and pharmacological relevance. *Natural Product Communications, 3*(7),1934578X0800300. https://doi.org/10.1177/1934578x0800300728

Erdoğan, T., Gönenç, T. M., Çakılcıoğlu, U., & Kıvçak, B. (2014). Fatty acid composition of the aerial parts of some *Centaurea* species in Elazig, Turkey. *Tropical Journal of Pharmaceutical Research, 13*(4), 613. https://doi.org/10.4314/tjpr.v13i4.19

Eruygur, N., Uçar, E., Ataş, M., Ergül, M., & Sözmen, F. (2020). Determination of biological activity of *Tragopogon porrifolius* and *Polygonum cognatum* consumed intensively by people in Sivas. *Toxicology Reports, 7,* 59-66. https://doi.org/10.1016/j.toxrep.2019.12.002

Esmaeili, A., Rustaiyan, A., Nadimi, M., Masoudi, S., Tadayon, F., Sedaghat, S., Ebrahimpur, N., & Hajyzadeh, E. (2005). Volatile constituents of *Centaurea depressa* MB and *Carduus pycnocephalus* L. two compositae herbs growing wild in Iran. *Journal of Essential Oil research, 17*(5), 539-541. https://doi.org/10.1080/10412905.2005.9698988

Espina, L., Gelaw, T. K., Lamo-Castellví, S. d., Pagán, R., & García-Gonzalo, D. (2013). Mechanism of bacterial inactivation by (+)-limonene and its potential use in food preservation combined processes. *Public Library of Science One, 8*(2), e56769. https://doi.org/10.1371/journal.pone.0056769

Fan, F., Zhou, S., Qian, H., Zong, B., Huang, C., Zhu, R., Guo, H-W., & Gong, S. (2022). Effect of yellowing duration on the chemical profile of yellow tea and the associations with sensory traits. *Molecules, 27*(3), 940. https://doi.org/10.3390/molecules27030940

Farzaei, M. H., Rahimi, R., Attar, F., Siavoshi, F., Saniee, P., Hajimahmoodi, M., Mirnezami, T., & Khanavi, M. (2014). Chemical composition, antioxidant and antimicrobial activity of essential oil and extracts of *Tragopogon graminifolius*, a medicinal herb from İran. *Natural Product Communications, 9*(1), 1934578X1400900. https://doi.org/10.1177/1934578x1400900134

Fukuda, T., Okazaki, K., & Shinano, T. (2013). Aroma characteristic and volatile profiling of carrot varieties and quantitative role of terpenoid compounds for carrot sensory attributes. *Journal of Food Science, 78*(11). https://doi.org/10.1111/1750-3841.12292

Fulton, S., Cardwell, C., McKinley, M., & Woodside, J. V. (2011). The effect of increasing fruit and vegetable consumption on overall diet: a systematic review and meta-analysis. *Proceedings of the Nutrition Society, 70*(OCE3). https://doi.org/10.1017/s0029665111001066

García-Carrasco, B., Fernández-Dacosta, R., Dávalos, A., Ordovás, J. M., & Rodríguez-Casado, A. (2015). In vitro hypolipidemic and antioxidant effects of leaf and root extracts of *Taraxacum officinale*. *Medical Sciences, 3*(2), 38-54. https://doi.org/10.3390/medsci3020038

Ghaderi, R., Zardast, M., Hosseini, M. K., Delgir, B., & Hassanpour, M. (2012). Comparison of antibacterial effect of *Cichorium intybus* L. with vancomycin, ceftriaxone, ciprofloxacin and penicillin (in vitro). *Clinical and Experimental Pharmacology, 02*(02). https://doi.org/10.4172/2161-1459.1000113

Gomaa, N. H., Hassan, M. O., Fahmy, G. M., González, L., Hammouda, O., & Atteya, A. M. (2014). Allelopathic effects of *Sonchus oleraceus* L. on the germination and seedling growth of crop and weed species. *Acta Botanica Brasilica, 28*(3), 408-416. https://doi.org/10.1590/0102-33062014abb3433

Gözcü, S., Uğan, R. A., Özbek, H., Gündoğdu, B., & Güvenalp, Z. (2023). Evaluation of antidiabetic and antioxidant effects of *Polygonum cognatum* Meisn. and phytochemical analysis of effective extracts. *Biomedical Chromatography, 38*(3). https://doi.org/10.1002/bmc.5809

Guo, L., Huang, L., Cheng, X., Gao, Y., Zhang, X., Yuan, X., Xue, C., & Chen, X. (2022). Volatile flavor profile and sensory properties of vegetable soybean. *Molecules, 27*(3), 939. https://doi.org/10.3390/molecules27030939

Gürbüz, İ., Özkan, A. M. G., Yeşilada, E., & Kutsal, O. (2005). Anti-ulcerogenic activity of some plants used in folk medicine of pinarbasi (kayseri, turkey). *Journal of Ethnopharmacology, 101*(1-3), 313-318. https://doi.org/10.1016/j.jep.2005.05.015

Hidajat, M. J., Jo, W., Kim, H., & Noh, J. (2020). Effective droplet size reduction and excellent stability of limonene nanoemulsion formed by high-pressure homogenizer. *Colloids and Interfaces, 4*(1), 5. https://doi.org/10.3390/colloids4010005

Honěk, A. and Martinková, Z. (2010). Body size and the colonisation of cereal crops by the invasive slug *Arion lusitanicus*. *Annals of Applied Biology, 158*(1), 79-86. https://doi.org/10.1111/j.1744-7348.2010.00442.x

Hong, J. & Gruda, N. (2020). The potential of introduction of Asian vegetables in Europe. *Horticulturae, 6*(3), 38. https://doi.org/10.3390/horticulturae6030038

Hussein, I. A., Radhakrishnan, S., El-Hela, A. A., Mohammad, A. I., & Ross, S. A. (2019). Antimicrobial secondary metabolites from *Silene rubella* growing in Egypt. *Journal of Biomedical and Pharmaceutical Research, 8*(6). https://doi.org/10.32553/jbpr.v8i6.694

Hussein, M. A. and Gobba, N. A. (2014). Biochemical study on rule of *Sonchus oleraceus* L. extracts against paracetamol-induced liver toxicity. *Scientific Journal of October 6 University, 2*(1), 1-11. https://doi.org/10.21608/sjou.2014.32865

Ibrahim, L., Saleh, A., Ammar, M., Mansour, M., & El-Hamid, H. A. (2022). Allelopathic effect of some wild species on germination and growth of *Bidens pilosa*. *Advances in Environmental and Life Sciences, 3*(1), 21-30. https://doi.org/10.21608/aels.2022.177060.1025

İlgün, S., Akkol, E. K., İlhan, M., Polat, D. Ç., Kılıç, A. B., Coşkun, M., & Sobarzo-Sánchez, E. (2020). Sedative effects of latexes obtained from some *Lactuca* L. species growing in Turkey. *Molecules, 25*(7), 1587. https://doi.org/10.3390/molecules25071587

Jędrzejczyk, I. and Rewers, M. (2020). Identification and genetic diversity analysis of edible and medicinal *Malva* species using flow cytometry and ISSR molecular markers. *Agronomy, 10*(5), 650. https://doi.org/10.3390/agronomy10050650

Jerković, I., Marijanović, Z., Kranjac, M., & Radonić, A. (2015). Comparison of different methodologies for detailed screening of *Taraxacum officinale* honey volatiles. *Natural Product Communications, 10*(2), 1934578X1501000. https://doi.org/10.1177/1934578x1501000238

Jovin, E., Simin, N., Orčić, D., Balog, K., Beara, I., Lesjak, M., & Dukic, N. M. (2011). Antioxidant and anti-inflammatory properties of *Rumex patientia* L. *Planta Medica, 77*(12). https://doi.org/10.1055/s-0031-1282915

Jürgens, A., Witt, T., & Gottsberger, G. (2002). Flower scent composition in night-flowering *Silene* species (Caryophyllaceae). *Biochemical Systematics and Ecology, 30*(5), 383-397. https://doi.org/10.1016/S0305-1978(01)00106-5

Kaplan, Ö. and Gökşen Tosun, N. (2023). Biosynthesis of iron, copper and silver nanoparticles using polygonum cognatum and tragopogon porrifolius extracts and evaluation of their antimicrobial potentials. *Duzce University Science and Technology Journal, 11*(4), 2155-2167. https://doi.org/10.29130/dubited.1093468

Karioti, A., Milošević-Ifantis, T., Pachopos, N., Niryiannaki, N., Hadjipavlou-Litina, D., & Skaltsa, H. (2014). Antioxidant, anti-inflammatory potential and chemical constituents *of Origanum dubium* Boiss., growing wild in Cyprus. *Journal of Enzyme Inhibition and Medicinal Chemistry, 30*(1), 38-43. https://doi.org/10.3109/14756366.2013.871008

Kaya, E., Akbaş, P., Ceyhan, G., Erdem, T. K., & Alkan, H. (2020). Determination the fatty acid composition of the rumex patientia l. leaves and in vitro antimicrobial activity of their different extracts. *Suleyman Demirel University Science Institute Journal, 24*(2), 362-367. https://doi.org/10.19113/sdufenbed.643154

Kenny, O., Brunton, N. P., Walsh, D., Hewage, C. M., McLoughlin, P., & Smyth, T. J. (2015). Characterisation of antimicrobial extracts from dandelion root (*Taraxacum officinale*) using LC-SPE-NMR. *Phytotherapy Research, 29*(4), 526-532. https://doi.org/10.1002/ptr.5276

Keyrouz, E., Feghali, P. A. R. E., Jaafar, M., & Nawas, T. (2017). *Malva neglecta*: a natural inhibitor of bacterial growth and biofilm formation. *Journal of Medicinal Plants Research, 11*(24), 380-386. https://doi.org/10.5897/jmpr2017.6422

Khan, A. S., Arif, K., Munir, B., Kiran, S., Jalal, F., Qureshi, N. A., Hassan, S.M., Soomro, G.A., Nazir, A., Ghaffar, A., Tahir, M. A. & Iqbal, M. (2018). Estimating total phenolics in *Taraxacum officinale* (L.) extracts. *Polish Journal of Environmental Studies, 28*(1), 497-501. https://doi.org/10.15244/pjoes/78435

Kim, K. H., Lee, K. H., Choi, S. U., Kim, Y. H., & Lee, K. R. (2008). Terpene and phenolic constituents of *Lactuca indica* L. *Archives of Pharmacal Research, 31,* 983-988. https://doi.org/10.1007/s12272-001-1256-8

Kim, J., Lee, H., Choi, J., & Lee, S. (2022). Phytochemical constituents of *Lactuca serriola* leaves and their content analysis by HPLC-UV. *Journal of Applied Biological Chemistry, 65*(3), 153-158. https://doi.org/10.3839/jabc.2022.020

Kiyama, R. (2017). Estrogenic terpenes and terpenoids: Pathways, functions and applications. *European Journal of Pharmacology, 815*, 405-415. https://doi.org/10.1016/j.ejphar.2017.09.049

Küpeli, E., Orhan, İ. E., & Yeşilada, E. (2007). Evaluation of some plants used in Turkish folk medicine for their anti-inflammatory and antinociceptive activities. *Pharmaceutical Biology, 45*(7), 547-555. https://doi.org/10.1080/13880200701498895

Lackus, N. D., Lackner, S., Gershenzon, J., Unsicker, S. B., & Köllner, T. G. (2018). The occurrence and formation of monoterpenes in herbivore-damaged poplar roots. *Scientific Reports, 8*(1). https://doi.org/10.1038/s41598-018-36302-6

Lendzion, K., Gornowicz, A., Bielawski, K., & Bielawska, A. (2021). Phytochemical composition and biological activities of *Scorzonera* species. *International Journal of Molecular Sciences, 22*(10), 5128. https://doi.org/10.3390/ijms22105128

Leyo, I. H., Ousmane, Z. M., Nomaou, D. L., Guimbo, I. D., Salaou, I. A., Francis, F., & Megido, R. C. (2022). Effect of maggot production residue on amaranth growth parameters. *Open Journal of Soil Science, 12*(12), 571-585. https://doi.org/10.4236/ojss.2022.1212024

Li, X. and Yang, P. (2018). Research progress of *Sonchus* species. *International Journal of Food Properties, 21*(1), 147-157. https://doi.org/10.1080/10942912.2017.1415931

Liu, R. H. (2013). Dietary bioactive compounds and their health implications. *Journal of Food Science, 78*(s1). https://doi.org/10.1111/1750-3841.12101

Ma, L., Song, J., Shi, Y., Wang, C., Chen, B., Xie, D., & Jia, X. (2012). Anti-hepatitis b virus activity of chickweed [*Stellaria media* (L.) Vill.] extracts in HEPG2.2.15 cells. *Molecules, 17*(7), 8633-8646. https://doi.org/10.3390/molecules17078633

Maletha, D., Singh, S. P., & Ramanarayanan, S. (2022). Hepatoprotective and nephroprotective efficacy of *Cichorium intybus* following imidacloprid induced subchronic toxicity in wlh cockerels. *The Indian Journal of Animal Sciences, 92*(8), 940-945. https://doi.org/10.56093/ijans.v92i8.123891

Mamadalieva, N. Z., Lafont, R., & Wink, M. (2014). Diversity of secondary metabolites in the genus *Silene* L. (caryophyllaceae)—structures, distribution, and biological properties. *Diversity, 6*(3), 415-499. https://doi.org/10.3390/d6030415

Maruyama, T., Ito, M., Kiuchi, F., & Honda, G. (2001). Molecular cloning, functional expression and characterization of d-limonene synthase from *Schizonepeta tenuifolia*. *Biological and Pharmaceutical Bulletin, 24*(4), 373-377. https://doi.org/10.1248/bpb.24.373

Meinert, L., Frøst, M., Bejerholm, C., & Aaslyng, M. D. (2011). Enhancing the sensory quality of vegetables by decreasing some less-desired sensory properties with low-fat pork gravy. *Journal of Culinary Science & Technology, 9*(2), 113-131. https://doi.org/10.1080/15428052.2011.584496

Mewalal, R., Rai, D. K., Kainer, D., Chen, F., Külheim, C., Peter, G. F., & Tuskan, G. A. (2017). Plant-derived terpenes: A feedstock for specialty biofuels. *Trends in Biotechnology, 35*(3), 227-240. https://doi.org/10.1016/j.tibtech.2016.08.003

Miguel, M. G. (2010). Antioxidant and anti-inflammatory activities of essential oils: a short review. *Molecules, 15*(12), 9252-9287. https://doi.org/10.3390/molecules15129252

Mohammed, F. S., Uysal, I., Yaz, H. H., & Sevindik, M. (2023). Papaver species: usage areas, essential oil, nutrient and elements contents, biological activities. Prospects in Pharmaceutical Sciences, 21(4), 1-9. https://doi.org/10.56782/pps.142

Mohammadhosseini, M. (2021). Chemical composition of the essential oils from the aerial parts of *Malva neglecta* Wallr. from Khorramabad, Lorestan Province, Iran using solvent free microwave extraction (SFME) method. *Trends in Phytochemical Research, 5*(3), 155-163. https://doi.org/10.30495/tpr.2021.685071

Monteiro, J. A., Júnior, J. M., Oliveira, I. R. N. d., Batista, F. L. A., Pinto, C. C. C., Silva, A. A. S., Morais, S.M. & Silva, M. G. V. (2018). Bioactivity and toxicity of *Senna cana* and *Senna pendula* extracts. *Biochemistry Research International, 2018*, 1-10. https://doi.org/10.1155/2018/8074306

Muthukumaran, P., Kumaravel, S., & Nimia, N. (2019). Phytochemical, GC-MS and FT-IR analysis of *Papaver somniferum* L. *Journal of Pharmaceutical and Biological Sciences, 7*(1), 1-8. https://doi.org/10.18231/j.jpbs.2019.001

Nasimi Doost Azgomi, R., Karimi, A., Tutunchi, H., & Moini Jazani, A. (2021). A comprehensive mechanistic and therapeutic insight into the effect of chicory (*Cichorium intybus*) supplementation in diabetes mellitus: A systematic review of literature. *International Journal of Clinical Practice, 75*(12), e14945. https://doi.org/10.1111/ijcp.14945

Nouidha, S., Selmi, S., Guigonis, J., Pourcher, T., Chekir-Ghedira, L., & Kilani-Jaziri, S. (2023). Metabolomics profiling of Tunisian *Sonchus oleraceus* L. extracts and their antioxidant activities. *Chemistry &Amp; Biodiversity, 20*(8). https://doi.org/10.1002/cbdv.202300290

Page, P., Favre, A., Schiestl, F. P., & Karrenberg, S. (2014). Do flower color and floral scent of *Silene* species affect host preference of *Hadena bicruris*, a seed-eating pollinator, under field conditions? *PLoS ONE, 9*(6), e98755. https://doi.org/10.1371/journal.pone.0098755

Pearson, N., Ball, K., & Crawford, D. (2010). Predictors of changes in adolescents' consumption of fruits, vegetables and energy-dense snacks. *British Journal of Nutrition, 105*(5), 795-803. https://doi.org/10.1017/s0007114510004290

Power, S., O'Toole, P. W., O'Connor, E. M., & Fitzgerald, G. F. (2011). Consumption of fruit and vegetables among elderly Irish people in long-term institutionalised care: the ELDERMET project. *Proceedings of the Nutrition Society, 70*(OCE3). https://doi.org/10.1017/s002966511100156x

Quintana-Rodríguez, E., Morales-Vargas, A. T., Molina-Torres, J., Adame-Álvarez, R. M., Acosta-Gallegos, J. A., & Heil, M. (2014). Plant volatiles cause direct, induced and associational resistance in common bean to the fungal pathogen *Colletotrichum lindemuthianum*. *Journal of Ecology, 103*(1), 250-260. https://doi.org/10.1111/1365-2745.12340

Ramseier, D., Connolly, J., & Bazzaz, F. A. (2005). Carbon dioxide regime, species identity and influence of species initial abundance as determinants of change in stand biomass composition in five-species communities: an investigation using a simplex design and RGRD analysis. *Journal of Ecology, 93*(3), 502-511. https://doi.org/10.1111/j.1365-2745.2005.00999.x

Ren, F., Zhang, Y., Qin, Y., Shang, J., Wang, Y., Wei, P., Guo, J., Jia, H. & Zhao, T. (2022). Taraxasterol prompted the anti-tumor effect in mice burden hepatocellular carcinoma by regulating t lymphocytes. *Cell Death Discovery, 8*(1). https://doi.org/10.1038/s41420-022-01059-5

Riu-Aumatell, M., Vargas, L., Vichi, S., Guadayol, J. M., López-Tamames, E., & Buxaderas, S. (2011). Characterisation of volatile composition of white salsify (*Tragopogon porrifolius* L.) by Headspace Solid-Phase Microextraction (HS-SPME) and Simultaneous Distillation–Extraction (SDE) coupled to GC–MS. *Food Chemistry, 129*(2), 557-564. https://doi.org/10.1016/j.foodchem.2011.04.061

Rufino, A. T., Ribeiro, M., Sousa, C., Judas, F., Salgueiro, L., Cavaleiro, C., & Mendes, A. F. (2015). Evaluation of the anti-inflammatory, anti-catabolic and pro-anabolic effects of E-caryophyllene, myrcene and limonene in a cell model of osteoarthritis. *European Journal of Pharmacology, 750*, 141-150. https://doi.org/10.1016/j.ejphar.2015.01.018

Sakul, A. A., Kurtul, E., Özbek, H., Kırmızı, N. İ., Bahtiyar, B. C., Saltan, H., & Açıkara, Ö. B. (2021). Evaluation of antidiabetic activities of *Scorzonera* species on alloxan induced diabetic mice. *Clinical and Experimental Health Sciences, 11*(1), 74-80. https://doi.org/10.33808/clinexphealthsci.797747

Saleem, U., Khalid, S., Zaib, S., Anwar, F., Ahmad, B., Ullah, I., Zeb, A. & Ayaz, M. (2020). Phytochemical analysis and wound healing studies on ethnomedicinally important plant *Malva neglecta* Wallr. *Journal of Ethnopharmacology, 249*, 112401. https://doi.org/10.1016/j.jep.2019.112401

Sánchez-Aguirre, O. A., Sánchez-Medina, A., Juárez-Aguilar, E., Barreda-Castillo, J. M., & Cano-Asseleih, L. M. (2024). *Sonchus oleraceus* L.: ethnomedical, phytochemical and pharmacological aspects. *Naunyn-Schmiedeberg's Archives of Pharmacology, 397*, 4555–4578. https://doi.org/10.1007/s00210-024-02966-3

Siegmund, B., Urdl, K., Jurek, A., & Leitner, E. (2017). “More than Honey”: Investigation on volatiles from monovarietal honeys using new analytical and sensory approaches. *Journal of Agricultural and Food Chemistry, 66*(10), 2432-2442. https://doi.org/10.1021/acs.jafc.6b05009

Suleimen, E. M., Sissengaliyeva, G. G., Ishmuratova, M. Y., & Jalmakhanbetova, R. I. (2019). The component composition of the tragopogon orientalis volatile constituents and its biological activity. *Chemistry of Plant Raw Material, (3),* 103-108. https://doi.org/10.14258/jcprm.2019034859

Tang, Y. J., Park, H., Scher, H. B., & Jeoh, T. (2022). The role of a moisture-barrier latex in controlling retention, stability and release of d-limonene from complex coacervated matrix microparticles formed during spray drying. *Frontiers in Nutrition, 9*, 1-12, 979656. https://doi.org/10.3389/fnut.2022.979656

Taskin, T., & Bitis, L. (2013). Antioxidant activity of *Silene alba* subsp. divaricata and *Stellaria media* subsp. media from Caryophyllaceae. *Spatula DD-Peer Reviewed Journal on Complementary Medicine and Drug Discovery, 3*(1), 1-5.

Theis, N., & Lerdau, M. (2003). The evolution of function in plant secondary metabolites. *International Journal of Plant Sciences, 164*(S3), S93-S102. https://doi.org/10.1086/374190

Ullah, F., Ayaz, A., Saqib, S., Zaman, W., Butt, M. A., & Ullah, A. (2019). *Silene conoidea* L.: a review on its systematic, ethnobotany and phytochemical profile. *Plant Science Today, 6*(4), 373-382. https://doi.org/10.14719/pst.2019.6.4.571

Unlu, H. O., Unlu, H., & Karakurt, Y. (2017). The minerals and phenolic compositions of some edible wild plants consumed as vegetables. *Fresenius Environmental Bulletin, 26*(11), 6841-6847.

Unver, T., Uzuner, U., Celik-Uzuner, S., Gurhan, I., Sivri, N. S., & Ozdemir, Z. (2023). Phytochemical composition, antimicrobial, anticancer properties and molecular docking profiles of *Tragopogon coelesyriacus* Boiss. extracts. *Research Square,1*, 1-33. https://doi.org/10.21203/rs.3.rs-3429191/v1

Vivaldo, G., Masi, E., Taiti, C., Caldarelli, G., & Mancuso, S. (2017). The network of plants volatile organic compounds. *Scientific Reports, 7*(1). https://doi.org/10.1038/s41598-017-10975-x

Xu, L., Wang, J., Tian, A., Wang, S., Zhao, K., Rao, Z., Wu, X., Liu, Y., Liu, X., Chen, K., Li, X., Karrar, E., Gao, P., Ying, X., Xiao, G., & Ma, L. (2023). Characteristic volatiles fingerprints in olive vegetable stored at different conditions by HS-GC-IMS. *Food Chemistry: X*, 18, 100707. https://doi.org/10.1016/j.fochx.2023.100707

Yang, Y. J., Yao, J., Jin, X. J., Shi, Z. N., Shen, T. F., Fang, J. G., Yao, X.J., & Zhu, Y. (2016). Sesquiterpenoids and tirucallane triterpenoids from the roots of *Scorzonera divaricata*. *Phytochemistry, 124*, 86-98. https://doi.org/10.1016/j.phytochem.2016.01.015

Yeşil, Y., Çelik, M., & Yılmaz, B. (2019). Wild edible plants in Yeşilli (Mardin-Turkey), a multicultural area. *Journal of Ethnobiology and Ethnomedicine, 15*(1). https://doi.org/10.1186/s13002-019-0327-y

Yıldırım, A. O., Mavi, A., & Kara, A. (2002). Antioxidant and antimicrobial activities of *Polygonum cognatum* Meissn extracts. *Journal of the Science of Food and Agriculture, 83*(1), 64-69. https://doi.org/10.1002/jsfa.1288

Yılmazer, M., Karagöz, S. G., Ozkan, G., & Karacabey, E. (2016). Aroma transition from rosemary leaves during aromatization of olive oil. *Journal of Food and Drug Analysis*, *24*(2), 299-304. https://doi.org/10.1016/j.jfda.2015.11.002

Zengin, G., Mahomoodally, M. F., Ceylan, R., Uysal, Ş., Mocan, A., Yılmaz, M. A., Picot-Allain C.M.N, Ćirić A., Glamočlija, J. & Sokóvić, M. (2018). Functional constituents of six wild edible silene species: a focus on their phytochemical profiles and bioactive properties. *Food Bioscience, 23*, 75-82. https://doi.org/10.1016/j.fbio.2018.03.010

Zhang, N., Chen, T., Ye, S., Gao, S., & Dong, Y. (2022). Comparative analysis with GC–MS of fatty acids and volatile compounds of *Taraxacum kok-saghyz* Rodin and *Taraxacum officinale* as edible resource plants. *Separations*, *9*(10), 314. https://doi.org/10.3390/separations9100314

Zhao, Y. and Kang, L. (2002). Role of plant volatiles in host plant location of the leafminer, *Liriomyza sativae* (diptera: agromyzidae). *Physiological Entomology*, *27*(2), 103-111. https://doi.org/10.1046/j.1365-3032.2002.00275.x

Zulaikha, S. (2015). Hazardous ingredients in cosmetics and personal care products and health concern: A review. *Journal of Public Health Research*, *5*, 7-15.

Zulak, K. G., & Bohlmann, J. (2010). Terpenoid biosynthesis and specialized vascular cells of conifer defense. *Journal of Integrative Plant Biology, 52*(1), 86-97. https://doi.org/10.1111/j.1744-7909.2010.00910.x