Article published online: 2020-12-09

A Review of the Phytochemistry, Traditional Uses and Biological Activities of the Essential Oils of Genus *Teucrium*

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Key words

Teucrium, Lamiaceae, ethnopharmacology, essential oil, biological properties

received June 23, 2020
accepted after revision October 17, 2020
published online December 9, 2020

Bibliography

Planta Med 2021; 87: 432–479

DOI 10.1055/a-1293-5768

ISSN 0032-0943

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Georg Thieme Verlag KG, Rüdigerstraße 14, 70469 Stuttgart, Germany

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ABSTRACT

The genus *Teucrium* is a large and polymorphic genus of the Lamiaceae family distributed in mild climate zones, particularly in the Mediterranean basin and Central Asia. Studies of nonvolatile constituents of *Teucrium* species showed that they are a rich source of *neo*-clerodane diterpenoids, considered as chemotaxonomic markers of the genus. In addition to the nonvolatile metabolites, there has been a large interest in the essential oils of this genus. In this review, a complete survey of the chemical composition and biological properties of the essential oils isolated from *Teucrium* taxa is provided. In traditional medicine, since ancient times, species of this genus have been widely implemented for their biological properties, including antimicrobial, anti-inflammatory, antispasmodic, insecticidal, anti-malaria, etc. Therefore, a complete review of all of the traditional uses of *Teucrium* taxa are also reported.

Introduction

The genus *Teucrium* L. is a large and polymorphic genus of the Lamiaceae family, represented mostly by perennial, bushy, or herbaceous plants, living commonly in sunny habitats [1]. The Plant List [2], which has been used to validate the scientific names of the species, includes more than one thousand scientific plant names of species rank for the genus *Teucrium*. Of these, 415 are accepted names, including species, subspecies, varieties, forms, and hybrids, and they have been divided into ten sections [Teucropsis Benth., Teucrium Benth., Chamaedrys (Mill.) Schreb., Polium (Mill.) Schreb., Isotriodon Boiss., Pycnobotrys Benth., Scorodonia (Hill) Schreb., Stachyobotrys Benth., Scordium (Mill.) Benth., and Spinularia Boiss], identifiable through the calyx shape, the inflorescence structure, and pollen morphology [1,3,4], although different authors modified this number from eight up to fifteen and created several subsections [5,6].

The species of the genus *Teucrium* grow in mild climate zones, particularly in the Mediterranean basin and Central Asia. As the species can be found in southern, southwestern, and southeastern parts of Europe, the continent is regarded as the main center of differentiation of the genus. A significant number of species have also been observed in Southwestern Asia, Northwestern Africa, southern North America, and southwestern South America. As for Australia, the species of the genus *Teucrium* are distributed in both southern parts of the continent and certain nearby islands [7,8].

Studies of nonvolatile constituents of *Teucrium* species showed that they are a rich source of *neo*-clerodane diterpenoids, considered as chemotaxonomic markers of the genus. Up to now, 279 *neo*-clerodanes have been identified and their occurrence has

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been widely reviewed [9–14]. Other metabolites isolated from species of this genus include abietane diterpenes, sesquiterpenes, triterpenes, steroids, flavonoids, iridoids, and aromatic compounds [14].

In this review, a complete survey of the chemical composition and biological properties of the EOs isolated from *Teucrium* taxa is provided. Moreover, the traditional uses of *Teucrium* taxa are also reported. The available information on these genera was collected from scientific databases and covers 1972 up to 2019. The following electronic databases were used: PubMed, SciFinder, Science Direct, Scopus, Web of Science, and Google Scholar. The search terms used for this review included *Teucrium*, all of the botanical names of the species, both accepted names or synonyms, EOs, volatile components, traditional uses, activity, pharmacology, and toxicity. No limitations were set for languages. ▶ **Table 1** reports the taxa of *Teucrium* investigated so far, their synonyms, the accepted botanical names, and their section.

Traditional Uses

Teucrium species have been used as medicinal herbs for more than 2000 years, and many of them are also currently in use in folk medicine. A summary of their traditional uses is presented in ▶ **Table 2**. The first record of the medicinal properties of these species dates back to Greek mythology from ten centuries BC. The name *Teucrium* is derived from Teucer, a son of Telamon, king of Salamis, who was the first to use these plants for curative purposes [157].

By far the most utilized species of this genus in the ethnomedicine of many countries is *Teucrium polium* (felty germander). It is a wild growing, flowering species; it is a perennial, aromatic plant, 20–50 cm high, with green-grayish leaves, and white to light pink flowers that occurs from June to August and is found abundantly in Southwestern Asia, Europe (Mediterranean region), and North Africa [158].

T. polium is largely used in traditional Iranian medicine. Its tea is utilized to treat many diseases such as abdominal pain, indigestion, common cold, urogenital diseases, and rheumatism. The aqueous extract of the dried aerial parts of *T. polium* is used by many type-2 diabetic patients, particularly in Southern Iran, as an antidiabetic drug. Furthermore, antimutagenic, cytotoxic, antinociceptive, antioxidant, antimicrobial, antihypertensive, antihyperlipidemic, anti-inflammatory, antispasmodic, and analgesic properties of this plant have been reported [159].

T. polium is also largely utilized in North Africa. In traditional Moroccan medicine, where it is locally called "Jaada", aerial parts from the plant are used by the Moroccan population for the treatment of various human diseases, including digestive disorders, liver problems, inflammation, hypertension, fever, diabetes, rheumatism, and parasitic diseases [103], whereas in Algeria (local name "Kheyata" or "Jaada"), the species was traditionally used in folk medicine due to its hypoglycemic, hypolipidemic, anti-inflammatory, antibacterial, and antioxidant properties [82]. It is also known in Tunisia as "Jaadah" and some biological and therapeutic effects have been reported such as anti-inflammatory, antioxidant, antimicrobial, antinociceptive, antipyretic, anti-gastric ulcer, hepatoprotective, hypolipidemic, and hypoglycemic [124].

Traditionally, the local Palestinian population has used hot water leaf extracts of *T. polium* for centuries as a treatment for intestinal and cardiac disorders and the infusion of its leaves is drunk after each meal for its antispasmodic and antidiarrheal effects. The treatment is usually prescribed by the local Arab traditional practitioner alongside other forms of treatments. Furthermore, it has been reported that *T. polium* is a traditional medicinal plant used by the Bedouins in the south of the country [107, 108]. It is also known in traditional ethnoveterinary Palestinian medicine with the name الصبيان, and used orally in sheep, cows, and goats to treat diarrhea, colic, scabies, and flatulence. The crushed leaves are applied to the skin as a poultice to treat scabies [106]. In Israel and the Golan Heights, a standard decoction is prepared from 50 g of leaves of *T. polium* and taken orally, 100 cc, three times/day to treat kidney and liver diseases, diabetes, stomach and intestine pain, and inflammation [38]. In Saudi Arabian folk medicine, germander (*T. polium*) is known under the vernacular name of "Jaada" or "Jaa'd". Arial parts from the plant and infusion of tender leaves are used by the local population of Bedouins for treatment of febrifuge, vermifuge, stomach, and intestinal troubles. The plant is also used in a steam bath for colds and fevers [113, 114]. Also, in Jordan, where it is known with similar names (Jeada, Jadeh), *T. polium* has been used for treatment of several diseases such as inflammation, pain, diabetes, kidney stones, cancer, fever, rheumatism, etc. [97–100].

T. polium has also been largely employed in Turkish traditional medicine. In the area of Bayramiç (West Turkey), the infusion of the aerial part of *T. polium*, known as Mayasıl otu, is used against hemorrhoids and eczema [49], while people in Silopi (Turkey) use it as a spice in meals. It is drunk for diseases of the stomach, and it is used as a drug by applying the hard parts of it on the wounds after it is boiled [122]. Many other ethnopharmacological uses in Turkey are reviewed in ▶ **Table 2**.

Traditionally, in the Mediterranean countries, *T. polium* has been used for various types of pathological conditions, in fact, its utilization as a digestive aid in Albania [81], for gastrointestinal disorders in Bosnia and Herzegovina [27, 28], as tonic, anti-icteric, and antihelmintic in Spain [44], and for myalgias, stomach pains, cold, menopause disorders, toothache pains, insect bites, and skin diseases in Sardinia (Italy) [63, 64] has been reported. The phytochemistry and medicinal properties of *T. polium* have been reviewed by Bahramikia and Yazdanparast [159] and its complete ethnopharmacological uses are resumed in ▶ **Table 2**.

Another species largely employed in the folk medicine of several countries is *Teucrium chamaedrys*, a Mediterranean and Middle European species present throughout all of Europe except for northern Europe. It is also present in North Africa and West Asia. It is a semi-perennial plant growing mostly on rocky calcareous soil, but it can also be found in meadows, pastures, steppes, and sand. It is used for the preparation of teas, tinctures, wines, etc., due to its beneficial therapeutic effects on the digestive and immune systems, skin, and anemia. The species is an ingredient of several liquors, vermouth, and rakjas [160].

The blossoms of *T. chamaedrys* have long been used in folk medicine in the Middle East and Mediterranean region as treatment for dyspepsia, obesity, diabetes, and abdominal colic.

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▶ **Table 1** *Teucrium* taxa studied for their EOs and their synonymous (accepted botanical name in bold).

Taxa	Synonyms	Sect. [4–6, 15–21]
T. abutiloides L'Her		*Teucriopsis*
T. africanum **Thumb.**		*Teucrium*
T. algarbiensis **(Cout.) Cout.**		*Polium*
T. alopercus **Noë**		*Polium*
T. alyssifolium **Stapf**		*Teucrium*
T. antiatlanticum **(Maire) Sauvage & Vindt**		*Polium*
T. antitauricum **Ekim**		*Isotriodon*
T. apollinis **Maire & Weiller**		*Polium*
T. arduini **L.**		*Stachybotrys*
T. asiaticum **L.**		*Scorodonia*
T. atratum **Pomel**		Not determined
T. betonicum **L'Her**		*Teucriopsis*
T. botrys **L.**		*Spinularia*
T. brevifolium **Schreb.**		*Teucrium*
T. canadensis **L.**		*Scorodonia*
T. carolipaui **Vicioso ex Pau**		*Polium*
T. cavernarum **P. H. Davis**		*Isotriodon*
T. chamaedrys L.		*Chamaedrys*
T. chamaedrys ssp. *chamaedrys*	***T. chamaedrys*** **L.**	*Chamaedrys*
T. chamaedrys **ssp.** ***lydium*** **O. Schwarz**		*Chamaedrys*
T. chamaedrys **ssp.** ***syspirense*** **(K.Koch) Rech f.**		*Chamaedrys*
T. chamaedrys **ssp.** ***trapezunticum*** **Rech f.**		*Chamaedrys*
T. creticum **L.**		*Teucrium*
T. cyprium ssp. *cyprium* Boiss.	***T. cyprium*** **Boiss**	*Polium*
T. divaricatum **ssp.** ***canescens*** **(Celak.) Holmboe**		*Chamaedrys*
T. divaricatum ssp. *divaricatum*	***T. divaricatum*** **Sieber ex Heldr.**	*Chamaedrys*
T. divaricatum ssp. *villosum* (Celak.) Rech.f.	***T. divaricatum*** **Sieber ex Heldr.**	*Chamaedrys*
T. flavum **L.**		*Chamaedrys*
T. flavum **ssp.** ***flavum***	***T. flavum*** **L.**	*Chamaedrys*
T. flavum **ssp.** ***glaucum*** **(Jord. & Fourr.) Ronniger**		*Chamaedrys*
T. flavum **ssp.** ***hellenicum*** **Rech.f.**		*Chamaedrys*
T. fruticans **L.**		*Teucrium*
T. gnaphalodes **L'Her**		*Polium*
T. haenseleri **Boiiss.**		*Polium*
T. hetrophyllum **L'Her**		*Teucriopsis*
T. hyrcanicum **L.**		*Stachybotrys*
T. kotschyanum **Poech**		*Scorodonia*
T. lamiifolium **ssp.** ***lamiifolium*** **d'Urv Mem**		*Stachybotrys*
T. lamiifolium ssp. *stachyophyllum* (P. H.Davis) Hedge & Ekim	***T. stachyophyllum*** **P. H.Davis**	*Stachybotrys*
T. lepicephalum **Pau**		*Polium*
T. leucocladum **Boiss.**		*Polium*
T. libanitis **Schreb.**		*Polium*
T. lusitanicum **Schreb.**		*Polium*
T. lusitanicum ssp. aureiformis (Rouy) Valdes Berm.		*Polium*
T. maghrebinum **Greuter & Burdet**		*Spinularia*
T. marum **L.**		*Chamaedrys*

continued

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▶ **Table 1** *Continued*

Taxa	Synonyms	Sect. [4–6, 15–21]
T. marum ssp. *drosocalyx* Mus, Rossellò & Mayol	***T. marum*** **L.**	*Chamaedrys*
T. marum ssp. *marum*	***T. marum*** **L.**	*Chamaedrys*
T. marum ssp. *occidentale* Mus, Rossellò & Mayol	***T. balearicum*** **(Coss. ex Pau) Castrov. & Bayon**	*Chamaedrys*
T. mascatense **Boiss.**		*Polium*
T. massiliense **L.**		*Scorodonia*
T. melissoides **Boiss. & Hausskn.**		*Scordium*
T. micrpopodiodes **Rouy**		*Polium*
T. montanum **L.**		*Polium*
T. montanum ssp. *jailae* (Juz.) Soó		*Polium*
T. montbretii **ssp.** ***heliotropifolium*** **(Barbey) P.H. Davis**		*Isotriodon*
T. multicaule **Montbret. & Aucher ex Benth.**		*Teucrium*
T. orientale **ssp.** ***glabrescens*** **(Hausskn. ex Bornm) Rech.f.**		*Teucrium*
T. orientale ssp. *orientale*	***T. orientale*** **L.**	*Teucrium*
T. orientale **var.** ***puberulens*** **(T.Ekim)**		*Teucrium*
T. orientale **ssp.** ***taylori*** **(Boiss.) Rech.f.**		*Teucrium*
T. oxylepis ssp. *oxylepis*	***T. oxylepis*** **Font Quer**	*Stachybotrys*
T. oxylepis ssp. *marianum* Ruiz Torre & Ruiz Cast.	***T. oxylepis*** **Font Quer**	*Stachybotrys*
T. paederotoides **Boiss.**		*Isotriodon*
T. parviflorum **Schreb.**		*Teucrium*
T. persicum **Boiss.**		*Isotriodon*
T. pestalozzae **Boiss.**		*Teucrium*
T. polium **L.**		*Polium*
T. polium ssp. *album* (Poir.) Breistr.	***T. capitatum*** **L.**	*Polium*
T. polium **ssp.** ***aurasiacum*** **(Maire) Greuter & Burdet**		*Polium*
T. polium ssp. *aureum* (Schreb.) Arcang.	***T. aureum*** **Schreb.**	*Polium*
T. polium ssp. *capitatum* (L.) Arcang.	***T. capitatum*** **L.**	*Polium*
T. polium ssp. *gabesianum* Le Houer	***T. luteum*** **ssp.** ***gabesianum*** **(S.Puech) Greuter**	*Polium*
T. polium ssp. *geyrii* Maire	***T. helichrysoides*** **(Diels) Greuter & Burdet**	*Polium*
T. polium ssp. *pilosum* Decne	***T. decaisnei*** **C.Presl**	*Polium*
T. polium ssp. *valentinum* (Schreber) Borja		*Polium*
T. pruinosum **Boiss.**		*Teucrium*
T. pseudochamaepitys **L.**		*Teucrium*
T. pseudoscorodonia ssp. *baeticum*	***T. pseudoscorodonia*** **Desf.**	*Scorodonia*
T. puechiae Greuter & Burdet	***T. dunense*** **Sennen**	*Polium*
T. quadrifarium **Buch.-Ham**		*Pycnobotrys*
T. ramosissimum **Desf.**		*Polium*
T. royleanum **Wall. ex Benth.**		*Scorodonia*
T. salviastrum **Schreb.**		*Scorodonia*
T. sandrasicum **O. Schwarz**		*Teucrium*
T. sauvegi **Le Houer**		*Polium*
T. scordium **L.**		*Scordium*
T. scordium **ssp.** ***scordiodes*** **(Schreb.) Arcang.**		*Scordium*
T. scorodonia **L.**		*Scorodonia*
T. scorodonia ssp. *baeticum*	***T. pseudoscorodonia*** **Desf.**	*Scorodonia*
T. scorodonia ssp. *scorodonia*	***T. scorodonia*** **L.**	*Scorodonia*
T. siculum **(Raf.) Guss.**		*Scorodonia*

continued

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▶ **Table 1** *Continued*

Taxa	Synonyms	Sect. [4–6, 15–21]
T. stocksianum **Boiss.**		*Polium*
T. stocksianum **ssp.** ***gabrielae*** **(Bornm.) Rech.f.**		*Polium*
T. stocksianum ssp. *stocksianum*	***T. stocksianum*** **Boiss.**	*Polium*
T. trifidum **Retz.**		*Teucrium*
T. turredanum **Losa & Rivas Goday**		*Polium*
T. yemense **Deflers**		*Polium*
T. zanoni **Pamp.**		*Polium*

In traditional medicine of Balkan countries, its properties include treatment of inflammations of the skin, open wounds, joint pain, liver diseases, diarrhea, pulmonary disorders, coughs, asthma, abscesses, conjunctivitis, and as a digestive and diuretic agent [27, 36, 41, 42].

In Turkey, *T. chamaedrys* and its subspecies lydium are mainly utilized against hemorrhoids, although it has also been reported to treat mouth ulcers, kidney infection, hearth disease, malaria, and stomachache (▶ **Table 2**). It has also been used in traditional English medicine as part of the Portland Powder for treating rheumatism and gout [37]. Several applications of *T. chameadrys* have been reported: a decoction of the leaves and seeds is applied to inflamed eyes; a decoction prepared from leaves and stems is taken orally, three times/day to treat stomach and intestine pain and inflammation, lack of appetite, and jaundice [38].

Despite its wide use, in the early 1990 s, it was found that herbal preparations, in the form of tea or capsules, could cause significant liver injury, probably due to the presence of some *neo*-clerodane diterpenoids such as teucrin A. The injury is characterized by a hepatocellular pattern associated with marked jaundice in the absence of immunoallergic or autoimmune features. The latency before onset of injury is short and usually occurs within 30 days from consuming the preparation. Although fatal cases and liver transplants have been reported, the injury generally resolves after cessation of consumption of the causing agent [161].

Many other species have been used in the folk medicine of various countries, and they are grouped below according to their geographical areas.

Europe

Teucrium scorodonia, common name woodland germander or wood sage, is a perennial herb, native to Western Europe and Tunisia. It is cultivated in many places as an ornamental plant in gardens, and naturalized in several regions (New Zealand, Azores, and North America). The plant resembles hops in taste and flavor. An infusion of the leaves and flowers is used as a hops substitute for flavoring beer in some areas. It is said to clear the beer more quickly than hops but imparts too much color to the brew. The herb is astringent, carminative, diaphoretic, diuretic, emmenagogue, tonic, and vulnerary. It is often used in domestic herbal practice in the treatment of skin afflictions, diseases of the blood, fevers, colds, etc. [69]. In Italian folk medicine, *T. scorodonia* L. is known for its astringent, anti-scurvy, antiseptic, and eupeptic properties [140], whereas in Britain, Ireland, and the Isle of Man, it has been used against amebic dysentery, rheumatism, gripe, indigestion, palpitations, colds and coughs, and tuberculosis [137]. *T. scorodonia* is used in border regions of Cantabria (Spain), where it is known as "hierba lobera/hoja de lobo" to wash infected wounds caused by wolf or dog bites [141]. Furthermore, its tincture has been applied in the treatment of mastitis in ruminants [139].

Teucrium scordium L. (garlic germander) is a perennial plant that grows in South and Southeast Europe, the Middle East, and North Africa. In traditional medicine, the flowering branches are used for tea and tonic-based medicinal preparation for the treatment of some gastrointestinal ailments, wound healing, and as a spice plant [69]. The herb is anthelmintic, antifungal, antiseptic, and tonic, making it an excellent remedy for all inflammatory diseases [69]. It was reported to be used in Spain as an antidote for poisons and also as an antiseptic and anthelmintic, though it is scarcely used nowadays [44]. In Bosnia and Herzegovina, the infusion of the aerial parts has been utilized for treatment of gastrointestinal ailments and diarrhea [27, 28], whereas in Israel it has been utilized for chronic skin disease, dyspepsia, and hemorrhoids [96]. The plant Maryamnokhodi Batlaghi has similar uses in Iran, where it has also been used in the treatment of tuberculosis [138]. In Britain, it has been in use by women "very frequently" in a decoction to suppress menstruation or as a vermicide [137].

Teucrium marum is an aromatic herb, diuretic, nervine, stimulant, stomachic, and tonic. The plant is supposed to possess very active powers and has been recommended in the treatment of many diseases, being considered useful in treating cases of nervousness [69]. It is used in the treatment of gallbladder and stomach problems [70]. The root bark is considerably astringent and has been used to controlling hemorrhages. It is said to be effective against small threadworms in children [69]. In Sardinia (Italy), where it is called "Gattaria/Erba de gattus", it is known for its antibacterial, anti-inflammatory, antipyretic, and cicatrizing properties [64].

Similar febrifuge and anti-malaric activities have been reported in Sardinia for *Teucrium massiliense* (Cramediu eru) [65]. *Teucrium flavum* ssp. *glaucum* (Cramediu 'e istropios) [65] and *T. flavum* (Querciola maggiore/Crammediu) [64] are also largely utilized in Sardinia for their cicatrizing properties. The last species is also

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▶ **Table 2** Ethnopharmacological uses of all *Teucrium* taxa.

Species	Vernacular names	Area	Use	Ref
T. alopecurus	H'chichit ben salem	Tunisia	anti-inflammatory properties, flavoring	[22, 23]
T. africanum	Akkedispoot, ubu-Hlungu ambeibos-sie, bitterbossie, paddaklou	South Africa	tonic, against snakebites and anthrax, hemorrhoids, sore throat, stomach disorders, eye inflammations, colds, and fever	[24]
T. antiatlanticum		Morocco	to treat burns and fevers	[25]
T. apollinis	Jada	Libya	antidiabetic, antihypertensive, and for extruding kidney stones	[26]
T. arduini	Arduinijeva iva	Bosnia and Herzegovina	stomach ailments	[27, 28]
T. betonicum	Abrotona, erva branca, herva branca	Portugal, Madeira	stomachic, tonic	[29]
T. bidentatum Hemsl.		China, Guizhou	treatment of dysentery and leukoderma	[30]
T. buxifolium Schreb.		Spain	rheumatism, inflammation	[31]
T. canadensis		Canada	diaphoretic, diuretic, emmenagogue, antiseptic	[32]
T. chamaedrys			astringent, antirheumatic, digestive, fever, anti-inflammatory, diuretic, treatment of wounds, dyspepsia, anorexia, nasal catarrh, chronic bronchitis, gout, rheumatoid arthritis, fever, uterine infections, to reduce body weight	[33–35]
		Balkans	inflammations of the skin, open wounds, joint pain, liver diseases, digestive, diuretic	[36]
	Dubačac	Bosnia and Herzegovina	diarrhea	[27]
		England	treating rheumatism and gout	[37]
	جعده الصبيان	Israel, Golan	stomach, intestine pain and inflammation, lack of appetite, jaundice, eye inflammation, inflammation of teeth and gums	[38]
		Iran	diuretic, antiseptic, antipyretic and antihelmintic	[39]
		Palestine	treatment of digestive disorders	[40]
	Podubnica	Serbia	treatment of digestive and pulmonary disorders, coughs, asthma, abscesses, conjunctivitis	[41–43]
	Camedrio, Encinillo	Spain	tonic, stomachic, febrifuge, vesicant, emmenagogu	[44]
	Kisa mahmut, Sancti otu	Turkey	hemorrhoids	[45]
	Uzun mahmut	Turkey, Balikesir	abdominal pain, kidney stones	[46]
	Kısacıkmahmut	Turkey, Central	stomachache	[47]
T. chamaedrys ssp. *lydium*	Mayasil otu	Turkey, Ayvacik	hemorrhoids	[48]
	Mayasil otu	Turkey, Bayramiç	hemorrhoids, eczema	[49]
T. chamaedrys ssp. *chamaedris*	Bodurca mahmut, Kinin otu	Turkey, Acipayam	hemorrhoids, hearth diseases, malaria	[50]
	Kisamahmut otu	Turkey, Bilecik	ulcer in mouth, kidney infection	[51]
	Kisamahmut otu	Turkey, Kirklareli	diuretic, kidney stones, diarrhea, abdominal pain	[52]
	Kisacik mahmut, Sancti otu, Bodurmahmut	Turkey, Ulukışla	hemorrhoids	[45, 53]

continued

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▸ **Table 2** *Continued*

Species	Vernacular names	Area	Use	Ref
T. creticum		Palestine	antidiabetic	[54]
T. cubense Jacq.	Agrimonia, verbena	Mexico, Yucatan	diabetes mellitus, bowel diseases, skin infections, anti-inflammatory	[55–57]
T. cyprium ssp. *cypryum*		Cyprus	against fever and jaundice, astringent, antipruritic	[58]
T. divaricatum ssp. *canescens*		Cyprus	stomachic, fever, colds, cicatrisant	[58]
T. divaricatum ssp. *divaricatum*		Cyprus	cicatrisant	[59]
	Mürcüotu, buhurcuoğlu otu, böceotu	Turkey, Marmaris	cough, tonic for eyes, sickness, stomachache, urinary diseases, gallbladder disease, kidney stones	[60]
T. divaricatum ssp. *villosun*		Lebanon	stomachic, fever, colds, cicatrizant	[61]
T. flavum	Chamaidrya, Moskhokhortaro, Dontokhorti	Greece	antidiabetic, astringent, to heal skin eruptions and wounds	[62]
	Querciola maggiore/Crammediu.	Italy, Sardinia	antipyretic, cicatrizant, antiseptic	[63, 64]
T. flavum ssp. *glaucum*	Cramediu 'e istropios	Italy, Sardinia	cicatrizant	[65]
T. fruticans		Italy, Tuscany	depurative and diuretic	[66]
	Erba ricottara	Italy, Sicily	hemorrhoids	[67]
T. kotschyanum		Cyprus	antipyretic, antidiabetic	[58]
T. kraussi Codd.	ubuHlungu, isiHlungu, umnunuwenk-khangala	South Africa	tonic, against snakebites and anthrax	[24]
T. maghrebinum	kayatat el gerah	Algeria	burns, fevers, antimicrobial	[68]
		Morocco	to treat burns and fevers	[25]
T. marum			diuretic, nervine, stimulant, stomachic, tonic, nervous complaints, astringent, hemorrhoids, worms in children	[69, 70]
	Gattaria/Erba de gattus	Italy, Sardinia	antibacterial, anti-inflammatory and antipyretic, cicatrizant	[64, 65]
T. mascatense	ja'dah	Oman	fever remedy, blood menstruation, stomachache, colic, diabetes	[71, 72]
T. massiliense	Cramediu eru	Italy, Sardinia	febrifuge, anti-malaric	[65]
T. micropodiodes		Cyprus	sedative, antispasmodic, gastric ulcer, gastrointestinal inflammation, diuretic, carminative, antidiarrheal, antipyretic, stimulant, stomachic, anthelmintic, emmenagogue, antidiabetic, against rhumatism, antipruritic, antiseptic	[58]
T. montanum	Iva trava	Bosnia and Herzegovina	liver and stomach diseases	[27]
	Marmahooz	Iran	headache	[73]
	Dubačac mal	Serbia	diuretic, stomachic, analgesic, antispasmodic, antibacterial, antifungal, anti-inflammatory, antioxidant activity	[41, 74]
	Trava iva	Serbia, south	abdominal disorders, headaches, tonic, improving appetite, antipyretic, antituberculosis, immune system strengthening	[43, 75]

continued

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▶ **Table 2** *Continued*

Species	Vernacular names	Area	Use	Ref
T. oliverianum (Ging. ex Benth.) R.Br.	Qassapa	Saudi Arabia	for diabetes	[76]
T. orientale	Ja'ada	Lebanon	wound skin and injuries, fever	[77]
	Maryam nokhodi, Chaye alafi	Iran	antipyretic, hot flashes in women	[78, 79]
T. parvifolium	Dağ kekeği	Turkey	hemorrhoids	[45]
T. persicum	Marv-e-talkh, Arak	Iran	abdominal pain, headaches	[80]
T. polium	Bar majasili	Albania	digestive	[81]
	Kheyata	Algeria	hypoglycemic, hypolipidemic, anti-inflammatory, antibacterial, antioxidant	[82]
	Jaada	Algeria	anti-inflammatory, antidiarrhea, antibacterial, facilitates digestion, disinfectants, antidiabetes, anti-eczema, tonic, for skin diseases	[83]
		Armenia	stomach diseases, gynecological diseases, analgesic, anti-inflammatory, antibacterial	[84]
	Iva mediteranska	Bosnia and Herzegovina	stomach diseases	[27, 28]
	جعده الصبيان	Israel, Golan	kidney and liver diseases, diabetes, stomach and intestine pain and inflammation	[38]
	Ab Lileh, Olileh	Iran, Boyer Ahmad	menstruation disorders, toothache, body and joint pain, abortion, gynecological infections, carminative	[85]
	Maryam nokhodi	Iran	antimicrobial	[78]
	Ja'deh	Iran	for learning and memory	[86]
		Iran	antimalarial	[87]
		Iran, Fars	antidiabetic, anti-inflammatory, antinociceptive, antibacterial, antihypertensive, antihyperlipidaemic	[88]
	Kalpoureh, Alpe, Chez Koochi	Iran	diabetes	[89]
	Kalpoureh	Iran	menstruation	[90]
	Kalpooreh	Iran	antimicrobial, antidiabetic, anti-inflammatory, antispasmodic, analgesic, antioxidant	[91]
	Kalpureh	Iran	antidiarrheal, hypnotic, antiparasitic, antifungal, antitussive, diabetes mellitus, rheumatoid arthritis, paranasal sinusitis, bloating, menorrheal, discharge, wound disinfection, gingivitis, tonsillitis, acne, itching, dyspepsia, amenorrhea	[92, 93]
	Kalpurak	Iran Saravan	antipyretic, insect, snake and scorpion bites, wound healing, stomachache, abdominal pain, flatulency, emesis, stomach acidification, hypertension, sedative, toothache, diabetes, hyperlipidemia	[94]
		Iran	diuretic, hypoglycemic, antifungal, antispasmodic, antirheumatic, anti-inflammatory, antibacterial	[95]
		Israel	kidney stones, liver diseases, stomach and intestine inflammation	[96]

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▸ **Table 2** *Continued*

Species	Vernacular names	Area	Use	Ref
	Polio/Tumbu feminedda	Italy, Sardinia	myalgias, vulnerary, stomach pain, colds, menopause disorders, sedative for toothache, against insect bites, skin diseases	[63, 64]
	Jeada, Jadeh	Jordan	anti-inflammatory, antispasmodic, antiflatulent, antidiabetic, for kidney stones and cancer	[97–99]
		Jordan	diuretic, diaphoretic, tonic, antispasmodic and cholagogic, antipyretic, antibacterial, anti-inflammatory, antirheumatic, hypoglycemic, antioxidant, antinociceptive	[100]
	Jeada	Jordan, Badia	stomach and colic spasm, inflammation, anorexia, and jaundice	[101]
	Gaada	Lybia, Cyrenaica	diabetes, gastritis, thyroiditis, anemia, common cold, hypertension, renal stones	[102]
	Jaada	Morocco	digestive disorders, liver problems, inflammation, hypertension, fever, diabetes, rheumatism, parasitic diseases	[103–105]
	الصبيان	Palestine	veterinary: diarrhea, colic, bleeding, scabies, flatulence	[106]
	Ja'da	Palestine	antispasmodic, antidiarrheal effects	[107]
	Ja'da	Palestine	intestinal and cardiac disorders	[108]
		Palestine	abdominal pain, indigestion, diabetes, liver diseases, hypertension, anti-inflammatory	[109–111]
	Takmezout, Djaida	Sahara	chills, fever	[112]
	Jaada, Jaa'd	Saudi Arabia	febrifuge, vermifuge, stomach, intestinal troubles, colds, fevers	[113, 114]
	Polio de flor blanca, Polium blanc	Spain	tonic, antiicteric, antihelmintic	[44]
	Gurisa, Jaadeh, جعدة	Syria, Aleppo	diabetes, cancer, antispasmodic, stomach hyperacidity	[115]
	Kısamahmut	Turkey	diabetes, kidney stones	[46]
	Several vernacular names	Turkey	hemorrhoids	[45]
	Kokar yavşan, Peryavşanotu, Sırçanotu, Yavşan	Turkey, Central	colds, antipyretic, rheumatic pain, stomachache	[47]
	Kisa Mahmut Otu	Turkey, Ayvacik	antipyretic, cough, tonic	[48]
	Cay kekigi, Kekikmisi	Turkey, Acipayam	diabetes, abdominal pain	[50]
	Merwend (Kurdish)	Turkey, Batman	abdominal pain, digestive, colds, diabetes, stomachache, antitussive	[116]
	Mayasil otu	Turkey, Bayramiç	hemorrhoids, eczema	[49]
	Aci yavşan	Turkey, Bilecik	stomach diseases, wounds, carminative	[51]
	Periyavşan	Turkey, Kahramanmaraş	lung inflammations, stomach ulcers, diabetes disease, fever lowering	[117]
	Kefen otu	Turkey, Karaisalı	menstruation, common cold	[118]
	Kckik	Turkey, Kirkalareli	flu, colds, abdominal pain	[52]
	Urper	Turkey, Maden	diabetes, stomachache, antipyretic, colds, liver disorders, inflammation, stomachic, wounds	[119, 120]

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▸ Table 2 *Continued*

Species	Vernacular names	Area	Use	Ref
	Cığde	Turkey, Midyat	stomachache	[121]
	Kısamahmut	Turkey, Silopi	stomach diseases, wounds	[122]
	Meyremxort	Turkey, Solhan	antihypertensive, colds and flu, diabetes, diarrhea, headache, stomachache	[123]
	Jaadah, Al-Ja'adeh', Khayata', Gattaba	Tunisia	anti-inflammatory, antioxidant, antimicrobial, antinociceptive, antipyretic, anti-gastric ulcer, hepatoprotective, hypolipidemic, hypoglycemic, cicatrizant	[124]
T. polium ssp. *capitatum*		Greece	refreshing, spice, diabetes, intestinal troubles	[125]
	Ja'ada	Lebanon	diabetes, insomnia, neurological disorders, abdominal cramps	[77]
	جعدة	Palestine	veterinary: diarrhea, colic, bleeding, scabies, flatulence	[106, 126]
	Cat Thyme, Jedeh Subian	Palestine	diuretic, antipyretic, diaphoretic, antispasmodic, tonic, anti-inflammatory, antihypertensive, anorexic, analgesic, antibacterial, antidiabetic effects	[54, 127]
T. polium ssp. *geyrii*	Takmazzut	Algeria	wound healing, as tea and a spice, analgesic	[128, 129]
T. pruinosum	Ja'ada	Lebanon	gastrointestinal disorders, wounds, fever, colds	[77]
T. quadrifarium		China	colds, inflammation	[130]
T. ramosissimum		Tunisia	intestinal inflammation, gastric ulcer, as a cicatrizing agent	[131]
	Hachichet belgacem ben salem	Tunisia	digestive disorders	[132]
T. royleanum		India, Lahaul: Udaipur	allelopathic, antibacterial, antifungal, antispasmodic, astringent, antipyretic, anti-allergic	[133]
	Katheri	Pakistan, Kutlla Valley	eye diseases, nervous debility	[134]
T. sandrasicum		Turkey	diuretic, diaphoretic, tonic, antipyretic, antidiabetic, antispasmodic, cholagogic	[135]
T. sauvegi		Tunisia	wound healing, antidiabetic, anti-inflammatory, and to treat ulcers, colic, and food poisoning	[136]
T. scordium			gastrointestinal ailments, wound healing, anthelmintic, antifungal, antiseptic, diaphoretic, tonic, antidote for poisons, anti-inflammatory, antitubercular	[69]
	Iva mediteranska	Bosnia and Herzegovina	diarrhea	[27]
	Vodena iva	Bosnia and Herzegovina	gastrointestinal ailments	[28]
	Water germander	Britain, Cambridgeshire	to suppress menstruation, vermicide	[137]
	Maryamnokhodi Batlaghi	Iran	tonic, antitussive, for treatment of lung tuberculosis, jaundice, hemorrhoids for healing of wounds	[138]
		Israel	chronic skin disease, dyspepsia, hemorrhoid	[96]
		Spain	diaphoretic, anti-venomous, antihelmintic	[44]

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Table 2 *Continued*

Species	Vernacular names	Area	Use	Ref
T. scorodonia			astringent, carminative, diaphoretic, diuretic, emmenagogue, tonic and vulnerary, skin and blood diseases, fevers, colds	[69]
		Canada, British Columbia	ethnoveterinary: mastitis	[139]
		Italy	astringent, anti-scurvy, antiseptic and eupeptic properties	[140]
	Wood sage	England, Isle of Man	amoebic dysentery	[137]
	Wood sage	Britain, various parts	tea, rheumatism, headache, jaundice	[137]
	Wood sage	Ireland	rheumatism, gripe, indigestion, palpitations, colds and coughs, tuberculosis	[137]
	hierba lobera/hoja de lobo	Spain, Cantabria	infected wounds	[141]
T. stocksianum	ja'dah	Oman, UEA	against fever, stomachache	[71, 142]
		UEA	gastric ulcers and abdominal discomfort	[143]
		Iran, Hormozgan	against fever, stomachache, and intestinal problems	[144]
	Spariki	Pakistan, Dir lower	hypertension	[145]
	Ger Boota	Pakistan, Chonthra Karak	typoid fever, jaundice	[146]
	Masstura	Pakistan, Darra Adam Khel	diabetes, cooling agent	[147]
	Speer botay	Pakistan, Malakand	diabetes, gastrointestinal ailments, inflammatory conditions, burning feet syndrome, jaundice, cough, diarrhea, pyrexia, sore thoat, expectorant	[148–151]
T. trifidum	Aambeibossie, Akkedispoot, Kaaitjiedrieblaar, Koorsbossie, etc.	South Africa	indigestion, hemorrhoids, fever and influenza, against snakebites and anthrax, healing of wounds	[24]
T. viscidum Blume	Shan-Huo-Xiang	China	hemoptysis, hematemesis, pulmonary abscesses, traumatic injuries, bites of rabies-stricken dogs or venomous snakes	[152]
		Taiwan	dysmenorrhea	[153]
	Pawn tshis nyeg	Thailand	promoting fetal stabilization, treating coughs, fever, stomachache, dysmenorrhea	[153]
T. yemense	Rechal Fatima, Istaqutas	Saudi Arabia, Yemen	diabetes, kidney problems, rheumatism, anthelmintic, insect repellent	[154–156]
T. zanoni	Jada	Libya	antidiabetic, antihypertensive, and for extruding kidney stones	[26]

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known in Greece (vernacular names: Chamaidrya, Moskhokhortaro, Dontokhortiis) as an antidiabetic, astringent, and to heal skin eruptions and wounds [62]. Another plant used locally in Italy is *Teucrium fruticans*, which, in Tuscany, is known for the depurative and diuretic effects of its infusion [66], whereas in Sicily, where it is known as "Erba ricottara", the direct application of the leaves is used in the treatment of hemorrhoids [67].

In the isle of Madeira, Portugal, *Teucrium betonicum*, locally known as "abrotona, erva branca, herva branca" is used as stomachic and tonic [29].

Teucrium arduini is an Ilyric-Balcanic endemic species distributed in Mediterranean and sub-Mediterranean areas in Croatia, Bosnia and Herzegovina, Montenegro, Serbia, and northern Albania. The aerial parts of this species ("Arduinijeva iva") are used in Bosnia and Herzegovina in the form of tea to help heal stomach discomforts [27, 28].

Teucrium montanum, commonly known as mountain germander (dubačac mali in Serbian), is a perennial plant, distributed in Europe and the Middle East. It is a South European mountain species and grows on limestone rocks, pastures, and pine forests in the mountain regions. This plant species has long been consumed both as an herbal medicine and as a nourishing food. It is widely used in Serbia as a diuretic, stomachic, analgesic, and also as an antispasmodic, antibacterial, antifungal, anti-inflammatory, and antioxidant activity agent [74]. In the eastern part of the same country, where it is known as "Trava-iva", the infusion of the whole plant has been utilized for immune system strengthening [75], disorders of the abdominal organs, headaches, as tonic, for improving appetite, and antipyretic ("bitter tea"-blend: mixed with other herbs). Externally, it has been used for treatment of tuberculosis [bath soak: add to yellow camomile (*Anthemis tinctoria*) or by inhalation of the smoke] [43]. In Bosnia and Herzegovina, the infusion of the aerial parts has been reported for treating liver and stomach diseases [27]. Its use has also been reported in Iran to treat headaches [73].

North Africa

Several species of *Teucrium* growing in North Africa have been used in the traditional medicine of this area. *Teucrium ramosissimum* grows widely in the arid Mediterranean climate and in calcareous substrates. Since ancient times, its aerial parts have been used in Tunisian traditional medicine, where it is known as "Hachichet belgacem ben salem" for the treatment of intestinal inflammation, as a remedy for gastric ulcer, and in external use as a cicatrizing agent [131, 132]. *Teucrium alopecurus* (H'chichit ben salem) is an endemic species limited to South Tunisia widely used in its traditional medicine and known to possess anti-inflammatory properties, and its aerial parts have been used for many years as an infusion alone or in combination with other species [22]. In the folk medicine of this region, many people apply the powder of this species on the external inflamed area to reduce swelling and pain [23]. Additionally, *Teucrium sauvagei*, endemic to the same area of Tunisia, has been utilized in the following ways: the leaves have been applied for wound healing, antidiabetic and anti-inflammatory remedies, treating ulcers, colic, and against food poisoning [136]. *Teucrium maghrebinum*, in Algeria called "kayatat el gerah", is used in traditional medicine of this country and Morocco to treat burns, fevers, and microbial infections [68]. A similar usage has been reported in Morocco for *Teucrium antiatlanticum* [25]. *Teucrium apollinis* and *Teucrium zanoni*, both known in Lybia as "Jada", have been used for its antidiabetic and antihypertensive effects, and for extruding kidney stones [26]. *T. polium* ssp. *geyrii* (Takmazzut) in Algeria is reported for wound healing, as a tea and spice, and as an analgesic [128, 129].

Middle East

T. polium subsp. *capitatum* (syn. T. capitatum) is a perennial, pubescent, aromatic plant, 20–50 cm high, with green-greyish leaves and white flowers, which appears from June to August. It grows wild in Southern Europe, Central and Southwest Asia, and North Africa. The plant is mixed with boiled water and sugar to form a refreshing beverage. The leaves are used in cooking as a spice [125]. In Lebanon, the infusion of its aerial parts (Ja'ada) are utilized for diabetes, insomnia, neurological disorders, and abdominal cramps [77]. The plant is also used in Palestine, where it is known as "Cat Thyme, Jedeh Subian and جعدة", for its diuretic, antipyretic, diaphoretic, antispasmodic, tonic, anti-inflammatory, antihypertensive, anorexic, analgesic, antibacterial, antidiabetic effects [54, 127], and, in veterinary medicine, to treat diarrhea, colic, bleeding, scabies, and flatulence [106, 126].

Several other taxa are utilized in the folk medicine of the eastern part of the Mediterranean Sea. In Lebanon, *Teucrium pruinosum* (Ja'ada) is used for gastrointestinal disorders, wounds, fever, and cold [77], *Teucrium divaricatum* ssp. *villosum* is used for fever and colds, and as a cicatrizant and stomachic [61], and *Teucrium orientale* is used for wounded skin and fever [77]. This last one is also used as an antipyretic and for women's hot flashes in Iran, where it is known as "Maryam nokhodi" and "Chaye alafi" [78, 79]. In Palestine, *Teucrium creticum* is well known for its antidiabetic properties [54].

The ethnopharmacological activities of *Teucrium* taxa growing in Cyprus has been reviewed by Arnold [162]. *Teucrium micropodioides* has been by far the one most used: the infusion of the flowering parts as a sedative and against tuberculosis; the infusion of the whole plant as an antispasmodic (gastric ulcer, gastrointestinal inflammation), diuretic (kidney stones and cystitis), carminative, and emmenagogue (sterility in the female); the infusion of the leaves as an antipyretic (cold), stimulant, stomachic, anthelmintic, and antidiabetic; the application of compresses from pounded fresh leaves in external use against rheumatism as well as an antipruritic and antiseptic (against skin eruption and boils) [58]. In the traditional medicine of this island, the whole plant of *Teucrium cyprium* ssp. *cyprium* is used in the form of an infusion against fever and jaundice. The topical application of the juice of the fresh plant has a healing, astringent, and antipruritic effect [58]. *Teucrium kotschyanum* is used in traditional medicine as an antipyretic and antidiabetic [58]. With regard to *T. divaricatum* ssp. *canescens*, the infusion of the flowering plant is mainly used as a stomachic. In cases of fever and the common cold, the steam is inhaled. Externally, the infusion of the plant is used as a cicatrizant [58]. *T. divaricatum* ssp. *divaricatum* has been reported in Cyprus as a cicatrizant [59], whereas the same species (Mürcüotu, buhurcuoğlu otu, böceotu) has been largely employed in Turkey for coughs, sickness, stomachache, urinary diseases, gallbladder

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disease, kidney stones, and as a tonic for eyes [60]. Two other Turkish species are noteworthy of mention. The aerial parts of *Teucrium sandrasicum* are widely used in the daily diet. The plant is also valued as a traditional medicine and is used for diuretic, diaphoretic, tonic, antipyretic, antidiabetic, antispasmodic, and cholagogic purposes [135]. The decoction of the aerial parts of *Teucrium parviflorum*, on the other hand, has been utilized in traditional treatment against hemorrhoids in Turkey [45].

Arabia-Pakistan-Iran-India

Teucrium yemense (Defl.), locally known as Reehal Fatima, is a perennial herb commonly grown in Djibouti, Ethiopia, Saudi Arabia, Sudan, and Yemen. In Yemeni folk medicine, the entire crushed plant is put into an with water, and the liquid is consumed orally to treat diabetes, kidney problems, and rheumatism and as an anthelmintic. Its use as an insect repellent has also been reported [154–156].

Teucrium mascatense Boiss. is an aromatic perennial plant that grows 25 cm high and is frequently seen on rocky hills and mountain slopes in northern Oman. It shares the common Arabic name ja'dah with the related species *Teucrium stocksianum* Boiss., a plant more common throughout the Middle East, whose properties have been reported above. *T. mascatense* is also used as a fever remedy and to reduce blood flow during menstruation. Omani people have been aware of this herb for several ages, and it has become popular and famous since a long time. The leaves are boiled in water for a long time, then the solution is cooled and consumed as a drink for stomachaches and colic. Dried leaves are burned, and the smoke is placed under bed covers for treating fevers. The leaves of *T. mascatense* are also boiled in water with the leaves of *Rhazya stricta, Fagonia indica*, myrrh, sea salt, and black salt (potassium chloride); the warm "tea" is taken for abdominal colic, fever, and diabetes. Drinking the water in which the leaves have been boiled is believed to reduce blood flow during menstruation [71, 72].

T. stocksianum Boiss. (Lamiaceae) is a perennial, woody, aromatic herb that is native to the mountainous regions of the United Arab Emirates (UAE), northern Oman, Pakistan, and Iran, and is also present in North Africa and the East Mediterranean zone. It is a popular treatment for stomachache, kidney problems, renal colic, colds, and diabetes, as well as an anti-fever remedy in the herbal medicine of the UAE and Sultanate of Oman and Iran [142, 144]. In Pakistan, where it is locally known as "Speer botay", the leaves and young shoots are commonly used for the preparation of traditional medicines to treat several ailments, including gastrointestinal ailments and inflammatory conditions. In addition to the gastroprotective effect, a decoction of *T. stocksianum* has been used for the treatment of diabetes, burning feet syndrome, as a blood purifier, and for the treatment of hypertension, epilepsy, and sore throats. The people of Malakand Division, Pakistan, have good knowledge about this plant for its medicinal use. Ethnobotanically, the juice of *T. stocksianum* is given for the treatment of jaundice and as a blood purifier, as well as a cooling agent. The decoction of the plant is also prescribed to treat chronic fever. Leaves are soaked in water overnight and the juice is consumed before breakfast to treat diarrhea and abdominal pain. Young leaves are boiled in water and the obtained juice is used for curing coughs [149]. In the Darra Adam Khel region of Pakistan, where it is known as Masstura, leaves and stems are kept in water for some time or boiled before taken as water and used as a cooling agent and against diabetes [147]. The native Khattak tribes of the Chonthra, district Karak, Pakistan, know this plant as Ger Boota. They use the decoction of the whole plant for curing undiagnosed fever. The plant is soaked overnight in water and the decoction is taken orally before breakfast for typhoid and jaundice [146]. The decoction of the whole plant (Spariki) has also been reported for the treatment of hypertension by the local people of the district Dir lower, Pakistan, although its abuse can cause body weakness [145].

In the same country, in the area of Kutlla Valley, the infusion of *Teucrium royleanum* (Katheri) is utilized for eye diseases and nervous debility [134]. The leaves and stems of *T. royleanum* are also used in India (Lahaul: Udaipur), where it is known for its allelopathic, antibacterial, antifungal, antispasmodic, astringent, antipyretic, and anti-allergic properties [133]. *Teucrium persicum* (Marv-e-talkh, Arak) is traditionally used in Iran for abdominal pain and headaches [80].

South Africa

The ethnopharmacological uses of three species of *Teucrium* growing in South Africa (*Teucrium africanum, Teucrium kraussii*, and *Teucrium trifidum*) have been exhaustively reviewed [24]. The Xhosa, Mfengu, Gcaleka, Mpondo, and Thembu ethnic groups drink an infusion of the leaf of *T. africanum* for snakebites and as a tonic. It is also used to sterilize anthrax-infected meat by boiling it with the plant. In the Willowmore district, a strong decoction is drunk for the treatment of hemorrhoids and is often applied locally for the same condition. The decoction is frequently taken as a diaphoretic in feverishness. Africans in the Butterworth district either chew the leaf or swallow a decoction of the leaf for the relief of a sore throat. Its use as a remedy for stomach disorders and in eye inflammations has also been reported.

T. trifidum is a popular remedy among the older Dutch folks. Brandy, in which the plant has been soaked, is taken as a stomachic in indigestion and tonic and a tea-like infusion is drunk for the relief of hemorrhoids. Both Europeans and Africans take a decoction for fever and influenza. The Xhosa use an infusion as a snakebite remedy, for sore throats, and to sterilize anthrax-infected meat by boiling it with the plant. Both the Xhosa and Gcaleka regard the plant as a tonic. Hewat states that it is a carminative. An infusion of the leaf is used by Europeans as a diabetes remedy and is said to be slightly purgative. Externally, a preparation of the plant is applied locally for whitlow and bee stings and to aid the healing of wounds [24].

Essential Oils

The chemical composition of EOs obtained from 99 *Teucrium* taxa has been investigated. The major compounds (> 3%) occurring in the chemical composition of the EOs are reported in ▶ **Table 3**.

In the EOs of *Teucrium* species, generally, the main compounds are represented by sesquiterpene hydrocarbons, such as germacrene D and β-caryophyllene, or monoterpene hydrocarbons such as α- and β-pinene. The taxa can be grouped into two different

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▸ **Table 3** Main compounds (> 3 %) of the EOs from *Teucium* taxa.

Taxa	Origin	Parts	Method	Main compounds	Ref.
Section ***Chamaedrys***					
T. chamaedrys	Corsica, Corti	ap	HD	*β*-caryophyllene (29.0), germacrene D (19.4), *α*-humulene (6.8), *δ*-cadinene (5.4), (*E*)-*β*-farnesene (4.4), caryophyllene oxide (3.2)	[163]
	Corsica	ap	HD	(*E*)-*α*-caryophyllene (33.9), germacrene D (18.5), *α*-humulene (7.5), (*E*)-*β*-farnesene (5.1), *δ*-cadinene (4.6), caryophyllene oxide (3.1)	[164]
	Croatia	ap	HD	*β*-caryophyllene (47.6), germacrene D (29.0), *β*-copaene (5.7), caryophyllene oxide (4.5)	[165]
	Iran, Mazandaran	ap	HD	germacrene-D (16.5), (*Z*)-*β*-farnesene (12.2), *β*-caryophyllene (10.5), *α*-pinene (9.1), *δ*-cadinene (7.4), *β*-pinene (4.8), *β*-bourbonene (3.8), *α*-*trans*-bergamotene (3.5)	[166]
	Iran	ap	HD	*α*-muurolene (15.3), *β*-caryophyllene (15.0), *α*-pinene (7.9), (*Z*)-*β*-farnesene (7.6), *β*-pinene (5.9), limonene (5.1), germacrene A (3.9), *α*-cadinene (3.8), *α*-copaene (3.0)	[167]
	Kossovo	ap	HD	germacrene D (24.1), hexadecanoic acid (12.7), eicosane (10.9), *δ*-cadinene (7.0), sclareolide (5.5), hexacosane (4.5), linoleic acid (4.0), *β*-caryophyllene (3.9), (*E*,*E*)-farnesyl acetate (3.3)	[168]
	Sardinia	ap	HD	*β*-caryophyllene (27.4), germacrene D (13.5), caryophyllene oxide (12.3), (*E*)-*β*-farnesene (6.5), *α*-pinene (4.4), *β*-pinene (3.4), *β*-bourbonene (3.0)	[163]
	Serbia-Montenegro	ap	HD	*β*-caryophyllene (26.9), germacrene D (22.8), *α*-humulene (6.7), caryophyllene oxide (5.5), *α*-pinene (5.3), 3-octanol (3.7), *δ*-cadinene (3.1)	[169]
	Turkey, Denizli	lv	DT	*β*-pinene (13.1), germacrene D (9.5), *α*-pinene (8.9), *α*-farnesene (8.0), *α*-gurjunene (7.8), *γ*-elemene (7.4), *γ*-cadinene (6.4), heptacosane (4.8)	[170]
	Turkey, Baskil	ap	HD	germacrene D (32.1), *β*-caryophyllene (14.2), *δ*-cadinene (13.1), bicyclogermacrene (6.7), *β*-farnesene (4.3), neophytadiene (4.1)	[171]
T. chamaedrys ssp. *chamaedrys*	Turkey, Kelkit	ap	HD	germacrene D (16.7), *α*-pinene (15.8), *β*-caryophyllene (11.8), *β*-pinene (8.9), *β*-myrcene (4.1), *β*-bourbonene (3.1)	[172]
T. chamaedrys ssp. *lydium*	Turkey, Çamli	ap	HD	*β*-caryophyllene (19.7), *α*-pinene (12.5), germacrene D (9.3), *β*-pinene (6.6), caryophyllene oxide (6.1), *β*-bourbonene (3.6)	[172]
T. chamaedrys ssp. *syspirense*	Turkey	ap	MD	caryophyllene oxide (27.7), *α*-pinene (11.4), caryophyllenol II (5.3), caryophyllenol I (4.0), *β*-pinene (3.9), humulene epoixide-II (3.7), oct-1-en-3-ol (3.1)	[173]
	Iran	ap	HD	*β*-caryophyllene (18.2), germacrene D (10.8), carvacrol (9.5), *α*-humulene (6.4), caryophyllene oxide (4.8), linalool (3.7), *α*-*trans*-bergamotene (3.3), *β*-bourbonene (3.2), *δ*-cadinene (3.1), (*E*,*E*)-*α*-farnesene (3.0)	[174]
T. chamaedrys ssp. *trapezunticum*	Turkey	ap	MD	*β*-caryophyllene (18.2), nonacosane (11.8), germacrene D (10.8), caryophyllene oxide (7.4), *α*-pinene (7.0), dodecanoic acid (4.5), oct-1-en-3-ol (3.6), pentacosane (3.0), *β*-bourbonene (3.2), *β*-pinene (3.1)	[173]
T. divaricatum ssp. *canescens*	Cyprus, Kambos	st	HD	*allo*-aromadendrene (17.7), *α*-copaene (8.2), *α*-cadinene (8.1), *trans*-*β*-bergamotene (6.5), *α*-cedrene (5.7), *trans*-*β*-farnesene (5.4)	[58]
	Cyprus, Katodrys	lv	HD	*β*-cubebene (26.7), *β*-caryophyllene (17.6), *α*-pinene (12.1), *β*-pinene (6.2), limonene (4.2), *α*- humulene (4.0), *γ*-elemene (4.0), *β*-bourbonene (3.0)	[58]
	Cyprus, Katodrys	st	HD	isopulegol (17.4), *α*-terpineol (17.0), myrtenal (7.2), *β*-bourbonene (6.0), *β*-guaiene (5.6), *α*-pinene (4.2), *α*-himachelene (3.5)	[58]
	Cyprus, Stavrouni	lv	HD	*β*-cubebene (23.7), *α*-pinene (18.1), *β*-caryophyllene (14.0), *β*-pinene (10.7), limonene (6.7), *α*-humulene (5.6), *γ*-elemene (3.9)	[58]
	Cyprus, Stavrouni	st	HD	*β*-cubebene (26.1), *β*-caryophyllene (17.0), *α*-humulene (7.9), *α*-pinene (7.7), *β*-pinene (5.7), *γ*-elemene (4.5), limonene (4.0), caryophyllene oxide (4.0)	[58]

continued

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▸ **Table 3** *Continued*

Taxa	Origin	Parts	Method	Main compounds	Ref.
T. divaricatum ssp. *divaricatum*	Greece	ap	HD	δ-cadinene (20.5–19.0), γ-cadinene (13.4–8.5), bisabolene (12.2–5.9), β-caryophyllene (12.5–10.4), limonene (8.5–1,2), α-humulene (5.7–2.9), α-pinene (4.9–1.3), *allo*-aromadendrene (3.7–0.5), spathulenol (3.3–1.1), β-pinene (3.1–0.6)	[175]
T. divaricatum ssp. *villosum*	Lebanon	ap	HD	β-caryophyllene (30.1), caryophyllene oxide (6.1), hexahydrofarnesyl acetone (4.6), linalool (3.4), hexadecanoic acid (3.1)	[61]
T. flavum	Croatia, Dalmatia	ap	HD	α-pinene (17.3), β-caryophyllene (15.8), β-pinene (11.2), *allo*-aromadendrene (9.2), limonene + 1,8-cineole (6.2), α-cubebene (4.3), γ-terpinene (3.5), δ-cadinene (3.2)	[176]
	Croatia, Split	ap	HD	β-caryophyllene (23.1), germacrene D (15.3), α-pinene (10.5), β-pinene (8.4), limonene (7.9), *n*-amyl-isovalerate (3.7)	[165]
	Greece, Mt Pileum	ap	HD	caryophyllene (12.2), 4-vinyl guanaco (9.7), caryophyllene oxide (7.9), α-humulene (6.0), linalool (3.4), β-bourbonene (3.1)	[177]
	Iran	lv	HD	β-caryophyllene (30.6), germacrene D (21.3), α-humulene (8.4), τ-cadinol (6.9), δ-cadinene (4.9), *trans*-α-bergamotene (4.8), spathulenol (4.5), caryophyllene oxide (3.8), β-bisabolene (3.1)	[178]
	Montenegro	ap	HD	β-bisabolene (35.0), α-pinene (17.5), β-pinene (11.5), limonene (6.4), β-caryophyllene (5.4), α-humulene (3.6)	[168]
	Sicily	lv	MHD	β-bisabolene (47.0–31.5), germacrene D (14.0–9.6), β-caryophyllene (4.6–3.1), δ-cadinene (4.1–2.3), viridiflorol (5.0–2.5), phytol (4.0–3.3)	[179]
	Sicily	fl	MHD	β-bisabolene (48.2), germacrene D (7.7), β-caryophyllene (4.7), δ-cadinene (4.3)	[179]
	Sicily	fr	MHD	β-bisabolene (48.7), germacrene D (4.3), β-caryophyllene (3.2)	[179]
T. flavum ssp. *flavum*	Italy, Marche	ap	SPEM	(*Z,E*)-α-farnesene (33.9–27.3), (*E*)-β-farnesene (13.3–12.3), germacrene D (13.2–3.1)	[180]
	Italy, Marche	ap, dry	HD	(*Z,E*)-α-farnesene (11.5), linalool (7.6), β-bisabolene (7.5), (*E*)-β-farnesene (7.3), 11-α*H*-Himachal-4-en-1-β-ol (6.2), β-caryophyllene (5.7), germacrene D (5.5), α-pinene (5.3), β-pinene (4.5), limonene (3.5)	[181]
	Italy, Marche	ap, fresh	HD	(*Z,E*)-α-farnesene (14.9), 11-α*H*-himachal-4-en-1-β-ol (10.1), germacrene D (6.6), (*E*)-β-farnesene (5.7), β-caryophyllene (5.1), β-bisabolene (5.0)	[181]
	Italy, Marche	ap, dry	SPEM	(*Z,E*)-α-farnesene (33.9), (*E*)-β-farnesene (12.3), α-zingiberene (6.0), β-caryophyllene (5.1), germacrene D (3.1)	[181]
	Italy, Marche	ap, fresh	SPEM	(*Z,E*)-α-farnesene (27.3), (*E*)-β-farnesene (13.3), germacrene D (13.2), β-caryophyllene (8.4), zingiberene (6.5)	[181]
	Italy, Liguria	ap	HD	α-pinene (19.0), germacrene D (11.9), β-pinene (10.6), limonene (9.0), α-bulnesene (8.9), (*Z,E*)-farnesolo (4.7), (*E*)-β-farnesene (3.3)	[182]
	Italy, Tuscany	ap	HD	α-pinene (22.6), β-pinene (15.8), limonene (13.2), germacrene D (6.9), *(E,E)*-α-farnesene (4.8)	[182]
	Greece, Zakynthos	ap	HD	caryophyllene (13.5), caryophyllene oxide (8.5), 4-vinyl guaiacol (6.0), α-humulene (5.0), hexahydrofarnesyl acetone (3.4), α-copaene (3.3)	[183]
	Corsica	ap	HD	α-pinene (21.9), limonene (20.0), β-pinene (18.1), (*Z*)-α-ocimene (15.5)	[164]
	Corsica	ap	HD	limonene (22.3–21.9), α-pinene (21.5–19.8), β-pinene (18.1–16.4), (*Z*)-β-ocimene (17.0–14.5)	[184]
	Tunisia	ap	HD	β-caryophyllene (32.5), α-humulene (17.8), germacrene D (6.0), caryophyllene oxide (4.9), (*Z*)-γ-bisabolene (4.0)	[185]

continued

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▸ **Table 3** *Continued*

Taxa	Origin	Parts	Method	Main compounds	Ref.
T. flavum ssp. *glaucum*	Corsica	ap	HD	limonene (27.4), α-pinene (12.2), β-pinene (10.3), (*Z*)-α-ocimene (6.0), (*E*)- phytol (4.5)	[164]
	Corsica	ap	HD	limonene (31.8–21.1), α-pinene (17.6–8.5), β-pinene (12.4–9.7), (*Z*)-β-ocimene (8.1–2.4), (*E*)-phytol (5.5–2.4), (*E*)-β-farnesene (4.4–1.3)	[184]
T. flavum ssp. *hellenicum*	Greece	lv	HD	germacrene D (21.9), β-caryophyllene (18.1), spathulenol (17.9), (*E*)-β-farnesene (7.3), β-bisabolene (7.1), β-cubebene (5.2), α-pinene (3.4), myrcene (3.7), β-pinene (3.1)	[65]
	Greece	fl	HD	germacrene D (22.3), β-caryophyllene (22.2), α-humulene (11.8), β-bisabolene (7.6), α-pinene (6.8), β-pinene (5.2)	[65]
T. marum	Corsica	ap	HD	caryophyllene oxide (9.8), (*E*)-α-bergamotene (8.2), β-bisabolene (7.5), (*E*)-β-caryophyllene (5.3), β-sesquiphellandrene (3.7), estragole (3.5), octadecyl acetate (3.3), humulene epoxide II (3.2), (3*Z*,6*E*,10*E*)-α-springene (3.2), geranyl acetate (3.0)	[164, 186]
T. marum ssp. *drosocalyx*	Balearic Is, Minorca Favaritx	ap	SDE	dolichodial (34.8), α-bergamotene (11.5), *p*-allyl-anisole (7.0), caryophyllene epoxide (5.6), β-bisabolene (5.1), β-caryophyllene (4.5), epidolichodial (3.0)	[187]
	Balearic Is, Minorca Canutells	ap	SDE	dolichodial (89.5), β-caryophyllene (3.2)	[187]
	Balearic Is, Minorca Biniancolla	ap	SDE	dolichodial (81.2), epidolichodial (7.8)	[187]
T. marum ssp. *marum*	Balearic Is, Minorca Favaritx	ap	SDE	dolichodial (48.3), β-caryophyllene (5.3), epidolichodial (3.5)	[187]
	Balearic Is, Minorca Barrac d'Algendar	ap	SDE	dolichodial (72.5–42.1), β-caryophyllene (7.7–5.2), caryophyllene oxide (7.0–2.6), epidolichodial (4.2–2.1)	[187]
	Balearic Is, Minorca Cala En Caldès	ap	SDE	dolichodial (35.8), caryophyllene epoxide (8.7), β-caryophyllene (7.8), α-bergamotene (8.4), β-bisabolene (7.1)	[187]
	Balearic Is, Minorca El Toro	ap	SDE	dolichodial (74.0), β-bisabolene (4.4), epidolichodial (3.7)	[187]
T. marum ssp. *occidentale*	Balearic Is, Mallorca Sierra de Alfabia	ap	SDE	β-caryophyllene (34.7–23.9), caryophyllene epoxide (30.6–20.7), δ-cadinene (10.2–1.6), α-humulene (8.3–5.8), β-bisabolene (10.0), α-bergamotene (5.9–0), humuladienone (5.5–4.3), α-bisabolol (4.1–1.5)	[187]
	Balearic Is, Mallorca Castel d'alarò	ap	SDE	β-caryophyllene (23.1–21.2), caryophyllene epoxide (23.9–19.3), δ-cadinene (12.9–10.5), β-bisabolene (9.5–9.4), α-humulene (6.0–5.0), α-bisabolol (6.2–5.1), γ-cadinene (5.0–3.9), humuladienone (3.8–3.2).	[187]
	Balearic Is, Mallorca Penyal Fumat	ap	SDE	caryophyllene epoxide (20.8), β-caryophyllene (14.3), α-bisabolol (10.5), δ-cadinene (8.1), γ-cadinene (7.6), humuladienone (3.8), dolichodial (3.5), α-humulene (3.5)	[187]
	Balearic Is, Mallorca Esporles	ap	SDE	dolichodial (28.9), β-caryophyllene (19.9), β-bisabolene (11,9), caryophyllene epoxide (11.6). δ-cadinene (8.5), α-humulene (4.4)	[187]
T. marum ssp. *marum*	Sardinia	ap	HD	*iso*-caryophyllene (20.2), β-bisabolene (14.7), β-sesquiphellandrene (11.3), α-santalene (11.0), dolichodial (9.4), α-caryophyllene (7.2), 4-allyl anisole (3.8), caryophyllene oxide (3.2)	[188]
Section *Isotriodon*					
T. antiatlanticum	Morocco	ap	HD	germacrene D (13.7), δ-cadinene (12.7), α-gurjunene (11.5), γ-muurolene (8.0), *allo*-aromadendrene (3.1)	[25]
T. cavernarum	Turkey	ap	HD	β-caryophyllene (32.9), germacrene D (20.7), caryophyllene oxide (14.1), bicyclogermacrene (6.3), α-humulene (3.9)	[189]

continued

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▸ **Table 3** *Continued*

Taxa	Origin	Parts	Method	Main compounds	Ref.
T. montbretii ssp. *heliotropifolium*	Greece, Karpathos	ap	HD	carvacrol (13.9), caryophyllene oxide (12.7), hexadecanoic acid (9.8), caryophyllene (7.8), caryophylladienol I (3.7), linalool (3.5), *β*-bourbonene (3.5)	[177]
	Greece, Karpathos	ap	HD	carvacrol (13.5), hexadecanoic acid (10.7), caryophyllene oxide (8.8), caryophyllene (8.2), germacrene D (3.7), caryophyllenol II (3.2)	[190]
T. paederotoides	Turkey	ap	SD	germacrene D (20.8), pulegone (9.5), bicyclogermacrene (9.2), hexadecanoicacid (7.9), spathulenol (6.5), *β*-pinene (3.9), *β*-bourbonene (3.6)	[189]
T. persicum	Iran, Fars	ap	HD	caryophyllene oxide (10.6), *α*-pinene (9.4), geranyl linalool (7.8), *γ*-cadinene (7.4), elemol (6.9), *α*-cadinol (5.5), elemol acetate (3.6), *β*-caryophyllene (3.0), *β*-eudesmol (3.0)	[191]
	Iran, Busheh	ap	HD	*epi*-*α*-cadinol (23.2), *α*-pinene (17.3), *α*-cadinol (9.7), *β*-pinene (5.8), *δ*-cadinene (5.4), limonene (4.6), mycrene (4.1), *β*-caryophyllene (4.1), *γ*-cadinene (3.8)	[192]
	Iran, Lar Mountain	ap	HD	*α*-cadinene (9.7), 1,4-cadinadiene (9.2), *α*-terpinyl acetate (7.9), linalyl acetate (7.7), linalool (7.6), cadinol (6.2), 1,8-cineole (5.7), *γ*-terpineol (4.4)	[80]
Section *Polium*					
T. algarbiensis	Portugal	ap	HD	limonene (11.8), *β*-pinene (10.2), germacrene D (7.6), sabinene (7.2), myrcene (5.7), *τ*-cadinol (5.0), *α*-cadinol (3.9), bicyclogermacrene (3.0), *δ*-cadinene (3.0)	[193]
T. alopercus	Tunisia, Matmata	ap	HD	*δ*-cadinene (13.4), nerolidyl acetate (12.3), *α*-humulene (12.3), *α*-guaiene (10.2), *β*-caryophyllene (8.2), *γ*-muurolene (4.5), (*E*)-nerolidol (4.5), bicyclogermacrene (4.1)	[194]
	Tunisia, Gafsa	ap	HD	*α*-bisabol (16.2), (+)-*epi*-bicyclosequiphellandrene (15.4), *α*-cadinol (8.5), pentane, 3-methyl (6.1), bicyclo[3.1.0]hex-2-ene, 4-methyl-1-(1-methylethyl)- (5.1), *β*-phellandrene (3.8)	[22, 23]
T. antitauricum	Turkey	ap	HD	germacrene D (28.2), *β*-caryophyllene (27.6), caryophyllene oxide (7.5), bicyclogermacene (5.5), *α*-humulene (4.2), aromadendrene (3.6)	[195]
T. apollonis	Libya	ap	HD	*β*-caryophyllene (22.4), limonene (11.8), germacrene D (11.8), *α*-pinene (5.8), sesquilavandulol (4.0), *β*-citronellene (3.8), *δ*-cadinene (3.7)	[196]
T. carolipaui	Spain, Alicante	ap	HD	*τ*-cadinol (17.0–5.0), *τ*-muurolol (12.3–11.3), *α*-cadinol (12.3–8.1), *β*-eudesmol (10.1–6.2), *δ*-cadinene (7.6–3.9), *γ*-cadinene (4.5–0.3), *α*-copaene (4.3–1.2)	[197]
	Spain, Almeira	ap	HD	*δ*-cadinene (14.3), 3-*β*-hydroxy-*α*-muurolene (9.4), *α*-cadinol (7.2), cadina-1,4-diene (4.3), caryophyllene oxide (4.5), 1-*epi*-cubenol (4.1), cubenol (3.5)	[198]
T. cyprium ssp. *cyprium*	Cyprus, Sun valley	lv	HD	sabinene (21.2), *δ*-cadinene (9.6), *α*-cadinene (8.4), *β*-guaiene (4.7), *β*-caryophyllene (4.6), *α*-pinene (3.3)	[58]
	Cyprus, Chionistra	lv + fl	HD	sabinene (11.9), *δ*-cadinene (8.1), *β*-caryophyllene (7.1), *α*-pinene (5.5). *γ*-terpinene (4.6), *p*-cymene (3.7)	[58]
	Cyprus, Chionistra	st	HD	*δ*-cadinene (11.4), *α*-cadinene (5.9), carvacrol (4.3), *β*-guaiene (4.0)	[58]
T. gnaphalodes	Spain	ap	HD	*β*-caryophyllene (12.1), sabinene (8.8), *trans*-pinocarveol (7.8), *β*-pinene (7.1), myrtenal (5.7), *p*-cymen-8-ol (4.5), ledol (4.1), dehydrosabinaketone (3.9), *allo*-aromadendrene (3.4), caryophyllene oxide (3.4), limonene (3.1)	[199]

continued

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▸ **Table 3** *Continued*

Taxa	Origin	Parts	Method	Main compounds	Ref.
T. haenseleri	Spain	fl	HD	β-pinene (30.3), α-pinene (20.0), (*E*)-pinocerveol (3.8), limonene (3.3), α-campholenal (3.1), β-mycene (3.0)	[200]
	Spain	lv-fl stage	HD	β-pinene (24.0), α-pinene (17.5), (*E*)-pinocerveol (5.4), α-campholenal (4.7), δ-cadinene (4.7), (*E*)-verbenol (3.4), myrtenal (3.2)	[200]
	Spain	lv-vg stage	HD	β-pinene (30.9), α-pinene (22.7), (*E*)-pinocerveol (5.4), (*E*)-verbenol (3.4), limonene (3.3), β-mycene (3.1), sabinene (3.0), δ-cadinene (3.0)	[200]
T. lepicephalum	Spain	ap	HD	sabinene (57.4–47.5), α-pinene (19.3–19.1), germacrene D (9.9–5.0), limonene (8.3–7.1), β-caryophyllene (4.6–1.7), germacrene B (3.7–0.9)	[197]
T. leucocladum	Egypt	ap	HD	patvhouli alcohol (31.2), β-pinene (12.7), α-pinene (11.0), α-cadinol (9.3), τ-cadinol (5.5), mycene (5.3), viridiflorol (5.4), epizonarene (4.5)	[201]
T. libanitis	Spain	ap	HD	α-pinene (21.2–9.9), τ-cadinol (11.8–1.1), δ-cadinene (9.7–5.3), sabinene (6.6–5.8), α-cadinol (6.0–0.9), germacrene D (4.3–1.4), α-cedrene (4.2–1.1), caryophyllene oxide (4.0–1.6)	[202]
T. lusitanicum	Portugal	ap	HD	elemol (12.0–2.6), β-pinene (11.9–2.5), limonene (11.5–1.2), sabinene (9.6–2.1), α-cadinol (9.1–4.2), α-pinene (8.5–0.8), myrcene (7.3–2.5), δ-cadinene (7.3–2.0), τ-cadinol (6.2–5.2), germacrene D (6.0–1.0), terpien-4-ol (5.5–1.9), β-selinene (4.0–1.0), β-caryophyllene (3.9–0.7)	[193]
T. lusitanicum ssp. *aereiformis*	Spain, Malaga	ap	HD	limonene (15.1), β-pinene (5.2%), α-copaene (4.5), terpinen-4-ol (3.5), α-cadinol (3.3)	[203]
T. mascatense	Oman, Jabal Al-Akdhar	lv	HD	linalool (27.8), linalyl acetate (12.6), β-eudesmol (10.1), limonene (5.7), α-bergamotene (5.0) *cis*-linalool oxide (furanoid) (4.6), *trans*-linalool oxide (furanoid) (4.1), α-terpineol (3.0)	[71]
	Oman, Nizwa	lv	HD	limonene (17.0), linalool (12.3), α-pinene (10.1), β-eudesmol (10.1), linalyl acetate (4.3), *trans*-α-bergamotene (4.2), β-pinene (3.5)	[204]
T. micrpopodiodes	Cyprus, Akamas	lv	HD	β-pinene (17.6), α-pinene (6.6), β-bisabolene (6.4), limonene (4.3), β-caryophyllene (4.3), sabinene (4.1), α-cedrene (3.7), *trans*-pinocarveol (3.5), γ-elemene (3.5)	[58]
	Cyprus, Akamas	st	HD	β-bisabolene (10.8), β-pinene (5.7), β-caryophyllene (5.0), *trans*-nerolidol (4.0), *trans*-pinocarveol (3.5)	[58]
	Cyprus, Kambos	fl	HD	α-cedrene (21.0), β-caryophyllene (16.3), α-humulene (7.8), γ-elemene (3.6), caryophyllene oxide (3.6)	[58]
	Cyprus, Kambos	st	HD	γ-elemene (6.0), β-bisabolene (5.5), *trans*-nerolidol (3.5), α-cedrene (3.3), α-himachalene (3.2), δ-cadinene (3.2), nerol (3.2), β-caryophyllene (3.0), *trans*-pinocarveol (3.0), caryophyllene oxide (3.0)	[58]
	Cyprus, Kambos	fr + fl	HD	α-cedrene (8.8), β-pinene (6.3), γ-elemene (5.9), *trans*-pinocarveol (3.9), α-pinene (3.0)	[58]
	Cyprus, Mosphiloti	lv + fl	HD	β-pinene (43.5), α-pinene (14.7), α-cedrene (5.9), limonene (5.8), *trans*-β-farnesene (4.8), myrtenal (3.7), pinocarvone (3.3), nerol (3.2), γ-elemene (3.0)	[58]
	Cyprus, Mosphiloti	st	HD	sabinene (18.8), β-pinene (11.2), α-cedrene (9.6), α-pinene (6.6), α-terpinene (6.0), γ-elemene (5.2)	[58]
T. montanum	Croatia	ap	HD	germacrene D (17.2), β-pinene (12.9), β-caryophyllene (7.1), limonene (4.6), myrcene (4.2), linalool (3.6), β-bourbonene (3.4), hexacosane (3.4), pentacosane (3.3), tetracosane (3.1)	[165]
	Turkey	ap	HD	sabinene (11.3), δ-cadinene (6.3), germacrene D (5.8), α-copaene (5.7), (*E*)-β-farnesene (5.5), τ-cadinol (5.4), α-pinene (5.2), linalool (3.2), β-pinene (3.1)	[205]
	Serbia-Mont Mt. Orjen	ap	HD	germacrene D (15.0), α-pinene (12.4), β-eudesmol (l0.l), β-caryophyllene (6.9), β-pinene (4.8), δ-cadinene (4.5), γ-cadinene (4.1), cadinol (3.6), bicyclogermacrene (3.5)	[169]
	Serbia, Jadovnik	ap	HD	δ-cadinene (17.2), β-selinene (8.2), α-calacorene (5.0), 1,6-dimethyl-4-(1-methylethyl)-naphthalene (4.9), caryophyllene (4.3), copaene (4.2), torreyol (3.9), 4-terpineol (3.9), cadina-1.4-diene (3.4), β-sesquiphellan-drene (3.3), γ-curcumene (3.2), τ-cadinol (3.1)	[206, 207]
	Serbia, Jabura	ap	HD	δ-cadinene (8.1), β-caryophyllene (5.1), τ-muurolol (4.2), α-pinene (4.0), dehydrosesquicineole (3.9), γ-cadinene (3.6), α-cadinol (3.5)	[208]

continued

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Table 3 *Continued*

Taxa	Origin	Parts	Method	Main compounds	Ref.
T. montanum ssp. *jailae*	Slovakia	ap	HD	germacrene D (12.8), *β*-caryophyllene (8.0), *epi*-*α*-cadinol (4.5), *α*-pinene (3.1), bicyclogermacrene (3.1), *epi*-cubenol (3.0), cubenol (3.0)	[209]
T. polium	Algeria, Bordj Bou Arreridj	ap	HD	germacrene D (13.8), *β*-eudesmol (8.7), bicyclogermacrene (4.9), *β*-caryophyllene (4.2), shyobunol (3.9), *β*-pinene (3.3), *trans*-calamenene (3.2), *δ*-cadinene (3.2)	[210]
	Algeria, Bordj Bou Arreridj	fl	HD	germacrene D (12.5), shyobunol (5.6), *δ*-cadinene (4.7), bicyclogermacrene (4.6), *β*-eudesmol (4.5), *α*-cadinol (3.6)	[210]
	Algeria, Bouira	ap	HD	germacrene D (25.0), *β*-pinene (11.3), bicyclogermacrene (10.4), spathulenol (5.8), limonene (4.0), *τ*-cadinol (3.5)	[211]
	Algeria	ap	HD	*β*-pinene (16.6), germacrene D (14.8), *α*-pinene (7.2), spathulenol (6.4), limonene (5.6), bicyclogermacrene (5.5)	[212]
	Algeria, Mt. Tessala	ap	HD	D-germacrene (18.9), (*E*)-*β*-ocimène (12.7), bicyclogermacrene (11.0), *β*-pinene (9.0), carvacrol (7.0), spathulenol (4.2), linalol (4.0), *α*-pinene (3.2)	[213]
	Algeria, Tlemcen	ap	HD	germacrene D (25.8), bicyclogermacrene (13.0), *β*-pinene (11.7), carvacrol (8.9), spathulenol (6.5), *δ*-cadinene (4.3), *α*-pinene (4.0), citronelle (3.6)	[214]
	Algeria, North East	ap	HD	*α*-pinene (18.0–14.1), *β*-pinene (18.1–15.0), germacrene D (19.0–3.8), myrcene (10.4–8.2), limonene (8.7–5.3), sabinene (4.3–2.7)	[215]
	Croatia	ap	HD	*β*-caryophyllene (52.0), germacrene D (8.7), limonene (5.9), *β*-thujone (5.7), *α*-humulene (4.6), (*Z*)-*β*-farnesene (4.3), *trans*-*α*-bergamotene (4.1)	[165]
	Algeria, Birska	ap	HS	*α*-guaiene (11.3), *β*-caryophyllene (9.5), *γ*-elemene (9.2), *β*-farnesene (7.6), farnesol (6.1), 6-methyl-5-hepten-2-one (4.4), *allo*-aromadendrene (4.3), *δ*-guaiene (4.2), geranyl acetone (3,6), *α*-gurjunene (3.4)	[216]
	Algeria, El Mamounia	ap	HD	limonene (29.9–26.4), spathulenol (17.2–13.3), 1-adamantanemethylamine (9.8–0), camphor (8.2–0), pinocarvone (7.8–5.6), *τ*-cadinol (5.4–3.7), pinene oxide (4.8–0), *α*-terpineol (4.6–0), *β*-myrcene (4.0–0), *α*-phellandrene (3.4–0)	[217]
	France, Montserrat	lv	DCM	germacrene D (26.4), *β*-pinene (19.3), myrcene (11.4), *α*-pinene (6.3), bicyclogermacrene (4.8), limonene (4.4), *β*-selinene (3.9), *trans*-*α*-bergamotene (3.0), *δ*-cadinene (3.0)	[218]
	France, Rougon	fl	DCM	germacrene D (34.4), *β*-pinene (14.1), *α*-pinene (10.3), myrcene (7.2), bicyclogermacrene (5.8), *β*-caryophyllene (5.4), *α*-humulene (4.7)	[218]
	France, Rougon	lv	DCM	germacrene D (31.9), *β*-pinene (14.0), myrcene (9.0), *α*-pinene (8.9), *β*-caryophyllene (7.4), *β*-bourbonene (7.1), bicyclogermacrene (6.2), *α*-humulene (5.8)	[218]
	France, Lure Mt.	fl	DCM	germacrene D (21.4), *α*-pinene (14.8), *β*-pinene (12.2), myrcene (9.9), *β*-caryophyllene (9.7), *α*-humulene (7.9), bicyclogermacrene (4.5)	[218]
	France, Lure Mt.	lv	DCM	germacrene D (18.1), *β*-pinene (15.4), *α*-pinene (14.6), *β*-caryophyllene (8.8), myrcene (8.6), *α*-humulene (5.6), *δ*-cadinene (4.7), sabinene (4.3), bicyclogermacrene (3.0)	[218]
	France, Rustrel	lv	DCM	germacrene D (35.0), *α*-pinene (20.0), *β*-pinene (10.9), myrcene (9.6), *δ*-cadinene (4.0), bicyclogermacrene (3.7), *β*-gujurnene (3.1)	[218]
	France, Gras	fl	DCM	*β*-pinene (22.7), *β*-caryophyllene (14.7), *α*-pinene (14.3), germacrene D (12.7), sabinene (6.5), myrcene (6.2), *α*-humulene (4.8), limonene (3.0)	[218]

continued

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▸ Table 3 *Continued*

Taxa	Origin	Parts	Method	Main compounds	Ref.
	France, Gras	lv	DCM	sabinene (25.5), *β*-pinene (17.9), *β*-caryophyllene (16.7), *α*-pinene (11.5), germacrene D (11.1), myrcene (5.0), *α*-humulene (3.7), *α*-thujene (3.2)	[218]
	France, Notre Dame la Brune	fl	DCM	sabinene (21.8), *β*-pinene (16.2), germacrene D (14.9), *β*-caryophyllene (12.1), *α*-pinene (9.7), myrcene (6.4), bicyclogermacrene (4.4), limonene (3.9)	[218]
	France, Notre Dame la Brune	lv	DCM	sabinene (20.1), *β*-pinene (14.9), germacrene D (12.1), *β*-caryophyllene (12.7), *α*-pinene (9.1), thymol (7.9), myrcene (6.5), bicyclogermacrene (3.3), limonene (3.7)	[218]
	Greece, Mt. Hymettus	lv + fl	HD	*τ*-cadinol (9.3), *β*-caryophyllene (7.7), caryophyllene oxide (5.9), *α*-cadinol (5.4), *α*-humulene (3.7), *trans*-verbenol (3.0), *γ*-cadinene (3.0)	[219]
	Greece, Mt. Hymettus	lv + fl	Et_2O/pent	*τ*-cadinol (10.8), caryophyllene oxide (9.0), *α*-cadinol (7.8), undecane (7.5), *ε*-cadinene (3.0), dodecane (3.0)	[219]
	Iran, Kashan	lv + fl	HD	*β*-caryophyllene (18.0), germacrene D (13.2), spathulenol (10.4), *β*-pinene (9.7), *α*-pinene (9.0), bicyclogernacrene (9.0), caryophyllene oxide (7.1), limonene (4.6), (*Z*)-*β*-famesene (3.1)	[220]
	Iran, Kashan	lv + fl	CO_2	germacrene D (23.6), *β*-caryophyllene (16.5), bicyclogernacrene (11.9), *α*-pinene (9.8), *β*-pinene (7.2), (*Z*)-*β*-famesene (6.0), spathulenol (4.0), limonene (3.7)	[220]
	Iran, Khuzestan	ap	HD	*γ*-muurolene (23.1), *γ*-elemene (16.8), spathulenol (11.6), *β*-caryophylene (9.2), limonene (9.2), 3-carene/*α*-pinene (8.0), *β*-eudesmol (7.5), *β*-pinene (5.8), germacrene B (3.4)	[221]
	Iran, Fars	ap	HD	limonene (37.7), 2,4-di-*tetr*-butylphenol (10.8), *p*-cymene (8.2), *α*-pinene (4.3), valerianol (3.9), *β*-pinene (3.7), hedycaryol (3.6)	[222]
	Iran	ap		bicyclodec-1-ene (11.7), 1,3-cyclooctadiene (9.7), *iso*-aromadendrene epoxide (4.9), 2,3,3-trimethyl-3-cyclopentene acetaldehyde (3.2), bicyclohexene,4-methylene (3.0)	[223]
	Iran, Kermanshah	ap	HD	(*Z*)-*a*-caryophyllene (19.5), cedrol (14.5), germacrene D (7.5), *α*-*epi*-cadinol (5.3), *α*-pinene (4.6), salicylic acid butyl ester (4.4), (*E*)-*γ*-bisabolene (3.9), (*E*)-*β*-famesene (3.7)	[224]
	Iran, Kermanshah	ap	SPME	(*Z*)-*a*-caryophyllene (18.9), cedrol (15.2), germacrene D (7.9), *α*-*epi*-cadinol (5.3), *α*-pinene (4.3), salicylic acid butyl ester (4.8), (*E*)-*γ*-bisabolene (4.0), (*E*)-*β*-famesene (3.9), *α*-humulene (3.0),	[224]
	Iran, Behbehan	ap	HD	*β*-bisabolol (23.0), 11-acetoxyeudesman-4*α*-ol (16.0), *β*-caryophylene (11.1), *α*-bisabolol (5.6), *α*-bisaboloxide B (3.7), *β*-pinene (3.3), dehydro-sesquicineol (3.2), bicyclogernacrene (3.1)	[225]
	Iran, Haft Kel	ap	HD	*β*-bisabolol (18.6), 11-acetoxyeudesman-4*α*-ol (16.9), *α*-bisabolol (14.2), *β*-caryophylene (10.5), caryophyllene oxide (4.4), *β*-pinene (3.6)	[225]
	Iran, Masjed-e-Solaiman	ap	HD	*α*-bisabolol (26.5), 11-acetoxyeudesman-4*α*-ol (18.1), *β*-caryophylene (11.2), caryophyllene oxide (6.6), *α*-bisaboloxide B (4.8), *β*-pinene (3.2), dehydro-sesquicineol (3.2), limonene (3.1)	[225]
	Iran, Lali	ap	HD	11-acetoxyeudesman-4*α*-ol (28.8), *α*-bisabolol (25.1), *β*-caryophylene (8.2), *α*-bisaboloxide B (5.0), caryophyllene oxide (4.5), dehydro-sesquicineol (3.2)	[225]
	Iran, Kerman	ap	HD	spathulenol (15.1), *β*-pinene (11.0), *β*-myrcene (10.0), germacrene B (10.1), germacrene D (8.1), bicyclogermacrene (8.2), linalool (4.0)	[226–228]
	Iran, Tehran	ap	HD	*β*-caryophyllene (29.0), farnesene (13.0), *β*-pinene (11.0), germacrene D (6.5), *α*-pinene (5.5), limonene (4.2), *β*-bisabolene (3.7)	[229]
	Iran	ap	HD	*α*-pinene (16.2), spathulenol (10.6), carvacrol (8.0), *β*-pinene (7.1), *trans*-verbenol (6.3), caryophyllene oxide (5.7), *β*-eudesmol (5.7), limonene (5.2), *β*-caryophyllene (3.7), germacrene D (3.5)	[230]

continued

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▶ **Table 3** *Continued*

Taxa	Origin	Parts	Method	Main compounds	Ref.
	Iran, Hormozgan	fr	HD	α-pinene (18.2), elemol (14.5), β-pinene (10.1), cubenol (10.0), limonene (5.0), β-caryophyllene (4.2), myrcene (3.4)	[231]
	Iran, Fars	ap	HD	11-acetoxyeudesman-4-α-ol (26.3), α-bisabolol (24.6), β-caryophyllene (9.8), caryophyllene oxide (5.3), β-pinene (4.2), dehydro-sesquicineol (3.7)	[232]
	Iran, Rayen	ap	HD	1,2,3,6,7,7a-hexahydro-5H-inden 5-one (25.8), terpinyl acetate (19.6), 3-methyl-4-propyl-2,5-furandione (13.2), (*E*,*E*)-1,3,5-undecatriene (9.0), β-phellandrene (6.2), 4-nitrophenyl laurate (5.9), pulegone (4.3)	[233]
	Iran, Kerman	ap	HD	spathulenol (18.4), epizonaren (9.6), bicyclo heptenol (6.8), germacrene D (6.3), β-caryophyllene (6.2), *p*-mentha-1,5-dien-8-ol (3.8), 7-*epi*-α-selinene (3.3)	[91]
	Iran, Kerman	ap	HD	α-pinene (11.2), *cis*-verbenol (6.2), α-terpineol (5.2), verbenol (4.3), (1*S*)-verbenone (4.2), myrtenol (3.2)	[234]
	Iran, Ilam,	st	HD	α-muurolol (25.0), α-cadinol (15.7), β-caryophyllene (10.9), caryophyllene oxide (6.5), elemol (5.5), hexadecanoic acid (5.2), γ-cadinene (3.8)	[235]
	Iran, Ilam,	lv	HD	α-muurolol (20.0), β-caryophyllene (10.1), α-cadinol (8.1), (*Z*)-nerolidol (7.1), β-pinene (6.6), γ-cadinene (4.6), caryophyllene oxide (3.8), elemol (3.2), limonene (3.1), α-humulene (3.1), δ-cadinene (3.0)	[235]
	Iran, Ilam,	rt	HD	α-muurolol (19.5), α-cadinol (13.0), β-caryophyllene (10.6), hexadecanoic acid (16.4), eicosane (4.9), (*E*)-9-octadecanoic acid (4.2), elemol (3.5), caryophyllene oxide (3.2)	[235]
	Iran, Ardebil	ap	HD	lycopersene (26.0), dodecane (14.8), 1,5-dimethyl-decahydronaphthalene (9.3), tridecane (7.4), undecane (7.2), decane (3.8), heptadecane (3.4)	[236]
	Iran, Kerman	lv	HD	α-pinene (12.5), linalool (10.6), caryophyllene oxide (9.7), β-pinene (7.1), β-caryophyllene (7.0), bornyl acetate (5.3), α-camphene (5.7), camphor (5.2), carvacrol (5.2), germacrene D (5.0), γ-cadinene (3.7), 1,8-cineole (3.6), 3-octanol (3.3), 1-octen-3-ol (3.0)	[237]
	Iran, Fars	ap	HD	α-pinene (30.8), β-pinene (12.0), myrcene (8.9), limonene (7.9), β-caryophyllene (5.6), germacrene D (6.9), bicyclogermacrene (4.5), valerianol (3.4), 7-*epi*-α-eudesmol (3.2)	[238]
	Iran, Fars	ap	HS	α-pinene (38.8), β-pinene (15.5), myrcene (21.0), limonene (13.1), *trans*-β-ocimene (3.4)	[238]
	Iran, Fars	ap	HD	α-pinene (25.8 %), myrcene (12.5), germacrene-D (11.8), β-pinene (11.8), limonene (8.5), bicyclogermacrene (7.2), spathulenol (4.6)	[239]
	Iran, Mashhad	ap	HD	(*E*)-piperitenone oxide (21.7), α-pinene (11.3), carvone (11.3), spathulenol (6.2), β-pinene (5.8), limonene (5.0), myrcene (4.3), β-eudesmol (4.3), caryophyllene oxide (3.4)	[240]
	Jordan, Al-Salt	ap	HD	8-cedren-13-ol (24.8), β-caryophhllene (8.7), germacrene D (6.8), sabinene (5.2), α-humulene (4.3), *allo*-aromadendrene (4.5), δ-cadinene (3.5)	[241]
	Jordan, Tlail	ap	Hex	bisoflex DNP (36.5), diethylphthalate (24.1), hexanedioic acid (10.3), nonacosane (5.6), *n*-hexatriocontane (3.6), cyclohexane (3.3), isooctane (3.2), spathulenol (3.0)	[242]
	Jordan, Batheyeh	ap	Hex	*n*-hexatriocontane (19.1), hexanedioic acid (12.3), nonacosane (10.7), diethylphthalate (7.3), bisoflex 91 (6.8), spathulenol (6.0), germacrene D (4.1), pentadecane (3.3), caryophyllene oxide (3.2)	[242]
	Jordan, Jdaideh	ap	Hex	phenol-2-methoxy-3-(2propenyl) (13.6–12.0), bisoflex DNP (12.8–6.4), hexanedioic acid (9.7–0), phthalic acid dinonylester (9.3–0), *n*-hexatriocontane (9.0–7.7), 2-hexanal (8.4–6.6), thyme-camphor (8.4–4.7), bisoflex 91 (7.7–6.4), heptane 3,4,5-trimethyl (4.8–0), pentadecane (4.6–2.6), 2-methylpent-2-en-4-one (4.2–1.9), carvacrol (3.5–2.8), 3,8-dimethylundecane (3.4–3.1), 6,6-dimethyl-5,6-dihydropyran (3.4–2.9), α-bisabolol (3.1–3.0)	[242]

continued

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▶ **Table 3** *Continued*

Taxa	Origin	Parts	Method	Main compounds	Ref.
	Jordan, Gawa'a	ap	Hex	spathulenol (21.9), isooctane (19.2), pentane 2.2.4-trimethyl (8.5), α–bisobaloloxide (5.5), 2-hexanal (4.9), heptane (4.4), δ-cadinene (3.6), nonacosane (3.3), phthalic acid dinonylester (3.2)	[242]
	Jordan, Ain Janna	fl	HD	gauilyl acetate (9.5), α-cadinol (9.4), τ-cadinol (9.2), guaiol (8.7), spathulenol (8.6), elemol (8.2), camphene (6.4), endobornyl acetate (5.9), α-terpineol (5.1), terpineol (5.0), verbenol (4.7), linalool (4.2)	[243]
	Montenegro	ap	HD	carvacrol (67.8), sabinen (10.7), α-pinene (3.6)	[244]
	Morocco, Midelt	ap	HD	3-carene (16.5), γ-muurolene (14.0), α-pinene (9.9), caryophyllene (7.5), α-phellandrene (6.9), muurolol (6.5), α-gurjunene (6.5), α-himachalene (5.6), τ-cadinol (5.1), germacrene D-4-ol (3.9), *allo*-aromadendrene (3.2)	[245]
	Oman	ap	SFME	ledeneoxide (II) (20.5), linalyl acetate (11.2), β-eudesmol (11.6), α-*trans*-bergamatene (6.8)	[246]
	Russia, Orgievsky	ap	HD	*trans*-cadina-1,4-diene (13.3), *trans*-β-farnesene (8.2), τ-cadinol (6.6), γ-chymachalene (6.6), germacrene D (6.2), β-curcumene (6.0), *cis*-β-farnesene (6.0), (1*E*,4*Z*)-germacrene B (5.1), cadalene (3.7), γ-elemene (3.6)	[247]
	Saudi Arabia, Sudair	ap	HD	cedrol > guaiol > δ-cadinene > limonene > cedrenol > γ-cadinene > linalool > α-phellandrene > terpinen-4-ol, > β-pinene*	[248]
	Saudi Arabia, Gabal Al-aquiq	ap	HD	(*E*)-3-caren-2-ol (12.1), δ-cadinene (8.4), spathulenol (7.0), τ-muurolene (5.9), terpinen-4-ol (5.8), (*E*)-pinocarveol (5.4), β-linalool (5.3), *p*-cymen-3-ol (4.3), τ-gurjunene (3.5), verbenone (3.0)	[249]
	Saudi Arabia, Tabuk	ap	HD	caryophyllene oxide (17.8), farnesol (14.3), spathulenol (11.9), *ar*-curcumene (7.2), ledene oxide (7.1), caryophyllene (5.2)	[250]
	Saudi Arabia, North	ap	HD	γ-muurolene (8.7), α-cadinol (5.9), δ-cadinene (5.1), β-pinene (4.6), β-gurjurene (4.43), α-limonene (4.3), α-pinene (3.8), α-thujene (3.7), spathulenol (3.4)	[251]
	Saudi Arabia, Riyadh	ap	HD	α-cadinol (49.5), δ-cadinene (10.2), limonene (3.6)	[252]
	Serbia, Nis	ap	HD	germacrene D (31.0), bicyclogermacrene (6.7), spathulenol (5.0), oct-1-en-3-ol (4.3), γ-cadinene (4.3)	[208]
	Serbia-Mont, Cijevna	ap	HD	β-pinene (19.8), germacrene D (11.9), α-pinene (6.4), limonene (4.5), *trans*-α-bergamotene (3.0)	[169]
	Syria, Aleppo	ap	HD	α-pinene (27.5), β-pinene (12.4), myrtenal (8.5), terpinol (8.5), α-humulene (3.6)	[253]
	Tunisia	ap	Hex	myrcene (15.5), germacrene D (9.0), α-pinene (6.6), β-pinene (5.8), α-cadinol (5.1), β-caryophyllene (4.0)	[254]
	Tunisia, South West	ap	HD	α-pinene (17.0), β-pinene (12.7), limonene (6.6), β-myrcene (6.1), germacrene D (5.9)	[255]
	Tunisia, North	ap	HD	carvacrol (56.1), β-caryophyllene (7.7), α-pinene (5.0)	[256]
	Turkey, Gaziantep	ap	HD	β-pinene (18.0), β-caryophyllene (17.8), α-pinene (12.0), caryophyllene oxide (10.0), myrcene (6.8), germacrene D (5.3), limonene (3.5), spathulenol (3.3)	[257]
	Turkey, Ardahan	ap	HD	(*Z*)-β-farnesene (15.5), β-phellandrene (10.8), α-farnesene (10.7), germacrene D (9.7), β-gurjunene (7.5), ledene (6.3), limonene (5.9)	[258]
	Turkey, Elazığ	ap	HD	β-pinene (10.2), germacrene D (17.8), α-pinene (8.9), β-caryophyllene (8.2), myrcene (6.2), bicyclogermacrene (5.5), limonene (4.1)	[259]
T. polium ssp. *album*	Egypt, Sinai	ap	HD	patchouly alcohol (33.3), 10-cadinol (9.0), α-cadinol (5.9), δ-cadinene (4.0), β-eudesmol (3.3)	[260]
T. polium ssp. *aurasiacum*	Algeriạ Aures	ap	HD	α-cadinol (46.8), 3-β-hydroxy-α-muurolene (22.5), α-pinene (9.5), β-pinene (8.3)	[261, 262]
	Algeria, Aures	ap	HD	limonene (34.7), α-pinene (25.4), β-pinene (8.6), β-myrcene (5.2), α-elemol (4.2)	[263]
T. polium ssp. *aureum*	Morocco, Midelt	ap	HD	caryophyllene (19.1), γ-muurolene (13.0), τ-cadinol, (11.0), α-gurjunene (9.2), rosifoliol (8.8), 3-carene (7.0), *allo*-aromadendrene (5.1), α-pinene (3.5), myrtenol (3.0)	[245]

continued

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▸ **Table 3** *Continued*

Taxa	Origin	Parts	Method	Main compounds	Ref.
T. polium ssp. *capitatum*	Algeria, Boussaada	ap	HD	*τ*-cadinol (18.3), germacrene D (15.3), *β*-pinene (10.5), carvacrol (5.5), bicyclogermacrene (5.5), *α*-pinene (4.1), limonene (3.1)	[264]
	Bulgaria	ap	HD	*β*-pinene (26.8), germacrene D (17.7), *α*-pinene (9.3), limonene (6.4), *trans*-nerodilol (4.6), bicyclogermacrene (4.0), myrtenal (3.3), spathulenol (3.2)	[265]
	Corsica	ap	HD	*α*-pinene (24.1), *β*-pinene (9.2), *α*-thujene (8.1), terpinen-4-ol (6.2), limonene (5.2), sabinene (4.1), *p*-cymene (4.0)	[212]
	Corsica, Corti	ap	HD	*α*-pinene (28.8), *β*-pinene (7.2), *p*-cymene (7.0), *α*-thujene (5.0), terpinen-4-ol (4.6), *p*-cymene-4-ol (3.0), limonene (3.0)	[266]
	Corsica	ap	HD	*α*-pinene (24.1), *β*-pinene (9.2), *α*-thujene (8.1), terpinen-4-ol (6.6), limonene (5.2), sabinene (4.1), *p*-cymene (4.0)	[164]
	Crete, Greece	ap	HD	caryophyllene (9.8), carvacrol (10.1), torreyol (7.6), *α*-cadinol (4.5), *cis*-verbenone (3.7) germacrene D (3.1), *α*-humulene (3.8), *δ*-cadinene (3.1), *α*-amorphene (3.0)	[177]
	Greece	ap	HD	*α*-pinene (14.8), *β*-pinene (12.8), *β*-caryophyllene (11.3), *epi*-*α*-cadinol (7.7), myrcene (5.5), germacrene D (4.8), sabinene (4.7), *α*-humulene (3.3), *α*-cadinol (3.2), limonene (3.1)	[267]
	Kos, Greece	lv+fl	HD	germacrene D (53.7), (*E*)-*β*-farnesene (10.0), bicyclogermacrene (9.1), spathulenol (3.2), limonene (3.1)	[268]
	Crete, Greece	ap	HD	caryophyllene (10.1), carvacrol (9.6), torreyol (6.5), caryophyllene oxide (5.0), *α*-cadinol (4.0), *cis*-verbenone (4.0) germacrene D (3.9), *α*-humulene (3.4), *δ*-cadinene (3.1), germacrene D 4-ol (3.0)	[190]
	Iran	ap	HD	*α*-cadinol (46.2), caryophyllene oxide (25.9), *epi*-*α*-muurolol (8.1), cadalene (3.7)	[269]
	Morocco	ap	HD	*endo*-borneol (33.0), naphthalene,1,2,3,5,6,8a-hexahydro-4,7-dimethyl-1-(1-methyl ethyl)-,(1s-*cis*)- (19.6), bronyle acetate (15.6), *α*-terpineol (12.0), bicyclo[3.1.0]hexan-3-ol,4-methyl-1-(1-methylethyl)-(10.9)	[270]
	Portugal	ap	HD	*τ*-cadinol (24.1–1.6), sabinene (11.2–1.1), *β*-pinene (10.3–1.3), *δ*-cadinene (9.8–3.0), *α*-cadinol (9.8–1.6), *α*-pinene (7.7–0.6), *γ*-cadinene (5.5–0), *β*-caryophyllene (5.4–3.3), germacrene D (3.6–0), myrcene (3.5–08), (*Z*)-verbenol (3.5–0), terpine-4-ol (3.5–1.4), limonene (3.1–0.6), carvacrol (3.0–0), *β*-cubebene (3.0–1.1)	[271]
	Serbia	ap	HD	germacrene D (31.8), linalool (14.0), *β*-pinene (10.7), *β*-caryophyllene (8.8), bicyclogermacrene (6.2), *α*-pinene (3.5)	[265]
T. polium ssp. *gabesianum*	Tunisia	ap	HD	*β*-pinene (36.0), *α*-pinene (13.3), *α*-thujene (8.5), *p*-cymene (5.2), verbenone (5.0), myrcene (4.7)	[272]
T. polium ssp. *geyrii*	Algeria	ap	HD	limonene (11.2), *δ*-cadinene (10.0), *β*-caryophyllene (9.1), caryophyllene oxyde (4.7), *τ*-cadinol (4.3), *cis*-*α*-bisabolene (3.4), *α*-humulene (3.2), germacrene B (3.1)	[273]
T. polium ssp. *pilosum*	Qatar	ap	HD	*β*-eudesmol (19.1), *γ*-cadinene (18.4), spathulenol (11.6), *δ*-cadinene (8.3), *α*-cadinol (5.1), germacrene D (4.4)	[260]
T. polium ssp. *valentinum*	Spain	ap	HD	*α*-pinene (15.8), *β*-pinene (11.7), sabinene (7.2), *trans*-pinocarveol (4.3), terpinen-4-ol (4.5), *p*-cymene (3.8), limonene (3.2)	[199]
T. puechiae	France	ap	HD	*β*-caryophyllene (16.7–16.0), germacrene-D (11.8–11.2), *α*-pinene (8.7–8.5), *γ*-elemene (6.0–5.5), *β*-pinene (5.0–4.9), *α*-humulene (4.6–4.0), *β*-myrcene (3.2–3.1), sabinene (3.2–3.1)	[274]

continued

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▸ Table 3 *Continued*

Taxa	Origin	Parts	Method	Main compounds	Ref.
T. ramosissimum	Tunisia, Gafsa	ap	HD	β-eudesmol (44.5), caryophyllene oxide (9.3), α-thujene (5.5), sabinene (4.7), τ-cadinol (3.9)	[131]
	Tunisia, Gafsa	ap	HD	β-eudesmol (22.1), *p*-cymene (13.0), α-cadinol (10.7), 1,6-germacradien-5-ol (10.0), α-thujene (7.3), sabinene (7.3), *allo*-aromadendrene (4.8), γ-cadinene (3.6), β-caryophyllene (3.2)	[275]
	Tunisia, Gafsa	ap	HD	δ-cadinene (23.8–15.3), δ-cadinol (18.7–8.4), β-eudesmol (17.5–7.8), α-thujene (6.3–0.7), tujol (5.7–0), γ-gurjunene (4.9–2.8), cubenol (4.7–0.4), 8-cedrene (4.9–2.1), *cis*-α-santalol (4.5–1.1), *o*-cymene (4.5–0), α-pinene (3.7–0.3), sabinene (3.5–0.4)	[276]
	Tunisia, Gafsa	ap	HD	δ-cadinol (18.7), δ-cadinene (18.6), β-eudesmol (12.13), γ-gurjunene (4.3), 8-cedrene (4.0)	[277]
	Tunisia, Gafsa	lv	HD	β-eudesmol (22.1), *p*-cymene (13.0), α-cadinol (10.7), 1,6-germacradien-5-ol (10.0), α-thujene (7.3), sabinene (7.3), *allo*-aromadendrene (4.8), γ-cadinene (3.6), β-caryophyllene (3.2)	[278]
T. sauvegi	Tunisia	lv	HD	β-eudesmol (28.8), τ-cadinol (17.5), α-thujene (8.7), γ-cadinene (5.6), sabinene (4.8), β-selinene (4.2)	[279]
T. stocksianum	UEA	ap	HD	α-cadinol (14.6), δ-cadinene (13.8), τ-cadinol (8.1), seychellene (6.4), β-caryophyllene (6.1), germacrene D-4-ol (3.0)	[280]
	South Iran	fr	HD	α-cadinol (37.6), α-pinene (9.7), caryophyllene oxide (4.9), β-selinene (3.9),δ-cadinene (3.8), β-pinene (3.5)	[281]
	Iran, Swat	ap BB	HD	caryophyllene oxide (37.1), *o*-cymene (18.6), germacrene B (5.6), caryophyllene (4.2), α-caryophyllene (3.2)	[282]
	Iran, Swat	ap FB	HD	*cis*-α-santalol (16.3), D-limonene (12.8), *o*-cymene (12.4), (*Z*)-β-farnesene (8.5), α-phellandrene (7.3), bicyclo [3.1.0] hexane,4-methylene-1-(1-methyl) (5.3), caryophyllene (3.5), *p*-cymen-8-ol (3.1), α-caryophyllene (3.1)	[282]
	Iran, Swat	ap AFB	HD	1H-cycloprop[e]azulen-7-ol,decahydro-1,1,7-trimethyl-4-methylene (38.2), *cis*-α-santalol (26.4), *o*-cymene (11.0), germacrene B (4.5)	[282]
	Pakistan, Swat	ap	HD	α-cadinene (12.9), α-pinene (10.3), myrcene (8.6), β-caryophyllene (8.2), seychellene (6.7), germacrene D (6.2)	[283, 284]
	South Iran	ap	HD	α-pinene (23.0), β-pinene (13.0), *epi*-α-cadinol (9.1), sabinene (6.6), myrcene (6.3), α-cadinol (3.3), limonene (3.2)	[144]
T. stocksianum ssp. *gabrielae*	South Iran	fl	HD	camphene (20.6), α-cadinol (19.7), myrcene (10.2), carvacrol (9.9), (*Z*)-γ-bisabolene (5.0), linalool (3.3), camphor (3.0)	[285]
	South Iran	ap	HD	α-pinene (22.0), *cis*-sesquisabinene hydrate (12.0 %), *epi*-β-bisabolol (6.6 %), β-pinene (6.5), guaiol (5.4 %), δ-cadinene (4.9), β-eudesmol (4.4 %), α-copaene (3.3)	[144]
	South Iran	ap	HD	α-pinene (36.6), β-pinene, (14.1), β-cubebene (5.0)	[286]
	Oman	lv	HD	α-cadinol (7.6), β-selinene (6.4), *trans*-verbenol (5.9), caryophyllene oxide (5.7 %), δ-cadinene (5.1 %), α-phellandren-8-ol (5.0), verbenone (5.0), τ-murrolol (3.4), β-caryophyllene (3.3)	[142]
T. turredanum	Spain	ap	HD	β-caryophyllene (32.6–15–6), α-humulene (10.1–4.7), β-bisabolol (8.3–6.4), *cis*-γ-bisabolene (6.9–4.6), caryophyllene oxide (4.5–3.1), β-bisabolene (3.3–2.0)	[202]
T. yemense	Yemen, Dhamar	lv	HD	7-epi-α-selinene (20.1), caryophyllene oxide (20.1), β-caryophyllene (11.2), γ-selinene (5.5), α-humulene (4.0), valancene (3.7), ledol (3.6), *cis*-sesquisabinene hydrate (3.4)	[287]
	Yemen, Taiz	lv	HD	β-caryophyllene (19.1), α-cadinol (9.5), δ-cadinene (6.5), α-humulene (6.4), τ-cadinol (5.7), τ-muurolol (4.9), shyobunol (4.6), caryophyllene oxide (4.3), germacrene D-4-ol (3.1)	[287]
	Yemen, Taiz	lv	HD	δ-cadinene (34.9), β-caryophyllene (22.7), α-humulene (6.1), α-selinene (5.4)	[156]
T. zanoni	Libya	fl	HD	β-pinene (14.1), linalool (11.0), linalyl acetate (11.1), germacrene D (8.8), γ-elemene (7.8), α-terpimol (5.6), D-limonene (3.5)	[288]

continued

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▶ Table 3 *Continued*

Taxa	Origin	Parts	Method	Main compounds	Ref.
Section ***Pycnobotrys***					
T. quadrifarium	India, Garampani	ap	HD	β-caryophyllene (38.3), germacrene D (9.4), α-humulene (5.9), α-pinene (5.7), α-salinene (5.4), sesquisabinene (4.8)	[289]
	India, Kumaun	ap	HD	β-caryophyllene (25.0), α-cubebene (20.1), copane 4-α-ol (10.0), aromadendrane (6.3), pinocamphene (3.3), α-pinene (2.3), *trans*-bergamotene (2.3), α-humulene (4.2), germacrene-D (3.7)	[290]
	China	ap	HD	germacrene D (8.8), linalool (8.2), camphene (7.8), β-caryophyllene (7.3), β-cadinene (6.8), 1,8-cineole (6.5), 4-terpineol (5.8), α-terpineol (5.1), *trans*-geraniol (3.2)	[130]
Section ***Scordium***					
T. melissoides	Iran	ap	HD	α-pinene (27.7), β-pinene (16.4), limonene (12.4), germacrene D (10.2), β-caryophyllene (8.9), (*Z*)-γ-bisabolene (7.5), α-humulene (4.5)	[291]
T. scordium	Serbia-Monten	ap	HD	α-pinene (17.7) β-pinene (10.0), cadinol (6.7), δ-cadinene (6.3), β-caryophyllene (5.5), α-copaene (5.2), α-cadinol (4.3), γ-cadinene (3.7)	[169]
	Iran, Mazandaran	ap	HD	β-caryophyllene (22.8), (*E*)-β-farnesene (10.4), caryophyllene oxide (8.6), 1,8-cineole (6.1), β-eudesmol (5.1), α-pinene (3.3), β-pinene (3.2)	[292]
	Iran, Kerman	ap	HD	pulegone (39.1), β-caryophyllene (20.1), β-farnesene (5.7), menthofuran (4.2), 1,8 cineole (4.1), α-humulene (3.1)	[293]
T. scordium ssp. *scordiodes*	Serbia	ap	HD	menthofuran (11.9), (*Z*)-octadec-9-enoic acid (11.5), (*Z,Z*)-octadeca-9,12-dienoic acid (7.9), hexadecanoic acid (6.3), β-caryophyllene (3.5), (*E*)-phytol (3.5)	[208]
	Italy, Sicily	ap	HD	carophyllene oxide (25.8), α-pinene (19.4), β-pinene (8.5), 4-(1,5-dimethylhex-4-enyl)cyclohex-2-enone (6.4), β-sesquiphellandrene (5.9), (*E*)-β-caryophyllene (4.4), β-bisabolene (3.8), sesquisabinene (3.4)	[294]
Section ***Scorodonia***					
T. asiaticum	Balearic Is.	ap	HD	calamenene (23.1), linalool (15.4), α-muurolene (9.9), α-calocorene (8.6), linalyl acetate (6.2), germacrene D (5.2), α-humulene + *allo*-aromadendrene (3.8), α-terpineol (3.2)	[295]
T. canadensis	Canada	lv	HD	germacrene D (32.7), caryophyllene (13.6), δ-cadinene (13.0), α-humulene (10.2), linalool (6.0)	[296]
T. kotschyanum	Cyprus, Spilia	lv	HD	β-cubebene (26.8), β-burbonene (23.0), β-caryophyllene (22.4), α-humulene (7.6), caryophyllene oxide (4.5), γ-terpinene (3.1)	[58]
	Cyprus, Spilia	fl	HD	β-caryophyllene (35.1), β-cubebene (25.1), α-humulene (12.2)	[58]
	Cyprus, Spilia	st	HD	β-burbonene (20.9), β-caryophyllene (20.6), β-cubebene (10.6), α-humulene (6.7), *allo*-aromadendrene (5.8), caryophyllene oxide (4.7), anethole (3.7), α-caryophyllene (3.2)	[58]
	Cyprus, Stavros	lv	HD	β-caryophyllene (19.3–18.9), β-cubebene (11.8–11.4), β-burbonene (11.4–7.1), caryophyllene oxide (7.7–0.3), α-humulene (7.2–6.1), *trans*-pinocarveol (3.9–2.7), δ-cadinene (3.4–3.2)	[58]
	Cyprus, Stavros	st	HD	β-caryophyllene (18.8–13.6), caryophyllene oxide (11.7–7.9), β-cubebene (10.2–4.2), β-burbonene (9.4–5.8), α-humulene (7.3–4.4), *trans*-pinocarveol (3.8–2.6), δ-cadinene (3.1–1.2)	[58]
	Cyprus, Cedar Valley	fr	HD	β-caryophyllene (31.6), β-cubebene (15.1), α-humulene (11.0), β-burbonene (4.5), caryophyllene oxide (4.2), δ-cadinene (3.4)	[58]
	Cyprus, Cedar Valley	st	HD	β-caryophyllene (22.8), β-cubebene (12.7), α-humulene (8.5), β-burbonene (6.7), caryophyllene oxide (5.9), δ-cadinene (3.3), *trans*-pinocarveol (3.1)	[58]

continued

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▶ **Table 3** *Continued*

Taxa	Origin	Parts	Method	Main compounds	Ref.
T. massiliense	Corsica	ap	HD	6-methyl-3-heptyl acetate (20.3), germacrene D (7.6), 3-octanyl-acetate (7.1), pulegone (6.7), isobutyl isovalerate (5.9), linalool (4.8), citronellol (3.6), 3-methyl butyl isovalerate (3.3), (*Z*)-*β*-ocimene (3.1)	[297]
	Corsica	ap	HD	6-methyl-3-heptyl acetate (19.1), 3-octanyl-acetate (7.0), pulegone (6.9), germacrene D (6.1), isobutyl isovalerate (5.8), linalool (5.2), citronellol (4.1), 3-methyl butyl isovalerate (3.4)	[164]
	Sardinia, Mt. Albo	ap	HD	3,7-dimethyloctan-2-one (15.2), butyl 2-methylbutyrate (12.1), linalool (10.6), linalyl acetate (7.1), zingiberene (4.7), *γ*-cadinene (4.1), (*E*,*E*)-*α*-farnesene (3.8), *δ*-3-carene (3.3), *β*-bisabolene (3.1)	[298]
	Sardinia, Cagliari	ap	HD	6-methyl-3-heptyl acetate (19.5), 3-octanyl-acetate (7.1), linalool (5.8), *β*-bisabolene (5.4), isobutyl isovalerate (3.0)	[297]
T. pseudoscorodonia ssp. *baeticum*	Morocco	lv	HD	*N*-formylmorpholine (25.1), 4-acetyl-morpholine, (17.6), 2-oxabicyclo[2, 2, 2]octan-6-one, 1,3,3-trimethyl- (6.5), heptylcyclohexane (6.0), 3-methyl-2-butenoic acid, 2-ethylcyclohexyl ester (3.7)	[299]
T. royleanum	Pakistan	ap	HD	*β*-santalene (20.7), *cis*-*α*-bisabolene (11.8), *o*-cymene (8.7), *α*-bisabolol (6.0), terpineol-4 (3.9), germacrene D (4.3), *β*-caryophyllene (3.2), *β*-eudesmol (3.0)	[300]
	India	ap	HD	*β*-caryophyllene (23.6), germacrene D (28.9), *α*-humulene (5.7), 9-*epi*-*β*-caryophyllene (5.6), 1-octen-3-ol (8.5), linalool (4.8)	[289]
T. salviastrum	Portugal	ap	HP	aristolene + *β*-caryophyllene (21.6), *α*-humulene + *allo*-aromadendrene (19.0), germacrene D (7.7), caryophyllene oxide + spathulenol (18.6), humulene epoxyde (3.0)	[295]
	Portugal	ap, lv, fl	HD	(*E*)-*β*-farnesene (29.3–26.1), *β*-caryophyllene (26.6–19.1), germacrene D (21.6–13.7), (*Z*)-*β*-ocimene (4.6–2.1), *α*-humulene (4.1–3.1), caryophyllene oxide (3.6–1.4)	[301]
T. scorodonia	Italy, Elba	lv	HD	*α*-cubebene (18.3), *β*-elemene (10.7), *cis*-caryophyllene (10.6), *α*-bergamotene (6.8), *β*-selinene (6.7), *β*-cubebene (5.2), eremophilene (3.2)	[302]
	Italy, Elba	br, ca, co	HD	*β*-elemene (21.4–0), sabinene (18.1–6.1), *α*-terpinolene (17.9–0), hex-3-enyl acetate (14.4–0), (*Z*)-hex-3-en-l-o1 (14.1–0), oct-1-en-3-ol (12.9–0), *α*-cubebene (12.4–0), hexenal (10.7–4.8), *cis*-caryophyllene (10.5–0.9), *α*-pinene (10.1–0), oct-7-en-1-ol (8.9–0), *α*-copaene (6.8–0), eremophilene (6.5–0), limonene (6.4–0), *α*-bergamotene (5.5–0), *β*-selinene (3.9–0), *β*-cubebene (3.5–0)	[302]
	Italy, Prealps	lv	HD	*β*-cubebene (7.8), *α*-terpinolene (7.7), *γ*-elemene (6.8), *cis*-caryophyllene (5.2), phenylacetaldehyde (4.9), *α*-bergamotene (4.8), *α*-cubebene (4.6), *β*-selinene (4.1), *β*-pinene (4.1), *α*-humulene (3.9), eremophilene (3.2)	[302]
	Italy, Prealps	br, ca, co	HD	phenylacetaldehyde (41.5–0), *α*-pinene (18.8–0), eremophilene (15.3–0), *β*-cubebene (15.2–1.5), sabinene (11.8–0), *γ*-elemene (10.4–0), *α*-bergamotene (10.0–0), *β*-pinene (9.6–0), oct-1-en-3-ol (8.9–0), linalool (8.5–0), *cis*-caryophyllene (6.9–0), 3-methylenecycloheptene (4.5–0), *β*-selinene (3.9–0), α-gurjunene (3.3–0)	[302]
T. scorodonia ssp. *baeticum*	Algeria	ap	HD	*β*-caryophyllene (35.4), germacrene D (22.1), *α*-humulene (9.3), caryophyllene oxide (4.3), bicyclogermacrene (3.8), linalool (3.5), spathulenol (3.2)	[303]
	Spain	ap	HD	aristolene + *β*-caryophyllene (39.7–35.1), aromadendrene (14.0–10.6), germacrene D (11.3–4.9), caryophyllene oxide + spathulenol (9.1–4.9), *α*-cubebene (6.0–4.5), humulene epoxyde (3.9–2.2)	[295]

continued

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▸ **Table 3** *Continued*

Taxa	Origin	Parts	Method	Main compounds	Ref.
T. scorodonia ssp. *scorodonia*	Corsica	ap	HD	(*E*)-α-caryophyllene (21.1), germacrene B (8.3), α-humulene (6.9), germacrene D (6.7), α-cubebene (6.2), δ-elemene (3.9), zingiberene (3.6), α-gurjunene (3.5), β-bisabolene (3.3)	[164]
	Corsica	ap	HD	β-caryophyllene (21.1), germacrene B (8.3), α-humulene (6.9), germacrene D (6.7), α-cubebene (6.2), γ-elemene (3.9), α-gurjunene (3.5), β-bisabolene (3.3)	[303]
	Italy	ap	HD	germacrene B (26.2), β-caryophyllene (25.2), α-cubebene (8.0), α-humulene (8.0), β-cubebene (6.5), germacrene D (6.3), α-gurjuene (6.0), α-copaene (4.3), α-cuprenene (3.2), δ-cadinene (3.0)	[304]
	Poland, cultived	ap	HD	β-caryophyllene (22.3), caryophyllene oxide (15.4), α-humulene (8.4), α-cubebene (5.3), oct-1-en-3-ol (4.4), humulene epoxide 2 (4.4), germacrene D (3.0)	[305]
	Spain	ap	HD	aristolene + β-caryophyllene (21.0–12.3), germacrene D (13.4–6.4), caryophyllene oxide + spathulenol (13.0–4.2), α-copaene (9.3–4.8), α-cubebene (8.5–4.7), aromadendrene (6.5–0.9), β-pinene (6.0–0.4), β-bourbonene (5.7–4.5), humulene epoxyde (5.4–2.6), δ-cadinene (3.6–2.2), longipinene (3.3-t), calamenene (3.2–2.6)	[295]
T. siculum	Italy, Euganei	lv	HD	α-pinene (28.6), α-bergamotene (13.7), phenylacetaldehyde (9.8), limonene (7.3), benzaldehyde (5.7), ethyl *trans*-cinnamate (3.9)	[302]
	Italy, Euganei	br, ca, co	HD	ethyl *trans*-cinnamate (51.7–0), α-pinene (28.7–0), phenylacetaldehyde (17.9–0), ethyl *cis*-cinnamate (14.5–0), benzaldehyde (13.7–0), 1-phenylethanol (8.1), hex-3-enyl acetate (7.6–0), α-bergamotene (6.9–0), limonene (6.3–0), eptanal (3.9–0), α-gurjunene (3.5–0)	[302]
	Italy, Tuscany	lv	HD	β-caryophyllene (32.9), β-selinene (7.3), β-farnesene (5.6), eugenol (3.5), sesquiphellandrene (3.1)	[302]
	Italy, Tuscany	br, ca, co	HD	linalool (75.7–0), isopropyl-3-methylbutyrate (24.2–0), carvone (9.5–0)	[302]
	Italy, Sicily	lv	HD	β-caryophyllene (25.6), isoeugenol (23.8), δ-cadinene (18.6), oct-1-en-3-ol (5.5), linalool (3.6)	[302]
	Italy, Sicily	br, ca, co	HD	isoeugenol (43.6–28.1), ethyl *trans*-cinnamate (39.1–15.5), β-farnesene (24.2–0), ethyl *cis*-cinnamate (21.4–11.2), linalool (11.3–0)	[302]
	Italy, Sicily	ap	HD	(*E*)-β-caryophyllene (30.9), 1-octen-3-ol (9.0), α-humulene (8.6), germacrene D (8.0), linalool (7.6), (2*E*)-hexanal (3.6), caryophyllene oxide (3.6)	[294]
Section *Spinularia*					
T. botrys	Serbia-Montenegro	ap	HD	β-caryophyllene (20.4), (*E*)-β-farnesene (17.7), α-humulene (13.9), α-pinene (8.1), β-pinene (7.9), limonene (5.5), caryophyllene oxide (4.4)	[169]
T. maghrebinum	Algeria	ap	HD	δ-cadinene (12.7), germacrene D (11.4), γ-cadinene (9.5), 4-vinylguaiacol, (4.0), β-caryophyllene (3.7), limonene (3.7), α-cadinol (3.3)	[68]
	cultived, Milan, Italy	ap	HD	germacrene D (14.3), δ-cadinene (13.5), γ-cadinene (7.5), caryophyllene (4.9), limonene (4.4), caryophyllene oxide (4.0)	[190]

continued

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▸ **Table 3** *Continued*

Taxa	Origin	Parts	Method	Main compounds	Ref.
Section ***Stachybotrys***					
T. arduini	Croatia, Poljicka	old apic p	HD	germacrene D (23.6), β-caryophyllene (17.3), δ-cadinene (9.7), cyperene (8.2)	[306]
	Croatia, Poljicka	young lv	HD	germacrene D (57.8), β-caryophyllene (13.5), germacene B (10.0)	[306]
	Croatia, Mt. Biokovo	ap	HD	β-caryophyllene (19.9), caryophyllene oxide (14.6), (*E*)-β-farnesene (5.6), δ-cadinene (5.3), spathulenol (5.0), aromadendrene (4.9), α-humulene (4.8), viridifloene (4.3)	[307]
	Croatia, Mt. Biokovo	ap	HD	β-cryophyllene (32.9), germacrene D (16.4), borneol (5.4), δ-elemene (3.6), β-thujone (3.5), camphor (3.2), β-bourbonene (3.1)	[308]
	Croatia, Mt. Biokovo	ap	HD	β-cryophyllene (35.2), germacrene D (18.7), borneol (4.9), camphor (4.4), δ-cadinene (4.2)	[309]
	Serbia-Mont, Njegusi	ap	HD	β-caryophyllene (24.5), germacrene D (21.9), α-humulene (5.3), caryophyllene oxide (5.1), bicyclogermacrene (4.3), 3-octanol (3.6)	[169]
	Montenegro, Kotor	ap	HD	germacrene D (17.0), β-caryophyllene (15.0), linalool (7.0), β-burbonene (5.6), α-terpinolene (5.2), 1-octen-3-ol (4.7), α-amorphene (4.7), α-cadinol (4.6)	[310]
	Croatia, Ucka	ap	HD	pulegone (26.3), β-caryophyllene (22.1), germacrene D (11.9), piperitone oxide (10.3), caryophyllene oxide (5.5)	[311]
	Croatia, Mt. Velebit, Susanj	ap	HD	β-caryophyllene (29.1), germacrene D (18.7), piperitone oxide (10.3), caryophyllene oxide (10.2), linalool (5.6), pulegone (3.5)	[311]
	Croatia, Mt. Velebit, Velaki	ap	HD	β-caryophyllene (35.4), caryophyllene oxide (17.1), germacrene D (9.6), linalool (5.6), pulegone (3.1)	[311]
	Croatia, Mt. Biokovo, Vosak	ap	HD	β-caryophyllene (33.7), caryophyllene oxide (14.6), germacrene D (12.2), pulegone (4.1)	[311]
	Croatia, Mt. Biokovo, Svjure	ap	HD	β-caryophyllene (28.8), caryophyllene oxide (14.2), germacrene D (12.5), linalool (3.4)	[311]
	Croatia, Mt. Sijeznca	ap	HD	β-caryophyllene (31.3), caryophyllene oxide (16.8), germacrene D (8.9), linalool (5.3), germacrone (4.6), spathulenol (4.5), α-humulene (3.2)	[311]
	Bosnia and Herzego-vina, Diva Grabov.	ap	HD	β-caryophyllene (30.1), germacrene D (28.9), caryophyllene oxide (6.1), α-humulene (3.5), spathulenol (3.3)	[311]
	Bosnia and Herzego-vina, Mt. Prenj	ap	HD	piperitone oxide (39.1), germacrene D (15.2), β-caryophyllene (8.2), linalool (6.6), caryophyllene oxide (4.4), spathulenol (4.1), limonene (3.9)	[311]
	Montenegro, Mt. Orjen	ap	HD	β-caryophyllene (29.2), germacrene D (17.3), caryophyllene oxide (8.9), pulegone (4.9), piperitone oxide (4.6), spathulenol (4.5), α-humulene (4.2), germacrone (3.9)	[311]
	Montenegro, Mt. Lovcen	ap	HD	β-caryophyllene (24.7), germacrene D (16.6), caryophyllene oxide (10.8), piperitone oxide (8.8), linalool (4.6)	[311]
	Montenegro, Trebjesa	ap	HD	β-caryophyllene (30.7), germacrene D (18.1), caryophyllene oxide (7.2), linalool (4.5), piperitone oxide (3.3), germacrone (3.2)	[311]
	cultived, Milan, Italy	ap	HD	caryophyllene (10.0), hexadecanoic acid (9.3), caryophyllene oxide (7.7), germacrene D (5.8), spathulenol (5.8), cedrenol (4.8), heptacosane (4.0), hexahydrofarnesylacetone (3.8), α-humulene (3.1)	[190]

continued

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▸ **Table 3** *Continued*

Taxa	Origin	Parts	Method	Main compounds	Ref.
T. hyrcanicum	Iran, Caspian	ap	HD	hexahydrofarnesyl acetone (12.7), linalool (11.7), (*E*)-β-farnesene (10.7), dihydroedulane (8.6), *ar*-curcumene (8.5), β-himachalene (4.2), *trans*-β-ionone (3.4)	[167, 312]
	Iran, Sari	ap	HD	(*E*)-α-bergamotene (65.5), linalool (20.9)	[313]
	Iran, Babol	ap	HD	(*E*)-α-bergamotene (57.5), α-terpineol (12.3), 6–10–14-trimethyl pentadecanone (4.1), linalool (3.4), phytol (3.1)	[313]
	Iran, Tonekabon	ap	HD	(*E*)-α-bergamotene (33.3), (*E*)-β-farnesene (16.4), camphene (6.0), 6–10-14-trimethyl pentadecanone (3.5), α-himachalene (3.3), β-bisabolene (3.2), linalool (3.1), *ar*-curcumene (3.1)	[313]
	Iran, Qaemshahr	ap	HD	(*E*)-α-bergamotene (86.9), 6–10-14-trimethyl pentadecanone (3.4)	[313]
	Iran, Amol	ap	HD	(*E*)-α-bergamotene (49.7), (*E*)-β-farnesene (7.6), phytol (4.9), linalool (4.5), 6–10-14-trimethyl pentadecanone (3.6)	[313]
	Iran, Shirgah	ap	HD	(*E*)-α-bergamotene (43.9), (*E*)-β-farnesene (6.4), phytol (5.6), 6–10-14-trimethyl pentadecanone (5.0), α-cadinol (4.1), 1,8-cineole (4.0), α-himachalene (3.7)	[313]
	Iran, Gorgan	ap	HD	(*E*)-α-bergamotene (54.5), (*E*)-β-farnesene (8.0), 6–10-14-trimethyl pentadecanone (6.9), phytol (5.8), α-cadinol (3.3), caryophyllene oxide (3.1)	[313]
	Iran, Ramsar	ap	HD	(*E*)-α-bergamotene (32.6), (*E*)-β-farnesene (11.0), *trans*-piperitone epoxide (6.4), 6–10-14-trimethyl pentadecanone 5.7), β-bisabolene (5.0), *cis*-piperitone epoxide (4.7), α-cadinol (4.1), caryophyllene oxide (3.8), linalool (3.1).	[313]
	Iran, Fooman	ap	HD	(*E*)-α-bergamotene (17.5), (*E*)-β-farnesene (21.4), α-cadinol (8.0), *ar*-curcumene (4.1), carvacrol (6.4), 6-10-14-trimethyl pentadecanone (6.6), caryophyllene oxide (6.4)	[313]
	Iran, Behshahr	ap	HD	(*E*)-α-bergamotene (21.4), 6–10-14-trimethyl pentadecanone (14.2), (*E*)-β-farnesene (7.8), α-cadinol (3.8), linalool (3.2)	[313]
	Iran, Savadkook	ap	HD	(*Z*)-β-farnesene (21.4), aromadendrene (4.3), β-caryophyllene (4.1), β-pinene (3.4), methyl hexadecanoate (3.4), (*E*)-β-ionone (3.2), *n*-hexadecanol (3.1)	[314]
T. lamiifolium ssp. *lamiifolium*	Turkey	ap	HD	β-caryophyllene (44.8–23.5), *trans*-β-bergamotene (26.4–0), germacrene D (22.2–5.6), (*Z*)-β-farnesene (14.0–3.0), caryophyllene oxide (8.1–2.7), hexadecanoic acid (5.8–0.7)	[315]
T. lamiifolium ssp. *stachyophyllum*	Turkey	ap	HD	*trans*-β-bergamotene (41.1–38.1), β-caryophyllene (8.9–8.7), α-humulene (6.4–6.1), germacrene D (7.4–6.6), hexadecanoic acid (4.6–2.8)	[315]
T. oxylepis ssp. *oxylepis*	Spain	ap	HD	α-cadinol (12.8), aristolene + β-caryophyllene (10.4), α-cubebene (8.5), *epi*-cubenol (7.7), δ-cadinene (7.2), α-copaene (4.8), calamarene (3.7), aromadendrene (3.6), sabinene (3.5), germacrene D (3.3)	[295]
T. oxylepis ssp. *marianum*	Spain	ap	HD	calamarene (13.1–7.9), linalool (12.9–7.1), τ-cadinol (9.2–5.7), α-cadinol (8.8–6.1), γ-cadinene (7.9–7.4), α-cubebene (6.1–0.2), germacrene D (5.9–5.2), α-copaene (4.8–3.3), aristolene + β-caryophyllene (4.3–3.5), *ar*-curcumene (3.1–0.8)	[295]
Section *Teucriopsis*					
T. abutiloides	Madeira	ap	HD	1-octen-3-ol (20.1), germacrene D (13.4), δ-cadinene (11.4), *allo*-aromadendrene (9.1), β-bisabolene (4.2), α-cadinol (3.8), γ-muurolene (3.0)	[316]
T. betonicum	Madeira	ap	HD	1-octen-3-ol (24.2), β-caryophyllene (12.1), bicycloelemene (6.8), linalool (6.2), zingiberene (5.2), caryophyllene oxide (5.0), phenylacetaldehyde (3.3), α-humulene (3.3), *n*-nonanal (3.0)	[316]

continued

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▸ **Table 3** *Continued*

Taxa	Origin	Parts	Method	Main compounds	Ref.
T. hetrophyllum	Madeira	ap-fl stage	HD	τ-cadinol (20.7), α-pinene (16.2), α-cadinol (11.0), β-pinene (8.7), 1-octen-3-ol (3.5)	[317]
	Madeira	ap-vg stage	HD	τ-cadinol (17.0), α-pinene (16.4), α-cadinol (9.0), 1-octen-3-ol (8.0), β-pinene (4.2)	[317]
	Canary Is	ap	HD	(*E*)-α-bisabolene (20.8), β-caryophyllene (15.1), α-pinene (8.5), caphene (5.2), β-pinene (4.3), linalool (3.0), α-humulene (3.4), β-bisabolene (3.3), caryophyllene oxide (3.4)	[318]
Section ***Teucrium***					
T. africanum	S. Africa	ap	HD	α-cubebene (23.9), β-cubebene (20.5), calamarene (4.0), pathoulene (3.7), α-copaene (3.2), bicyclosesqui-phellendrene (3.2), δ-cadinene (3.0)	[24]
T. alyssipholium	Turkey	ap	HD	*trans*-β-caryophillene (16.9), *ar*-curcumene (11.4), bisabolene (11.1), caryophyllene oxide (5.1), limonene (3.5)	[319]
T. brevifolium	Greece, Karpathos	ap	HD	spathulenol (9.0), δ-cadinene (4.2), caryophyllene oxide (3.8), *trans*-pinocarveol (3.8), β-pinene (3.6), viridiflorol (3.4), β-eudesmol (3.4), cadalene (3.4)	[177]
T. creticum	Cyprus, Kato Lefkara	fl + lv + fr	HD	β-caryophyllene (22.0), caryophyllene oxide (15.7), spathulenol (14.2), linalool (10.6), germacrene D (5.4), α-humulene (4.3), bicyclogermacrene (3.8), α-bisabolol oxide (3.4)	[320]
	Cyprus, Kato Lefkara	fl + lv	HD	linalool (23.1), β-caryophyllene (13.3), caryophyllene oxide (11.3), spatulenol (7.1), germacrene D (6.5), α-bisabolol oxide (6.2), bicyclogermacrene (5.9), β-bourbonene (3.8), geraniol (3.3), germacrene B (3.1), α-humulene (3.0)	[320]
	Cyprus, Kato Lefkara	st	HD	α-bisabolol oxide (16.7), β-bourbonene (9.9), linalol (8.1), calamenene (3.6), caryophyllene oxide (3.5)	[320]
	Cyprus, Katopyrgos	fl	HD	β-caryophyllene (21.5), caryophyllene oxide (13.8), germacrene D (10.8), spathulenol (8.6), α-humulene (5.7), geraniol (5.5), bicyclogermacrene (5.0)	[320]
T. fruticans	Italy, Tuscany	ap fl	HD	β-pinene (21.2), germacrene D (17.7), myrcene (12.8), β-caryophyllene (12.2), β-phellandrene (4.3), β-selinene (4.1), α-pinene (3.6), limonene (3.5), α-humulene (3.0)	[321]
	Italy, Tuscany	ap fr	HD	germacrene D (24.4), β-caryophyllene (21.8), β-pinene (7.1), β-selinene (6.9), myrcene (5.7), α-humulene (5.5)	[321]
	Italy, Sicily	ap	HD	germacrene D (29.4), 1-octen-3-ol (19.7), (*E*)-β-caryophyllene (19.6), *trans*-calamenene (7.3), linalool (6.0), α-humulene (5.6), *trans*-cadina-1,4-diene (4.0)	[294]
	Malta	ap	HD	germacrene D (50.0), (*E*)-β-caryophyllene (21.9), 1-octen-3-ol (7.4), α-humulene (3.3), linalool (3.2), *trans*-cadina-1,4-diene (3.0), β-pinene (3.0)	[294]
T. multicaule	Turkey, Erzincan	ap	HD	germacrene D (13.2), caryophyllene oxide (10.9), spathulenol (6.6), β-caryophyllene (5.6), (6*Z*,10*Z*)-pseudo phytol (4.1), myrtenol (3.8), α-cadinol (3.6), δ-cadinene (3.2), hexadecanoic acid (3.2)	[322]
	Turkey, Elazığ	ap	HD	caryophyllene oxide (31.1), thymol (13.2), terpineol (10.6), spathulenol (7.6), azulene (3.3)	[259]
T. orientale ssp. *glabrescens*	Iran	fl-ap	HD	β-cubebene (34.5), α-cubebene (16.6), α-copaene (10.1), β-caryophyllene (10.0), caryophyllene oxide (4.7), *n*-eicosane (4.7), α-amorphene (3.8)	[323]
	Turkey, Maras	ap	HD	α-pinene (18.2), elemol (14.5), β-pinene (10.1), cubenol (10.0) limonene (5.0), β-caryophyllene (4.2), myrcene (3.4)	[324]
	Turkey, Kusakkaya	ap	SPME	nonanal (25.0), thuja-2,4(10)-diene (22.9), tetracosane (15.2), pentacosane (7.2), eicosane (6.8), decanal (4.5), 2-amyl furan (3.9)	[325]

continued

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▸ **Table 3** *Continued*

Taxa	Origin	Parts	Method	Main compounds	Ref.
T. orientale ssp. *orientale*	Iran	ap	HD	caryophyllene oxide (33.5), linalool (17.0), β-caryophyllene (9.3), δ-cadinene (3.7), carvacrol (3.2), α-copaene (3.0)	[326]
	Turkey Erzurum	ap, bud st	HD	linalool (29.1), β-caryophyllene (23.6), 3-octanol (10.4), germacrene D (8.8), β-bourbonene (5.7), γ-gurjunene (3.6)	[327]
	Turkey Erzurum	ap fl st	HD	linalool (30.9), β-caryophyllene (13.8), 3-octanol (10.4), germacrene D (6.7), β-bourbonene (4.5)	[327]
	Turkey Erzurum	ap veg st	HD	β-bourbonene (19.2), 3-octanol (13.2), linalool (10.6), β-caryophyllene (9.5), α-cubebene (6.9), germacrene D (6.2), α-copaene (5.6), (*E*)-γ-bisabolene (5.2)	[327]
	Turkey, Erzurum	ap	HD	β-caryophyllene (15.3), germacrene D (14.2), caryophyllene oxide (14.0), spathulenol (6.4), bicyclogermacrene (3.6), hexadecanoic acid (3.1)	[328]
	Turkey, Karaman	ap	HD	germacrene D (246), β-caryophyllene (22.6), hexadecanoic acid (7.9), bicyclogermacrene (6.7), caryophyllene oxide (5.6)	[324]
T. orientale ssp. *puberulens*	Turkey, Tersun Mt.	ap	HD	β-caryophyllene (21.7), 2-methyl cumarone (20.0), germacrene D (10.6), α-humulene (4.8), δ-cadinene (4.1), bicyclogermacrene (3.4)	[172]
	Turkey, Erzurum	ap	HD	β-caryophyllene (15.3), germacrene D (14.2), caryophyllene oxide (14.0), spathulenol (6.4), bicyclogermacrene (3.6), hexadecanoic acid (3.1)	[328]
	Turkey, Aksaray	ap	HD	germacrene D (33.4), hexadecanoic acid (12.8), β-caryophyllene (8.5), bicyclogermacrene (8.5), β-cubebene (3.5)	[324]
T. orientale ssp. *taylori*	Iran	ap-fr	HD	linalool (28,6), caryophyllene oxide (15.6), 3-octanol (9.5), β-pinene (8.7), β-caryophyllene (7.3), 1,8-cineol (4.5), germacrene D (4.1), β-bisabolene (3.4)	[329, 330]
T. parviflorum	Turkey	ap	HD	β-caryophyllene (18.6), germacrene D (9.2), caryophyllene oxide (8.8), bicyclogermacrene (6.0), δ-cadinene (4.5), α-pinene (4.4), β-bisabolene (4.4), β-farnesene (3.7)	[331]
T. pestalozzae	Turkey	ap	HD	β-caryophyllene (27.6), germacrene D (13.8), α-humulene (5.6), (*E*)-β-farnesene (4.4), linalool (3.8), caryophyllene oxide (3.3), germacrene B (3.2), ledene (3.0)	[205]
T. pruinosum	Palestine	lv	MU	agarospirol (43.5), caryophyllene (19.3), D-limonene (3.7), α-caryophyllene (3.4), caryophyllene oxide (3.1)	[332]
T. pseudochamaepitys	Tunisia	ap	HD	hexadecanoic acid (26.1), apiole (7.1), caryophyllene oxide (6.3), myristicin (4.9), (*E*)-β-damascenone (4.6), α-cubebene (3.9), β-caryophyllene (3.5), elemicin (3.3), pentadecanol (3.1), cadidene-1,4-diene (3.1)	[333]
T. sandrasicum	Turkey	ap	HD	germacrene D (27.9), β-caryophyllene (9.1), sabinene (8.9), α-pinene (6.5), bicyclogermacrene (5.8), linalool (5.6), terpinen-4-ol (4.5), β-pinene (3.8), α-humulene (3.2), hexadecanoic acid (3.0)	[205]
T. trifidum	S. Africa	ap	HD	β-cubebene (31.1), α-cubebene (11.4), β-caryophyllene (7.7), δ-cadinene (5.2), bicyclosesquiphellendrene (4.2), *epi*-cubebol (4.2), cubebol (3.5)	[24]
Section not determined					
T. atratum	Algeria, cultivated	ap	HD	τ-cadinol (40.1), thymol (22.1), cravacrol (14.0), spatulenol (5.6), α-cubenol (5.0), α-cadinol (5.0)	[262, 334]

ap = aerial parts; fl = flowers; lv = leaves; fr = fruits; st = stems; br = bact; ca = calyx; co = corolla; rt = roots; BB = before bloom; FB = full bloom; AFB = after full bloom; CO_2 = Supercritical extraction; DCM = dichloromethane maceration; DT = direct thermal desorption method; Et_2O/pent = diethyl ether/pentane maceration; HD = hydrodistillation; Hex = Mmaceration in hexane; HS = headspace; MD = microdistillation; MHD = Mmicrowave-assisted hydrodistillation; MU = microwave ultrasonic; SDE = Ssimultaneous distillation-extraction; SFME = rapid solvent-free microwave extraction; SPME = headspace solid-phase micro-extraction; * percentage not reported in the original paper

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▸ **Table 4** The antioxidant activity of the essential oils from *Teucrium* taxa.

Species	Origin	Test type	Ref.
T. alyssipholium	Turkey	IC_{50} (µg/mL) DPPH 132	[319]
T. flavum ssp. *flavum*	Tunisia	IC_{50} (µg/mL) DPPH 1230	[185]
T. marum ssp. *marum*	Italy	IC_{50} (µg/mL) DPPH 13.13, X/XO 0.161	[188]
T. massiliense	Italy	IC_{50} (µg/mL) DPPH 13.30, LO 37.0	[298]
T. orientale ssp. *orientale*	Turkey	IC_{50} DPPH not determined	[327]
T. orientale ssp. *taylori*	Iran	IC_{50} (µg/mL) DPPH 121.6; *β*-carotene/LO 79.85 (comparable to BHT)	[329]
T. polium	Algeria	TEAC (mg TE/gr DWP): DPPH 19.14 (F) and 18.01 (B), FRAP 20.21 (F) and 18.21 (B)	[210]
T. polium	Algeria	IC_{50} (µg/mL) DPPH 547.68, ABTS 3.84, CUPRAC 9.82, *β*-carotene 33.47	[211]
T. polium	Iran	IC_{50} (µg/mL) DPPH 9200, LO > 2000	[226]
T. polium	Iran	IC_{50} (µg/mL) DPPH ca. 600, *β*-carotene/LO ca. 600	[232]
T. polium	Iran	IC_{50} (µg/mL) DPPH ca. 250	[233]
T. polium ssp. *aurum*	Marocco	IC_{50} (µg/mL) DPPH ca. 7200, FRAP 3500	[245]
T. polium ssp. *polium*	Marocco	IC_{50} (µg/mL) DPPH 3700, FRAP 2310	[245]
T. polium	Tunisia	IC_{50} (µg/mL) DPPH 20.0, FRAP ND, *β*-carotene 150	[255]
T. polium ssp. *aurasianum*	Algeria	IC_{50} (µg/mL) DPPH 58.63, EC_{50} (µg/mL): FRAP 48.19	[263]
T. polium ssp. *capitatum*	Algeria	IC_{50} (µg/mL) DPPH ca. 300	[264]
T. pruinosum	Palestine	IC_{50} (µg/mL) DPPH 16.98	[332]
T. sauvegi	Tunisia	IC_{50} (µg/mL) DPPH 1000, ABTS 590	[279]
T. pseudochamaepitys	Tunisia	IC_{50} (µg/mL) DPPH 770	[333]

classes: the sesquiterpene and monoterpene chemotypes. As can be seen, examining the composition of some very commonly studied taxa (e.g., *T. polium* or *T. polium* ssp. *capitatum*), this variation is intraspecific and probably due to different climatic or soil growing conditions.

Biological activities

Several biological activities have been disclosed for the EOs of the *Teucrium* genus, and they are discussed in the following paragraphs. Some of the effects, proven both *in vitro* and *in vivo*, can be associated to the traditional uses of the individual species. In other cases, a correlation between the ethnobotanical panorama and rigorous scientific evidence lacks.

The complexity of the chemical composition of EOs makes it rather arduous to interpret the results in terms of interactions with cellular molecular targets, even though the reductionist paradigm is more widely accepted; this is to attribute a particular bioactivity to the principal chemical component of the mixture or to one of the major components, for which a certain activity had been demonstrated for its pure form. The so-called "synergistic" model, based upon what the overall effect of the EO is higher than that of any single component, is advocated by some authors even though, in our opinion, it lacks strong experimental evidence.

Antioxidant activity

The antioxidant activity was evaluated for the EOs of several members of the genus *Teucrium*; ▸ **Table 4** reports the more relevant results. A great number of tests have been developed to measure the antioxidant power, which entail the interaction of a suitable probe with different molecules involved in the complex oxidative pathway, such as primary oxidation products hydroperoxides and/or secondary aldehydes, etc. Therefore, careful attention should be devoted to the selection of coherent data for a matter of comparison. However, most of the data reported in the literature concern the use of the DPPH radical scavaging test, based on radical hydrogen donation power of the sample. The activities disclosed vary from quite weak (order of magnitude of the IC_{50} in the DPPH assay 1000 µg/mL) to moderate (10–100 µg/mL) and, in some cases, stronger (1–10 µg/mL). In the case of EOs, the activity of the sample is related to the activity of the single components and attempts were made to make such a correlation explicit, even though these attempts are not always convincing. For example, Yildirim et al. [327] showed a direct correlation between the antioxidant activity of *T. orientale* EO harvested at different vegetative stages and its *β*-caryophyllene content. On other hand, other authors [319] did not recognize this compound as the main component responsible for the antioxidant activity of the *Teucrium alyssifolium* EO, even though it was found to be the major component (16.97%) in the oil. Surprisingly, the antioxidant activity of the oil was ascribed to the phenolic compounds present as minor components. Another group [188] justified the observed antioxidant activity of the EO of *T. marum* spp. *marum* to the presence of dolichodial.

Quite an interesting attempt to comprehensively rationalize the correlation between the antioxidant activity and the chemical composition of the EOs was made by Ruberto and Baratta [335],

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who investigated the radical scavenging activity of more than 100 individual compounds normally included in the EO composition of many species. They made use of two dinstinct assays (TBAR and ABAP) that gave comparable results: phenols, allylic alcohols, and unsaturated hydrocarbons, which can better stabilize unpaired electrons, were the more active compounds.

It would be useful and desirable that future investigations concerning the antioxidant activity of EOs will employ these two methods in order to better understand the molecular basis of the efficacy of different blends.

Antimicrobial activity

The antimicrobial activity of the EOs obtained from plants of *Teucrium* taxa has been largely explored. ▶ **Table 5** includes a survey of the most relevant available literature data, reported as MIC values – where available – as a matter for easier comparison. As can be seen, the range of these values is rather wide, being comprised within three orders of magnitude, from about 10^{-1} to 10^{2} mg/mL. Just for a matter of clarity, an arbitrary and qualitative classification of the efficacies reported could be stated as good (up to 1 mg/mL), medium (from 1 to 10 mg/mL), and weak (> 10 mg/mL). Only in one study, that is the evaluation of the antimicrobial activity of *T. polium* ssp. *aurasiacum* from Algeria, the results obtained showed MIC values notably high toward all of the tested microbial strains, ranging from 0.08 to 40 µg/mL [262]. The authors explained this remarkable antimicrobial potency with the presence of thymol as the major component in the oil, based upon the recognized antimicrobial effect of this compound.

Regarding EOs obtained from the species that showed an activity comprised in the range defined as "good", it is worth noting that most of them include a significant amount (ca. 9–25 %) of *α*-pinene, a well-recognized antimicrobial compound [337], in their composition, irrespective of their geographical origin. They are: *T. polium* from Greece [213]; *T. polim* ssp. *aurasiacum* [263, 264] from Algeria, ssp. *gabesianum* from Tunisia [272]; *T. flavum* ssp. *glaucum* from Corsica [164]; *T. stocksianum* from Pakistan [283] and *T. yemense* from Yemen [287].

An increasingly deep concern in the field of clinical infections control is the development of multidrug-resistant microbial strains in hospitalized patients. The efficacy of traditional antibiotics to combat this phenomenon is limited and the research on possible new remedies is welcomed and demanding. In this context, the use of new natural products, as well as EOs from plants, seems to be promising. An interesting work on this topic was published in 2016 by Lahmar et al. [275], who isolated multi drugs resistant *Acinetobacter baumannii* and lactamase-producing *Escherichia coli* strains from patients and tested the antimicrobial effect of the EO of three species belonging to Tunisian flora, among which was *T. ramosissimum*. The results showed that the MICs values for *T. ramosissimum* EO against MRSA (methicillin resistant *Staphylococcus aureus*) colonies varied from 0.25 to 1 mg/mL. In an attempt to reinduce antibiotic sensitivity, the EO was tested in combination with amoxicillin, tetracycilin, piperacillin, and ofloxacin, for which *A. baumanni* was shown to be resistant. No interaction was found between the EOs and piperacillin, but the active oil, at 15.6 mg/mL, restored the efficacy of ofloxacin by lowering the MIC values from 4- to 8-fold. The tendency of EOs to reduce antibiotic resistance is more pronounced against MRSA strains (138, 760, and 753). In the case of the MRSA 760 strain, the EO improved the effect of all antibiotics (amoxicillin, piperacillin, tetracycline, and oxacillin), with a reduction of their MIC value. However, the association was not efficient enough to modulate the antibacterial activity of ofloxacin (MIC of 4 mg/mL). The authors correlated the observed activity to the presence of *β*-eudesmol, *p*-cymene, 1,6-germacradien-5-ol, cedreanol, *β*-caryophyllene, and the above-cited *α*-pinene in the oil. However, it should be underlined that not all of these compounds had been previously shown to be individually active.

Klebsiella pneumoniae is an opportunistic pathogen that is known to develop multiple antibiotic-resistant strains responsible for dangerous nosocomial infections, including urinary tract, pneumonia, septicemia, and soft tissue infections. That is because the improvement in the chemical instruments available for its clinical control is of primary importance. In this regard, the good efficacy of *T. polium* EO from Iran [229] against *K. pneumoniae* ATCC 10031, as well as several strains isolated from urine of hospitalized patients, is relevant. However, the association that the authors made between the observed activity and the presence of the main components in the oil, caryophyllene oxide, *β*-caryophyllene, and *β*-pinene, seems to be poorly supported as none of the cited compounds was ever demonstrated to be active against *K. pneumoniae*, and *α*-pinene, also present in significant amounts in the oil of this sample of *T. polium*, possesses a wider antibiotic activity spectrum [337].

The above reported studies concerning possible clinical application of some EOs as effective antibiotics are surely interesting and promising for external use, but internal use requires much more additional safety and efficacy data.

An interesting potential application of the antimicrobial power of EOs concerns the implementation as preservative additives in food in order to fight microbial contaminations and development. In this context, the EO obtained from *T. polium* [228] was assessed for its efficacy; samples of yogurt and of probiotic yogurt were inoculated with different concentrations of the EO alone and together with variable amounts of *Lactobacillus casei* in order to investigate the inhibitory effect toward the growth of *Salmonella typhimurium* at intervals of 7 days. *T. polium* EO had the best *Salmonella* growth inhibition at 120 and 160 ppm and in synergistic combination with *L. casei*. No *Salmonella* was isolated during the 28 days of preservation of yoghurt or probiotic yoghurt (*L. casei* added) containing different concentrations of *T. polium* EO. The same combination of *T. polum* EO and *L. casei* was successfully applied as a conservative antibacterial agent against *E. coli* O157:H7 in samples of Kishk, a traditional Middle Eastern dish [91]. Further, *T. polium* EO was also evaluated as an additive in a commercial barley soup employing *Bacillus cereus* as a contaminant model [230].

The potential application as preservatives in the food industry is, in our opinion, much less problematic than the previously highlighted clinical one and, consequently, possesses a higher commercial appeal.

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▶ **Table 5** Antimicrobial activity of the EOs of *Teucrium* taxa.

Species	Origin	Test	Target	Ref
T. africanum	South Africa	MIC (mg/mL)	*B. cereus* ATCC 11778, *E. coli* ATCC 8739, *K. pneumoniae* ATCC 13883, *M. catarrhalis* ATCC 23246, *P. aeruginosa* ATCC 27858, *S. aureus* ATCC 2592: 4.0 to > 8.0; *S. pyogenes* ATCC 8668: 0.16	[24]
T. arduini	Croatia	MIC (mg/mL)	*S. aureus* ATCC 6538: 6.25, *E. faecalis* ATCC 21212: 37.50, *E. coli* ATCC 10536: 12.50, *P. aeruginosa* ATCC 27853: 6.25, *C. albicans* ATCC 10231: 7.81, *M. gypseum* MFBF S3: 12.50, *A. brasiliensis* ATCC 16404: 25	[308]
T. arduini	Montenegro	MIC (mg/mL)	*E. faecalis, E. coli, P. mirabilis, K. pnemoniae, P. aeruginosa, B. subtilis* FSB 2: 50, *E. faecalis* ATCC 29212: 50, *M. lysodeikticus* ATCC 4698: 50, *S. aureus* ATCC 25923: 25, *S. aureus* FSB 30: 25, *E. cloaceae* FSB 22: 25, *E. coli* ATCC 25922: 50, *K. pneumonia* FSB 26: 6.25, *P. mirabilis* FSB 34: 25, *C. albicans* ATCC 10259: 50	[310]
T. atratum	Algeria	MIC (µg/mL)	*E. aerogenes*: 5, *E. coli* ATCC 25922: 64, *K. pneumoniae*: 128, *P. mirabilis*: 128, *P. aeruginosa* ATCC 27853: 5, *S. typhimurium*: 64	[262]
T. capitatum	Morocco	MIC (µL/mL)	*T. rubrum*: 32.3, *T. mentagrophytes*: 32.3, *E. floccosum*: 32.3, *M. gypseum*: 20.4, *C. glabrata*: 20.4, *C. albicans*: 15.9, *M. canis*: 15.9, *A. niger*: 15.9	[270]
T. chamaedrys	France	MIC (mg/mL)	*S. aureus, S. epidermidis, L. innocua, EAEP289, E. aerogenes, C. jejuni:* 3.0, > 50.0, 3.0, > 50.0, > 50.0, 1.0	[164]
T. chamaedrys	Turkey	IZD (mm) at 1.0 mg/mL	*E. coli* ATCC 35218: 5–10, *Y. pseudotuberculosis* ATCC 911: 10–15, *K. pneumoniae* ATCC 13883: < 5, *S. marcescens* ATCC 13880: 5–10, *E. faecalis* ATCC 29212: 5–10, *S. aureus* ATCC 25923: 5–10, *B. subtilis* ATCC 6633: < 5, *C. albicans* ATCC 60193: < 5, *C. tropicalis* ATCC 13803: < 5	[172]
T. chamaedrys spp. *lydium*	Turkey	IZD (mm) at 0.5 mg/mL	*E. coli* ATCC 35218: < 5, *Y. pseudotuberculosis* ATCC 911: < 5, *K. pneumoniae* ATCC 13883: < 5, *S. marcescens* ATCC 13880: < 5, *E. faecalis* ATCC 29212: 5–10, *S. aureus* ATCC 25923: 10–15, *B. subtilis* ATCC 6633: 10–15, *C. albicans* ATCC 60193: < 5, *C. tropicalis* ATCC 13803: < 5	[172]
T. divaricatum	Lebanon	MIC (µg/mL)	*B. cereus* ATCC 11778: > 100, *B. subtilis* ATCC 6633: 50, *S. aureus* ATCC 25923: 100, *S. epidermidis* ATCC 12228: 25, *S. faecalis* ATCC 29212: > 100, *E. coli* ATCC 25922: > 100, *P. mirabilis* ATCC 25933: > 100, *P. vulgaris* ATCC 13315: > 100, *P. aeruginosa* ATCC 27853: > 100, *S. typhi* Ty2 ATCC 19430: > 100	[61]
T. flavum spp. *glaucum*	France	MIC (mg/mL)	*S. aureus, S. epidermidis, L. innocua, EAEP289, E. aerogenes, C. jejuni*: 0.8, 1.5, 1.5, 1.5, 1.5, 0.2	[164]
T. hyrcanicum	Iran	MIC (mg/mL)	*B. subtilis*: 2.5, *S. aureus*: 0.625, *E. coli*: NA, *S. typhi*: 5, *P. aeruginosa*: 10, *C. albicans*: NA, *A. niger*: 0.625	[314]
T. leucocladum	Egypt	IZD (mm) at 20 mg/mL	*E. coli*: 12, *P. aeruginosa*: 15, *S. aureus*: 12, *B. subtilis*: 30, *C. albicans*: 26	[210]
T. marum	France	MIC (mg/mL)	*S. aureus, S. epidermidis, L. innocua, EAEP289, E. aerogenes, C. jejuni*: 0.4, 25.0, 12.5, 0.4, 0.4, 1.0	[164]
T. marum spp. *marum*	Italy	MIC (mg/mL)	*R. solani*: 250, *F. oxysporum*: 450, *B. cinerea*: 1000, *A. solani*: 3800	[188]
T. mascatense	Oman	MIC (mg/mL):	*S. aureus* [NCTC6571]: 2.0, *S. aureus*: 2.5, *S. albus*: 2.0, *S. epidermidis*: 2.0, *Strept. mitis*: 1.5, *Strept. sanguis*: 1.5, *M. luteus*: 2.5, *B. subtilis*: 2.0, *B. cereus*: 1.5, *E. coli*: 6.0, *E. coli* [NCTC10418]: 7.0, *E. aerogenes*: 8.0, *K. pneumonia*: 8.5, *S. typhi*: 6.5, *P. vulgaris*: 8.5, *P. aeruginosa* [NCTC10662]: 8.0, *P. aeruginosa*: 8.5	[71]
		IZD (mm) at 20 mg/mL	*C. albicans*: 5.5, *S. cerevisiae*: 5, *R. stolonifera*: 4.5, *P. notatum*: 8.0, *F. oxysporum*: 4.0	
T. massiliense	France	MIC (mg/mL)	*S. aureus, S. epidermidis, L. innocua, EAEP289, E. aerogenes, C. jejuni*: 0.8, 0.8, 0.8, 6.0, 6.0, 1.0	[164]
T. montanum	Serbia	IZD (mm) at 0.3 mg/mL	*B. mycoides*: 25, *B. subtilis*: 26, *S. aureus*: 10, *A. tumefaciens*: 16, *A. chlorococcum*: 24, *E. cloaceae*: 24, *E. carotovora*: 18, *K. pneumonia*: 29, *Proteus* sp.: NA, *P. aeruginosa*: NA, *P. glycinea*: 20, *P. fluorescens*: 22, *P. phaseolicola*: 23, *A. niger*: 9, *F. oxysporum*: 17, *P. canescens*: 10	[206, 207]
T. orientale var. *puberulens*	Turkey	IZD (mm) at 0.5 mg/mL	*E. coli* ATCC 35218: < 5, *Y. pseudotuberculosis* ATCC 911: < 5, *K. pneumoniae* ATCC 13883: < 5, *S. marcescens* ATCC 13880: < 5, *E. faecalis* ATCC 29212: 10–15, *S. aureus* ATCC 25923: 5–10, *B. subtilis* ATCC 6633: 5–10, *C. albicans* ATCC 60193: < 5, *C. tropicalis* ATCC 13803: < 5	[172]

continued

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▸ **Table 5** *Continued*

Species	Origin	Test	Target	Ref
T. polium	Algeria	MIC (µL/mL)	*B. cereus* ATCC 11778: 5, *E. faecalis* ATCC 29212: 5, *E. coli* ATCC 25922: 4, *P. aeruginosa* ATCC 27853: NA, *S. aureus* ATCC 25923: 3	[214]
T. polium	Greece	IZD (mm) at 0.25 mg/mL	*E. coli*: 0.9, *S. aureus*: 17.5, *P. aeruginosa*: 12.5, *P. mirabilis*: 11	[213]
T. polium	Iran	MIC (µg/mL)	*K. pneumoniae* ATCC 10031 and patient urinary isolates: 0.62	[229]
T. polium	Morocco	MIC (µL/mL)	*S. aureus* ATCC 29213: 1.3, *E. coli* ATCC 25922: NA, *P. aeruginosa* ATCC 27853: NA *C. albicans* ATCC 10231: NA *A. brasiliensis* ATCC 1640: NA	[336]
T. polium	Morocco	MIC (mg/mL)	From individual patients: *K. pneumoniae*: 0.7, *P. aeruginosa*: 5. 62, *S. aureus*: 0.17, *A. baumannii*: 2.81, *C. koseri*: 2.81, *E. coli*: 5.62	[245]
T. polium spp. *aurasiacum*	Algeria	MIC (µg/mL)	*E. aerogenes*: 40, *E. coli* ATCC 25922: 0.08, *K. pneumoniae*: 32, *P. mirabilis*: 32, *P. aeruginosa* ATCC 27853: 0.08, *S. typhimurium*: 40, *S. aureus* ATCC 25923: 0.16	[262]
T. polium ssp. *aureum*	Morocco	MIC (mg/mL)	From individual patients: *K. pneumoniae*: 1.4, *P. aeruginosa*: 5.62, *S. aureus*: 0.17, *A. baumannii*: 1.4, *C. koseri*: 2.81, *E. coli*: 2.81	[245]
T. palium spp. *capitatum*	France	MIC (mg/mL)	*S. aureus, S. epidermidis, L. innocua, EAEP289, E. aerogenes, C. jejuni*: 0.4, 12.5, 6.0, 0.8, 0.8, 0.2.	[164]
T. polium ssp. *gabesianum*	Tunisia	MIC (mg/mL)	*E. coli* ATCC 25922, *E. faecalis* ATCC 29212, *S. aureus* ATCC 25923, *P. aeruginosa* ATCC 27853, *C. freundei, P. mirabilis*: >1; *M. canis*: 0.062	[272]
T. polium ssp. *geyrii*	Algeria	MIC (µL/mL)	*S. aureus* ATCC 27923: 4.9, *E. coli* ATCC 25922: 12.25, *P. aeruginosa* ATCC 25853: 12.25, *C. albicans*: 2.45	[273]
T. polium spp. *paurasianum*	Algeria	MIC (mg/mL)	*E. coli VL, Leisteria VL, Salmonella*: 0.66, *S. aureus*: 0.33, *Staphylococcus SP*: 0.33, *Proleus VL, K. pneumoniae*: 0.5	[263]
T. ramosissimum	Tunisia	MIC (mg/mL)	*S. aureus* ATCC 25923: 0.32, *E. faecalis* ATCC 29212: 0.36, *E. coli* ATCC 25922: 0.28, *S. enteritidis* ATCC 13076: 0.27, *S. typhimurium* NRRLB 4420: 0.24	[131]
T. sauvagei	Tunisia	MIC (mg/mL)	*C. albicans, C. neoforman, T. mentagrophytes* var. *mentagrophytes, T. mentagrophytes* var. *interdigitale, T. rubrum, T. soudanense, M. canis, M. gypseum, E. floccosum, A. fumigatus, S. brevicaulis, S. dimidiatum*: 0.8–1.0	[279]
T. scorodonia spp. *scorodonia*	France	MIC (mg/mL)	*S. aureus, S. epidermidis, L. innocua, EAEP289, E. aerogenes, C. jejuni*: 12.5, > 50.0, 50.0, 0.2, 1.5, 2.0	[164]
T. stocksianum	Oman	MIC (mg/mL)	*S. aureus* ATCC 9144: 4.5, *B. cereus* ATCC 11778: 4.5, *K. pneumoniae* ATCC 4352: 7.5, *P. aerugenosa* ATCC 25668: 11.0, *E. coli* ATCC 10536: 8.5, *S. aureus*: 5.5; wild strains from normal human flora: *S. albus*: 5.5, *S. epidermidis*: 5.0, *S. mitis*: 5.0, *S. sanguis*: 4.5, *E. coli*: 9.5, *E. aerogenes*: 8.0; wild strains from environment: *M. luteus*: 5.5, *B. subtilis*: 5.0, *S. typhi*: 6.5, *P. vulgaris*: NA, *P. aeruginosa*: 10.5	[142]
T. stocksianum	Pakistan	MIC (mg/mL)	*S. aureus*: 0.95, *B. subtilis*: 0.85, *B. cereus*: 0.45, *E. fecalis*: 1.8, *E. coli*: 0.45, *K. pneumoniae*: 3.6, *P. aeruginosa*: 0.25, *S. typhi*: 0.5	[283]
T. trifidum	South Africa	MIC mg/mL)	*B. cereus* ATCC 11778, *E. coli* ATCC 8739, *K. pneumoniae* ATCC 13883, *M. catarrhalis* ATCC 23246, *P. aeruginosa* ATCC 27858, *S. aureus* ATCC 25923: > 8.0; *S. pyogenes* ATCC 866: 4.0	[24]
T. yemense	Yemen	MIC (mg/mL)	*S. aureus*: 0.16, *B. cereus*: 0.16, *E. coli*: 0.31, *P. aeruginosa*: 1.25, *C. albicans*: 1.25, *A. niger*: 0.31, *B. cinerea*: 0.31	[287]

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▶ **Table 6** Antitumor activity of essential oils of *Teucrium* taxa.

Species	Origin	Cell type/cytotoxicity	Mechanism of action	Recognized targets	Ref
T. alopecurus	Tunisia	KBM5 human myeloid leukemia	Apoptosis activation by PARP cleavage;	PARP, Capsase-9	[23]
			Inhibition of antiapoptotic signalling;	cFLIP, XIAP, BCL-2, Survivin, c-IAP1/2, Bcl-xL, Mcl-1.	
			reduction of NF-κB p65 subunit translocation;	P65	
			reduction of NF-κB activity by blocking IκBα phosphorylation;	IκBα	
			inhibition of reporter gene expression;		
			inhibition of NF-κB-induced cell proliferation;	C-myc, cyclin D1	
			inhibition of NF-κB-induced angiogenesis and metastasis;	ICAM1, VEGF, MMP-9	
			inhibition of NF-κB binding to nucleus		
		HCT-116, U266, SCC4, Panc28, KBM5, MCF-7	Apoptosis activation by PARP cleavage;	PARP, Capsase-3, -8.–9 (HCT-116)	[22]
			production of ROS;		
			inhibition of STAT3 activity	C-myc, cyclin D1	
T. brevifolium	Greece	CACO-2, COR-L23 and C32. IC_{50} (µg/mL): 104, 80.7, > 200	NA	NA	[177]
T. flavum	Greece	CACO-2, COR-L23 and C32. IC_{50} (µg/mL): > 200, 104, > 200	NA	NA	[177]
T. montbretii ssp. *heliotropiifolium*	Greece	CACO-2, COR-L23 and C32. IC_{50} (µg/mL): 92.2, 143, 135	NA	NA	[177]
T. polium ssp. *capitatum*	Greece	CACO-2, COR-L23 and C32. IC_{50} (µg/mL): 52.7, 104, 91.2	NA	NA	[177]
T. yemense	Yemen	MCF-7, MDA-MB-231, HT29. IC_{50} (µg/mL): 24.4, 59.9, 43.7	NA	NA	[287]

Antitumor activity

Similar to other kinds of bioactivity, the cytotoxicity of *Teucrium* EOs toward cancer cells (▶ **Table 6**) was correlated with the presence in a mixture of a significant amount of molecules with a well-established anticancer effect, as in the case of α-bisabolol and (+)-*epi*-bicyclosesquiphellandrene in the oil extracted from *T. alopecurus* [22, 23], and (*E*)-caryophyllene, α-humulene, δ-cadinene, caryophyllene oxide, and α-cadinol that are present in relevant concentrations within the leaf EOs of *T. yemense* [287]. In other studies, the *in vitro* cytotoxicity was related, in a rather vague way, with the "presence of terpenes" in the oil [177].

NF-κB is a transcription factor with multiple genetic targets that, in tumor cells, control the expression of several proteins involved in cell proliferation and apoptosis as well as metastasis and angiogenesis [338]; this is because the modulation of its activation has been the focus of much research. Furthermore, it is known that EOs and many of their components can affect the response to TNF-induced inflammation by blocking NF-κB activation and p50/p65 units translocation, as well as by reducing the phosphorylation of IκBα. Such evidence offers a promising perspective in the possible application of EOs as anticancer agents in NF-κB-overexpressing tumors. Interestingly, the inhibition exerted by *T. alopecurus* EO on the TNF-induced activation of NF-κB was shown not to be cell specific [23]. The EO from this species was shown to be cytotoxic against KBM5 cells with a multiple mechanism including apoptosis protein activation, metastasis, and adhesion protein inhibition, as well as NF-κB/nucleus binding inhibition (▶ **Table 6**). The EO was also able to potentiate the apoptotic effect of anticancer drugs thalydomide, 5-fluorouracyle, and capecitabine.

Anti-inflammatory activity

The EOs of a number of *Teucrium* species were evaluated for their anti-inflammatory activity by different methods. The oils of *T. flavum, Teucrium montbretii* ssp. *heliotropiifolium, T. polium* ssp. *Capitatum*, and *Teucrium brevifolium* were evaluated as anti-inflammatory agents by measuring the inhibition of the lipopolysaccaride-induced nitric oxide release in macrophages RAW 264.7 [177]. All of the spp. were found to be very active, showing IC_{50} values ranging from 7.1 to 41.4 µg/mL, higher than that of the positive control indomethacin (52.8 µg/mL). This relevant result was attributed to the presence in the oil of sesquiterpenes spathu-

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lenol, δ-cadinene, caryophyllene, caryophyllene oxide, α-humulene, and torreyol. Further, the EO of Palestinian *Teucrium pruinosum*, obtained by an MU apparatus, was proven to be significantly efficient in inhibiting the activity of COX-1 and COX-2 enzymes with IC_{50} values of 0.103 and 0.208 µg/mL, respectively, with a COX-2/COX-1 ratio comparable to that of the NSAID drug etodolac [332].

Toxicity

In order to implement the possible therapeutic applications of EOs in human pathology, it is necessary to collect as much data as possible regarding both acute and chronic toxicity, and also the hypothesis that toxicity effects of the mixtures can be different from those already known for their single components.

A few papers deal with this kind of issue; in particular, the toxicity of *Teucrium pseudochamaepitys* was assessed by a viability test on Hep-2 cells, and the CC_{50} value was reported between 100 and 1000 µg/mL [333]. Unexpectedly, the authors do not furnish any explanation about the choice of this rather heterodox toxicity model. On the other hand, the toxicity of the *T. stocksianum* EO was evaluated by the more standard procedure of the brine shrimp test that gave a rather interesting LD_{50} value of 1200 µg/mL [283]. An *in vivo* study on rats concerning some pharmacological effects of *T. polium* gave evidence of hepatotoxicity after intraperitoneal administration of doses from 50 to 200 mg/kg bw of the EO [253].

Careful attention should be paid to the issue of the toxicity of *Teucrium* EOs in view of their possible biomedical applications in humans, both with systemic and topical administration routes. The lack of direct experimental evidence may be overcome by collecting data available for oils from other taxa with a similar composition or by combining available toxicity data for, at least, the major chemical constituents.

Other Bioactivities Related to Human Pharmacology

The antinociceptive activity was investigated for the EO of *T. polium* from Iran [339] by the writhing test in mice, a visceral pain model that measures the reduction of animal writhings caused by intraperitoneal administration of 0.6% acetic acid. The EO was effective in a dose-dependent manner and showed an ED_{50} value of 29.41 mg/kg bw, slightly higher than the positive controls hyoscine (14.17 mg/kg bw) and indomethacin (13.17 mg/kg bw). Furthermore, the antinociceptive effect observed in the ethanolic extract of the whole plant was proven to arise from the residual components of the EO in such an extract, as their complete removal by prolonged heating resulted in the full loss of activity. However, the composition of the EO was not given, so it was not possible to determine unambigous composition-activity correlations. The same species collected in Turkey [253] was evaluated by the tail flick latency test in rats. After intraperitoneal administration of the EO at 50, 100, and 200 mg/kg bw doses, significant results were obtained at 11 and 21 days and the antinociceptive effect observed was attributed to the presence of high levels of 1,8-cineole and β-pinene in the oil. Unfortunately, the range of effective doses is the same that induces hepatotoxicity, a circumstance that seriously limits the possibility of clinical application.

The antinociceptive effect of *T. stocksianum* EO from Pakistan [284] was assessed by the rat writhing test. Writhes induced by 0.6% acetic acid were effectively inhibited by the EO administrated intraperitoneally (ED_{50} of 31.5 mg/kg bw). The authors explained this positive effect with the similarity of the compositions of *T. stocksianum* and *T. polium* EOs. However, the perspective for an effective application in therapy is strongly limited, in our opinion, by the fairly high quantity of sample required, its apolar and water-insoluble nature, and the way of administration indicated.

The inhibition activity on the acetylcholinesterase enzyme was evaluated for the EOs of *T. mascatense* [340] and *T. polium* [211] and the results showed a poor effect in both the cases.

The EO obtained from *T. ramosissimum* showed an interesting antimutagenic activity in the bacterial reverse mutation assay conducted on *S. typhimurium* strains TA98, TA100, and TA1535 [341] with the mutagenic agent sodium azide, aflatoxin B1, benzo[a]pyrene, and 4-nitro-o-phenylenediamine. The efficacy was found to be dose dependent and different for the three targets; in particular, the EO introduced at 25 to 250 µg/plate doses reduced the aflatoxin B1- and benzo[a]pyrene-induced mutagenicity by 92 to 97% on the TA100 strain and by 45 to 89% on TA98. Further, the reduction of the sodium azide-induced mutagenicity for the two abovementioned strains was within 40–60%, while the inhibition on the TA1535 strain reached a rate of approximately 74% at the oil dose of 250 µg/plate. The authors did not explain the observed results with any specific correlation with the EO composition.

Other Bioactivities Not Related to Human Pharmacology

Phytotoxic activity

The effect of the EOs obtained from a set of four species belonging to *Teucrium* taxa, i.e., *arduini, maghrebinum, polium* ssp. *capitatum* and *montbretii* ssp. *heliotropiifolium*, were investigated for their phytotoxic activity by analyzing the germination and the initial radicle elongation of *Raphanus sativus* L. and *Lepidium sativum* L. [190]. *T. polium* was the only one able to affect the germination of *R. sativus* at a dose of 1.25 µg/mL, while *T. arduini* affected the germination of *L. sativum* at 2.5 µg/mL. On the other hand, the radicle elongation of *R. sativus* was significantly inhibited by all of the EOs tested. The authors interestingly compared the bioactivities of EOs with their main pure components, β-pinene, limonene, linalool, carvacrol, allo-aromadendrene, caryophyllene, and caryophyllene oxide, and confirmed that the bioactivity of the mixtures could be correlated to the presence of active monoterpenes, such as limonene.

Antiphytoviral activity

The antiphytoviral activity of the four Croatian endemic species *T. polium, T. flavum, T. montanum*, and *T. chamaedrys* was assessed toward the cucumber mosaic virus, inoculated to *Chenopodium quinoa* Willd. [165]. All of the EOs were active at various degrees in reducing the number of lesions. This activity was well corre-

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lated with the composition of the oils, in particular, with the percentage of β-caryophyllene, which explains the observed results for every species except *T. montanum*, which showed better antiviral activity regardless of having the lowest β-caryophyllene content. The presence of a significant percentage of germacrene D, β-pinene, and limonene can explain the relatively high antiviral activity of *T. montanum*.

Insecticidal activity

EOs are considered valid, ecofriendly, and human biocompatible alternatives to traditional chemical insecticides and pesticides. The literature reports many examples of this kind of research, also dealing with *Teucrium* taxa.

The larvicidal activity of *T. polium* EO was studied on *Musca domestica* [342]. The oil was proven to be active when mixed with feeding material withand had an LC_{50} of 80 µg/mL. The mechanism of action was attributed to the inhibition activity toward several digestive enzymes that were measured after dissection and removal of the larvae midguts. Inhibition rates were relevant for proteinase trypsin (61.5%), cathepsin B (79%), and cathepsin L (69%); also, carbohydrase activities were inhibited for α-amylase (93%), α-glucosidase (69.5%), and β-glucosidase (42%). The authors did not attempt to furnish any explanation about the activity-composition relationship of the oil.

T. polium EO was also tested against the larvae of *Ephestia kuehniella* Z. (Lep.: Pyralidae) [343], a pest commonly found in cereal flour. Its LC_{50} was found to be 4.91 µL/L, while α-pinene, which was claimed as the mayor component of the oil even though no analytical data were reported, showed an LC_{50} of 10.66 µL/mL. This larvicidal effect was associated to the reduction of the digestive enzymes activity, in particular, α-amylase, triacylglycerol lipase, general protease, serine proteases (trypsin and chymotrypsin-like), carboxypeptidases, and aminopeptidases. Another study about this species concerns the use of its EO as both a mosquitocidal and repellent agent against *Culex pipiens* L. [252]. The oil was moderately toxic with LC_{50} of approximately 25 µL/L and showed a better repellency of 292 min of protection at 2 µL/cm^2. The relation of the activity with the composition of this oil remains quite uncertain.

The EO obtained from *Teucrium leucocladum* was effective as a larvicidal agent against *C. pipiens, M. domestica*, and *Ceratitis capitata* with LC_{50} values ranging from 16 to 24 µg/mL [201]. Such an activity was related to the alcohols and monoterpenes compounds contained in the oil. The EO obtained from same species was investigated for its potential as a fumigant insecticide and antifeedant agent against *Tribolium castaneum* Herbst, a pest that is considered a dangerous threat for post-harvested cereals [236]. The oil was effective in both of the modes of use in a dose- and time-dependent fashion. The optimal fumigant toxicity versus the adult insects was reached after 72 min of exposure with a 20 µL/L solution, with a mortality rate of 98%. Further, a concentration of 14.13 µL/L was determined as the optimum value for obtaining a 95% Feeding Deferens Index with 92% desirability. No hypothesis was made about the possible mechanisms of action or the components mainly responsible for the reported insecticidal activity.

A limited fumigant toxicity (LC_{50} of 37.9 µL/L) against the adults of *Sitophilus oryzae* was observed for the EO of *Teucrium capitatum* from Greece [267]; this was attributed to the circumstance of the presence of sesquiterpenes as the principal constituents of the oil.

T. polium subsp. *capitatum* from Iran furnished an EO that was assessed as a fumigant and repellent agent against the stored product pests *Tribolium castaneum* and *Callosobruchus maculatus* [269]. The repellent activity was moderate towards both of the targets with a concentration-dependent repellency index ranging from about 20 to 60% at doses of 0.2 to 3 µL/mL of the oil in acetone. The fumigant toxicity was also limited, with LC_{50} values of 360 and 149 µL/L for *T. castaneum* and *C. maculatus*, respectively. It is the opinion of the authors that the presence of α-canidol as the main component (46.2%), which is known to be active against several insect species, and a high percentage (25.9%) of caryophillene oxide, possessing insecticidal activity against *T. castaneum*, could explain the activity found.

The EO of *Teucrium quadrifarium* collected in India was evaluated as a pesticide and insect growth regulator against *Spilarctia obliqua* [290]. Topical application of the oil on 3rd instar larvae determined an increase in larval and pupal periods, augmented both larval mortality and adult deformity, and caused a decrease in larval and pupal weight as well as in adult emergence. The composition of the oil is not given and the authors generically connected the observed findings with the high lipophilic character of the EO. The EO extracted from the same species growing in China showed a strong insecticidal activity against *Liposcelis bostrychophila* [130]. The oil was effective both as a contact toxic agent, with an LC_{50} value of 95.1 µg/cm^2, and as a fumigant agent, with an LC_{50} of 0.22 mg/L. Even though this paper reports the assessment of the oil composition, no clear connection was found concerning this data and the observed bioactivity.

The EO produced by the species *T. montanum* subsp. *jailae* collected in Slovakia was included in an investigation for the insecticidal activity against the insects *M. domestica* L., *Culex quinquefasciatus*, and *Spodoptera littoralis* [209]. The insecticidal activity toward *M. domestica* was poor, while the activity toward the other targets was relevant, with LD_{50} values of 56.7 µg per larva for *S. littoralis* and 180.5 µg/mL for *C. quinquefasciatus*. The authors admitted the inherent difficulty in relating the biological activity with the EO composition even though the presence of relatively high amounts of (*E*)-caryophyllene and germacrane D, both compounds active toward several pests, may be considered at least an important contribution to the overall action of the mixture.

The acaricidal activity of the EO obtained from an Iranian specimen of *T. polium* was tested in the leaf dipping and fumigant bioassays against the spotted spider mite *Tetranychus urticae* [344]. LC_{50} values obtained in the two tests were 1.784% and 5.395 µL/L respectively.

Antiprotozoal activity

The EO obtained from a sample of *T. polium* collected in Tunisia was an effective antileshmanial agent against the species *Leishmania major* (LCO3) and *Leishmania infantum* (LV20) directly isolated from infected patients [256]. The IC_{50} values were 0.15 and 0.09 µg/mL, respectively. The possible toxicity was tested on the

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RAW 264.7 macrophage cell line that showed an LC_{50} of 3.64 µg/mL. The same activity was tested for the main component (56 %) of the oil, carvacrol, and for other significantly represented compounds, such as β-caryophyllene and geraniol, all of them showing remarkable activity with IC_{50} values < 10 µg/mL.

An interesting activity was disclosed for the EO of *T. ramosissimum* (Tunisia) that was active against the *Acanthamoeba*, an infective agent responsible for a rare human keratitis that lacks definitive successful pharmacological approaches [277]. The oil showed a remarkable IC_{50} value of 25.7 µg/mL. The authors speculated that the presence of a relevant amount of sesquiterpenes in the oil may explain the observed activity and supported this claim with literature data concerning active pure sesquiterpene compounds that, however, were not present in their sample.

Conclusions

In this review, a complete recognition of the volatile secondary metabolites occurring in the *Teucrium* genus has been carried out. Some relevant studies on several biological activities have been reported that include antioxidant, anti-inflammatory, antibacterial, antifungal, antitumor, and antidiabetic, justifying the widespread implementation reported in the ethnomedicine of several countries.

Contributors' Statement

Conception and design of the work: M. Bruno, S. Rosselli, G. Fontana, R. Gagliano Candela. Data collection: M. Bruno, S. Rosselli, R. Gagliano Candela, G. Fontana. Analysis and interpretation of the data: M. Bruno, S. Rosselli, G. Fontana, R. Gagliano Candela. Drafting the manuscript: M. Bruno, S. Rosselli, G. Fontana. Critical revision of the manuscript: M. Bruno, S. Rosselli, G. Fontana, R. Gagliano Candela.

Acknowledgements

This work was supported by a grant from MIUR-ITALY PRIN 2017 (Project N. 2017A95NCJ).

Conflict of Interest

The authors declare that they have no conflict of interest.

References

[1] Tutin G, Wood D. Teucrium. In: Tutin G, Heywood VH, Burges NA, Moore DM, Valentine DH, Walters SM, Webb DA, eds. Flora Europaea 3. Cambridge: Cambridge University Press; 1972: 129–135

[2] Royal Botanic Gardens, Kew and Missouri Botanical Garden. The Plant List. Accessed March 25, 2020 at: www.theplantlist.org

[3] McClintock E, Epling C. A revision of *Teucrium* in the new world, with observations on its variation, geographical distribution and history. Brittonia 1946; 5: 491–510

[4] Dinç M, Doğu S. *Teucrium pruinosum* var. *aksarayense var. nov*. (Lamiaceae) from Central Anatolia, Turkey. Mod Phytomorphol 2016; 9: 13–17

[5] Navarro T, El Oualidi J, Trigo MM. Pollen morphology of *Teucrium* (Labiatae) and its taxonomic value. Belg J Bot 2004; 137: 70–84

[6] Melnikov D. The system of the genus *Teucrium* L. (Lamiaceae). In: Tzvelev N, ed. Novitates systematicae plantarum vascularium, Tomus 45. Petropoli, Russia: Institutum Botanicum nomine V. L. Komarovii; 2014: 63–68

[7] Hollis S, Brummitt RK. World geographical Scheme for recording Plant Distributions. Pittsburgh: Hunt Institute for Botanical Documentation; 1992

[8] Mesuel H, Jäger E, Rauschert S, Wienert E. Veirleichende Chronologie der Zentraleuropäiscen Flora, Vol. 2. Jena: VEB Gustav Fisher; 1978

[9] Piozzi F. The diterpenoids of *Teucrium* species. Heterocycles 1981; 15: 1489–1503

[10] Piozzi F, Rodriguez B, Savona G. Advances in the chemistry of the furanoditerpenoids from *Teucrium* species. Heterocycles 1987; 25: 807–841

[11] Piozzi F. Further research on the furoclerodaness from *Teucrium* species. Heterocycles 1994; 37: 603–626

[12] Piozzi F, Bruno M, Rosselli S. Further furoneoclerodanes from *Teucrium* genus. Heterocycles 1998; 48: 2185–2203

[13] Piozzi F, Bruno M, Rosselli S, Maggio A. Advances in the chemistry of furano-diterpenoids from *Teucrium* genus. Heterocycles 2005; 65: 1221–1234

[14] Ulubelen A, Topçu G, Sönmez U. Chemical and biological evaluation of genus *Teucrium*. Stud Nat Prod Chem 2000; 23: 591–648

[15] Navarro T, El Oualidi J. Flower and life strategy diversity in *Teucrium* L. (Lamiaceae). Acta Botanica Malacitana 1999; 24: 63–75

[16] Juan R, Pastor J, Millan F, Alaiz M, Vioque J. Amino acids composition of *Teucrium* nutlet proteins and their systematic significance. Ann Bot 2004; 94: 615–621

[17] Marin P, Petković B, Duletić S. Nutlet sculpturing of selected *Teucrium* species (Lamiaceae): a character of taxonomic significance. Plant Syst Evol 1994; 192: 199–214

[18] Marzouk RI, El-Darier SM, Askar ABS. Pollen morphology of *Teucrium* L. (Lamiaceae, Ajugoideae) in Libya. Bangladesh J Plant Taxon 2017; 24: 219–226

[19] Oybak E, İnceoğlu Ö. Pollen morphology of some *Teucrium* L. (Labiatae) species. Commun Fac Sci Univ Ank Serie C 1988; 6: 133–146

[20] Navarro T, El Oualidi J. Trichome morphology in *Teucrium* L. (Labiatae). A taxonomic review. Annales Jardin Botanico de Madrid 2000; 57: 277–296

[21] Codd LE. The South African species of *Teucrium* (Lamiaceae). Bothalia 1977; 12: 177–179

[22] Guesmi F, Tyagi AK, Prasad S, Landoulsi A. Terpenes from essential oils and hydrolate of *Teucrium alopecurus* triggered apoptotic events dependent on caspases activation and PARP cleavage in human colon cancer cells through decreased protein expressions. Oncotarget 2018; 9: 32305–32320

[23] Guesmi F, Prasad S, Tyagi AK, Landoulsi A. Antinflammatory and anticancer effects of terpenes from oily fractions of *Teucruim alopecurus*, blocker of IκBα kinase, through downregulation of NF-κB activation, potentiation of apoptosis and suppression of NF-κB-regulated gene expression. Biomed Pharmacother 2017; 95: 1876–1885

[24] Ruiters AK, Tilney PM, Van Vuuren SF, Viljoen AM, Kamatou GPP, Van Wyk BE. The anatomy, ethnobotany, antimicrobial activity and essential oil composition of southern African species of *Teucrium* (Lamiaceae). S Afr J Bot 2016; 102: 175–185

[25] Kartaha B, Harhar H, Elmonfaloutia H, Gharbya S, Guillaume D, Charroufa Z. Chemical composition of the essential oil of *Teucrium antiatlanticum* (Lamiaceae). Der Pharma Chem 2015; 7: 23–25

[26] Agiel N, Mericli F. A survey on the aromatic plants of Libya. Indian J Pharm Educ 2017; 51: S304–S308

[27] Redžić SS. The ecological aspect of ethnobotany and ethnopharmacology of population in Bosnia and Herzegovina. Coll Antropol 2007; 31: 869–890

This document was downloaded for personal use only. Unauthorized distribution is strictly prohibited.

[28] Šarić-Kundalić B, Dobeš C, Klatte-Asselmeyer V, Saukel J. Ethnobotanical study on medicinal use of wild and cultivated plants in middle, south and west Bosnia and Herzegovina. J Ethnopharmacol 2010; 131: 33–55

[29] Rivera D, Obón C. The ethnopharmacology of Madeira and Porto Santo Islands, a review. J Ethnopharmacol 1995; 46: 73–93

[30] Handong S, Xingliang C, Tianen W, Lutai P, Zhongwen L, Deyuant C. A *neo*-clerodane diterpenoid from *Teucrium bidentatum*. Phytochemistry 1991; 30: 1721–1723

[31] Fernandez Puntero B, Iglesias Peinado I, Villar de Fresno AM. Anti-inflammatory and antiulcer activity of *Teucrium buxifolium*. J Ethnopharmacol 1995; 55: 93–98

[32] Foster S, Duke JA. A Field Guide to medicinal Plants and Herbs of Eastern and Central North America. Boston: Houghton Mifflin Co.; 2000

[33] Bown D. Encyclopaedia of Herbs and their Uses. London: Dorling Kindersley; 1995

[34] Chiej R. Encyclopaedia of medicinal Plants. London: MacDonald; 1984

[35] Nencini C, Galluzzi P, Pippi F, Menchiari A, Micheli L. Hepatotoxicity of *Teucrium chamaedrys* L. decoction: role of difference in the harvesting area and preparation method. Indian J Pharmacol 2014; 46: 181–184

[36] Zdraveva P, Pavlova D, Krasteva I, Pencheva I. Phytochemical analysis on populations of *Teucrium chamaedrys* from serpentine sites in Bulgaria. CR Acad Bul Sci 2018; 71: 185–192

[37] Uritu CM, Mihai CT, Stanciu GD, Dodi G, Alexa-Stratulat T, Luca A, Leon-Constantin MM, Stefanescu R, Bild V, Melnic S, Tamba BI. Medicinal plants of the family lamiaceae in pain therapy: A review. Pain Res Manag 2018; 2018: 7801543

[38] Said O, Khalil K, Fulder S, Azaizeh H. Ethnopharmacological survey of medicinal herbs in Israel, the Golan Heights and the West Bank region. J Ethnopharmacol 2002; 83: 251–265

[39] Zargari A. Pharmaceutical Plants. Iran: Tehran University Publications; 1993: 127–130

[40] Ali-Shtayeh MS, Yaniv Z, Mahajna J. Ethnobotanical survey in the Palestinian area: a classification of the healing potential of medicinal plants. J Ethnopharmacol 2000; 73: 221–232

[41] Vujanović M, Zengin G, Đurović S, Mašković P, Cvetanović A, Radojković M. Biological activity of extracts of traditional wild medicinal plants from the Balkan Peninsula. S Afr J Bo 2019; 120: 213–218

[42] Nastić N, Švarc-Gajić J, Delerue-Matos C, Barroso MF, Soares C, Moreira MM, Morais S, Mašković P, Gaurina Srček V, Slivac I, Radošević K, Radojković M. Subcritical water extraction as an environmentally-friendly technique to recover bioactive compounds from traditional Serbian medicinal plants. Ind Crops Prod 2018; 111: 579–589

[43] Jarić S, Mačukanović-Jocić M, Djurdjević L, Mitrović M, Kostić O, Karadžić B, Pavlović P. An ethnobotanical survey of traditionally used plants on Suva planina mountain (south-eastern Serbia). J Ethnopharmacol 2015; 175: 93–108

[44] Gras A, Garnatje T, Ibáñez N, López-Pujol J, Nualart N, Vallès J. Medicinal plant uses and names from the herbarium of Francesc Bolòs (1773–1844). J Ethnopharmacol 2017; 204: 142–168

[45] Erbay MŞ, Sarı A. Plants used in traditional treatment against hemorrhoids in Turkey. Marmara Pharm J 2018; 22: 110–132

[46] Polat R, Satil F. An ethnobotanical survey of medicinal plants in Edremit Gulf (Balikesir-Turkey). J Ethnopharmacol 2012; 139: 626–641

[47] Sezik E, Yeşilada E, Honda G, Takaishi Y, Takeda Y, Tanaka T. Traditional medicine in Turkey X. Folk medicine in Central Anatolia. J Ethnopharmacol 2001; 75: 95–115

[48] Uysal I, Gücel S, Tütenocakli T, Öztürk M. Studies on the medicinal plants of Ayvacik-Çanakkale in Turkey. Pak J Bot 2012; 44: 239–244

[49] Bulut G, Tuzlaci E. An ethnobotanical study of medicinal plants in Bayramiç (Canakkale-Turkey). Marmara Pharm J 2015; 19: 268–282

[50] Bulut G, Haznedaroğlu MZ, Doğan A, Koyu H, Tuzlacı E. An ethnobotanical study of medicinal plants in Acipayam (Denizli-Turkey). J Herb Med 2017; 10: 64–81

[51] Ünsal Ç, Vural H, Sariyar G, Özbek B, Ötük G. Traditional medicine in Bilecik province (Turkey) and antimicrobial activities of selected species. Turk J Pharm Sci 2010; 7: 139–150

[52] Kültür S. Medicinal plants used in Kirklareli Province (Turkey). J Ethnopharmacol 2007; 111: 341–364

[53] Paksoy MY, Selvi S, Savran A. Ethnopharmacological survey of medicinal plants in UlukIşla (Niğde-Turkey). J Herb Med 2016; 6: 42–48

[54] Husein AI, Ali-Shtayeh MS, Jondi WJ, Zatar NAA, Abu-Reidah IM, Jamous RM. *In vitro* antioxidant and antitumor activities of six selected plants used in the Traditional Arabic Palestinian herbal medicine. Pharm Biol 2014; 52: 1249–1255

[55] Hernandez-Galicia E, Aguilar-Contreras A, Aguilar-Santamaria L, Roman-Ramos R, Chavez-Miranda AA, Garcia-Vega LM, Flores-Saenz JL, Alarcon-Aguilar FJ. Studies on hypoglycemic activity of Mexican medicinal plants. Proc West Pharmacol Soc 2002; 45: 118–124

[56] Vera-Ku M, Méndez-González M, Moo-Puc R, Rosado-Vallado M, Simá-Polanco P, Cedillo-Rivera R, Peraza-Sánchez SR. Medicinal potions used against infectious bowel diseases in Mayan traditional medicine. J Ethnopharmacol 2010; 132: 303–308

[57] Jacobo-Salcedo MDR, Alonso-Castro AJ, Salazar-Olivo LA, Carranza-Alvarez C, Gonzaĺez-Espińdola LA, Domińguez F, Maciel-Torres SP, Garciá-Lujan C, Gonzaĺez-Martińez MDR, Gomez-Sańchez M, Estrada-Castilloń E, Zapata-Bustos R, Medellin-Milań P, Garciá-Carrancá A. Antimicrobial and cytotoxic effects of Mexican medicinal plants. Nat Prod Commun 2011; 6: 1925–1928

[58] Arnold N, Bellomaria B, Valentini G, Rafaiani SM. Comparative study on essential oil of some *Teucrium* species from Cyprus. J Ethnopharmacol 1991; 35: 105–113

[59] Meikle RD. Flora of Cyprus, Vol. 2. Hilversum, Holland: Bentham Maxon Trust; 1985: 1332–1342

[60] Gürdal B, Kültür Ş. An ethnobotanical study of medicinal plants in Marmaris (Muğla, Turkey). J Ethnopharmacol 2013; 146: 113–126

[61] Formisano C, Napolitano F, Rigano D, Arnold NA, Piozzi F, Senatore F. Essential oil composition of *Teucrium divaricatum* Sieb. ssp. *villosum* (Celak.) Rech. fil. growing wild in Lebanon. J Med Food 2010; 13: 1281–1285

[62] Bellomaria B, Arnold N, Valentini G. Essential oil of *Teucrium flavum* subsp. *hellenicum* from Greece. J Essent Oil Res 1998; 10: 131–133

[63] Dall'Acqua S, Cervellati R, Loi MC, Innocenti G. Evaluation of *in vitro* antioxidant properties of some traditional Sardinian medicinal plants: Investigation of the high antioxidant capacity of *Rubus ulmifolius*. Food Chem 2008; 106: 745–749

[64] Sanna C, Ballero M, Maxia A. Le piante medicinali utilizzate contro le patologie epidermiche in Ogliastra (Sardegna centro-orientale). Atti Soc Tosc Sci Nat Mem Serie B 2006; 113: 73–82

[65] Camarda I. Ricerche etnobotaniche nel comune di Dorgali, Sardegna centro orientale. Boll Soc Sarda Sci Nat 1990; 27: 147–204

[66] Maccioni S, Guazzi E, Tomei PE. Le piante nella medicina popolare del Grossetano. I, Le colline fra l'Ombrone e l'Albegna (Toscana). Atti Mus Stor Nat Maremma 1997; 16: 25–46

[67] Tuttolomondo T, Licata M, Leto C, Gargano ML, Venturella G, La Bella S. Plant genetic resources and traditional knowledge on medicinal use of wild shrub and herbaceous plant species in the Etna Regional Park (Eastern Sicily, Italy). J Ethnopharmacol 2014; 155: 1362–1381

[68] Formisano C, Rigano D, Senatore F, Al-Hillo MRY, Piozzi F, Rosselli S. Analysis of essential oil from *Teucrium maghrebinum* Greuter et Burdet growing wild in Algeria. Nat Prod Commun 2009; 4: 411–414

[69] Grieve M. A Modern Herbal. New York: Dover Publications Inc.; 1972

This document was downloaded for personal use only. Unauthorized distribution is strictly prohibited.

[70] Chevallier A. The Encyclopaedia of medicinal Plants. London: Dorling Kindersley; 1996

[71] Hisham A, Pathare N, Al-Saidi S, Al-Salmi A. The composition and antimicrobial activity of leaf essential oil of *Teucrium mascatenses* Boiss. from Oman. J Essent Oil Res 2006; 18: 465–468

[72] Ghazanfar SA, Al-Sabahi AMA. Medicinal plants of Northern and Central Oman (Arabia). Econ Bot 1993; 47: 89–98

[73] Zarshenas M, Zargaran A, Maüller J, Mohagheghzadeh A. Nasal drug delivery in traditional Persian medicine. Jundishapur J Nat Pharm Prod 2013; 8: 144–148

[74] Jančić R, Stošić D, Mimica-Dukić N, Lakušić B. The aromatic Plants from Serbia. In: Gajić V, ed. NIP Dečije novine. Serbia & Montenegro: Gornji Milanovac; 1995

[75] Zlatković BK, Bogosavljević SS, Radivojević AR, Pavlović MA. Traditional use of the native medicinal plant resource of Mt. Rtanj (Eastern Serbia): ethnobotanical evaluation and comparison. J Ethnopharmacol 2014; 151: 704–713

[76] Ajabnoor MA, Al-Yahya MA, Tariq M, Jayyab AA. Antidiabetic activity of *Teucrium oliverianum*. Fitoterapia 1984; 55: 227–230

[77] Safaa B, Chalak L, Dalleh H, Arnold N. Ethnopharmacological survey of medicinal plants used in traditional medicine by the communities of Mount Hermon, Lebanon. J Ethnopharmacol 2015; 173: 139–156

[78] Bahmani M, Saki K, Shahsavari S, Rafieian-Kopaei M, Sepahvand R, Adineh A. Identification of medicinal plants effective in infectious diseases in Urmia, northwest of Iran. Asian Pac J Trop Bio 2015; 5: 858–864

[79] Bahmani M, Rafieian-Kopaei M, Saki K, Majlesi M, Bahmani F, Bahmani F, Sharifi A, Rasouli S, Sepahvand R, Abdollahi R, Moghimi-Monfared O, Baharvand S. Identification of medical plants acting on reproductive system disorders: An ethnobotanical study in Urmia, Northwest of Iran. J Chem Pharm Res 2015; 7: 493–502

[80] Miri A, Monsef-Esfahani HR, Amini M, Amanzadeh Y, Hadjiakhoondi A, Hajiaghaee R, Ebrahimi A. Comparative chemical composition and antioxidant properties of the essential oils and aromatic water from *Teucrium persicum* Boiss. Iran J Pharm Res 2012; 11: 573–581

[81] Pieroni A, Dibra B, Grishaj G, Grishaj I, Maçai SG. Traditional phytotherapy of the Albanians of Lepushe, Northern Albanian Alps. Fitoterapia 2005; 76: 379–399

[82] Ait Chaouche FS, Mouhouche F, Hazzit M. Antioxidant capacity and total phenol and flavonoid contents of *Teucrium polium* L. grown in Algeria. Med J Nutrition Met 2018; 11: 135–144

[83] Bouabdelli F, Djelloul A, Kaid-Omar Z, Semmoud A, Addou A. Antimicrobial activity of 22 plants used in urolithiasis medicine in Western Algeria. Asian Pac J Trop Dis 2012; 2 (Suppl. 1): S530–S535

[84] Galstyan HM. Standardization of felty germander (*Teucrium polium* L.) by natural phytoestrogens: phenylpropanoid and flavonoid glycosides. New Armen Med J 2014; 8: 53–58

[85] Mosaddegh M, Naghibi F, Moazzeni H, Pirani A, Esmaeili S. Ethnobotanical survey of herbal remedies traditionally used in Kohghiluyeh va Boyer Ahmad province of Iran. J Ethnopharmacol 2012; 141: 80–95

[86] Shojaii A, Ghods R, Fard MA. Medicinal herbs in Iranian traditional medicine for learning and memory. Afr J Tradit Complem 2016; 13: 199–209

[87] Feiz Haddad MH, Mahbodfar H, Zamani Z, Ramazani A. Antimalarial evaluation of selected medicinal plant extracts used in Iranian traditional medicine. Iran J Basic Med Sci 2017; 20: 415–422

[88] Bahramikia S, Ardestani A, Yazdanparast R. Protective effects of four Iranian medicinal plants against free radical-mediated protein oxidation. Food Chem 2009; 115: 37–42

[89] Asadi-Samani M, Moradi MT, Mahmoodnia L, Alaei S, Asadi-Samani F, Luther T. Traditional uses of medicinal plants to prevent and treat diabetes; an updated review of ethnobotanical studies in Iran. J Nephropathol 2017; 6: 118–125

[90] Tajallaie-Asl F, Mardani M, Shahsavari S, Abbaszadeh S. Menstruation phytotherapy according to Iran ethnobotanical sources. J Pharm Sci Res 2017; 9: 986–990

[91] Sadrizadeh N, Khezri S, Dehghan P, Mahmoudi R. Antibacterial effect of *Teucrium polium* essential oil and *Lactobacillus casei* probiotic on *Escherichia coli* O157:H7 in Kishk. Appl Food Biotechnol 2018; 5: 131–140

[92] Mikaili P, Shayegh J, Asghari MH. Review on the indigenous use and ethnopharmacology of hot and cold natures of phytomedicines in the Iranian traditional medicine. Asian Pac J Trop Bio 2012: 2 (Suppl. 2): S1189–S1193

[93] Haghighi M, Mozafariyan M. The introduction of extinct endemic vegetables of Iran. J Med Plant Res 2011; 5: 7085–7107

[94] Sadeghi Z, Kuhestani K, Abdollahi V, Mahmood A. Ethnopharmacological studies of indigenous medicinal plants of Saravan region, Baluchistan, Iran. J Ethnopharmacol 2014; 153: 111–118

[95] Fallah Huseini H, Abdolghaffari AH, Ahwazi M, Jasemi E, Yaghoobi M, Ziaee M. Topical application of *Teucrium polium* can improve wound healing in diabetic rats. Int J Low Extrem Wounds 2020; 19: 132–138

[96] Azaizeh H, Saad B, Khalil K, Said O. The state of the art of traditional Arab herbal medicine in the Eastern region of the Mediterranean: a review. Evid Based Complement Alternat Med 2006; 3: 229–235

[97] Abu-Rish EY, Kasabri V, Hudaib MM, Mashalla SH, AlAlawi LH, Tawaha K, Mohammad MK, Mohamed YS, Bustanji Y. Evaluation of antiproliferative activity of some traditional anticancer herbal remedies from Jordan. Trop J Pharm Res 2016; 15: 469–474

[98] Nawash O, Shudiefat M, Al-Tabini R, Al-Khalidi K. Ethnobotanical study of medicinal plants commonly used by local bedouins in the badia region of Jordan. J Ethnopharmacol 2013; 148: 921–925

[99] Talib WH, Mahasneh AM. Antiproliferative activity of plant extracts used against cancer in traditional medicine. Sci Pharm 2010; 78: 33–45

[100] Dababneh BF. Antimicrobial activity of selected Jordanian medicinal plant extracts against pathogenic microorganisms. J Food Agric Environ 2008; 6: 134–139

[101] Alzweiri M, Sarhan AA, Mansi K, Hudaib M, Aburjai T. Ethnopharmacological survey of medicinal herbs in Jordan, the Northern Badia region. J Ethnopharmacol 2011; 137: 27–35

[102] El-Mokasabi FM, Al-Sanousi AF, El-Mabrouk RM. Taxonomy and ethnobotany of medicinal plants in eastern region of Libya. J Environ Sci Toxicol Food Technol 2018; 12: 14–23

[103] El Atki Y, Aouam I, El Kamari F, Taroq A, Lyoussi B, Taleb M, Abdellaoui A. Total phenolic and flavonoid contents and antioxidant activities of extracts from *Teucrium polium* growing wild in Morocco. Mater Today Proc 2019; 13: 777–783

[104] El Amrani F, Rhallab A, Alaoui T, El Badaoui K, Chakir S. Ethnopharmacological survey of some plants used for the treatment of diabetes in the region of Meknès-Tafilalet (Morocco). Phytotherapie 2010; 8: 161–165

[105] Fakchich J, Elachouri M. Ethnobotanical survey of medicinal plants used by people in Oriental Morocco to manage various ailments. J Ethnopharmacol 2014; 154: 76–87

[106] Ali-Shtayeh MS, Jamous RM, Jamous RM. Traditional Arabic Palestinian ethnoveterinary practices in animal health care: A field survey in the West Bank (Palestine). J Ethnopharmacol 2016; 182: 35–49

[107] Jaradat NA, Ayesh OI, Anderson C. Ethnopharmacological survey about medicinal plants utilized by herbalists and traditional practitioner healers for treatments of diarrhea in the West Bank/Palestine. J Ethnopharmacol 2016; 182: 57–66

[108] Suleiman MS, Abdul-Ghani AS, Al-Khalil S, Amin R. Effect of *Teucrium polium* boiled leaf extract on intestinal motility and blood pressure. J Ethnopharmacol 1988; 22: 111–116

This document was downloaded for personal use only. Unauthorized distribution is strictly prohibited.

[109] Khader M, Bresgen N, Eckl PM. Antimutagenic effects of ethanolic extracts from selected Palestinian medicinal plants. J Ethnopharmacol 2010; 127: 319–324

[110] Qabaha KI. Antimicrobial and free radical scavenging activities of five Palestinian medicinal plants. Afr J Tradit Complement Altern Med 2013; 10: 101–108

[111] Harlev E, Nevo E, Mirsky N, Ofir R. Antidiabetic attributes of desert and steppic plants: a review. Planta Med 2013; 79: 425–436

[112] Hammiche V, Maiza K. Traditional medicine in Central Sahara: pharmacopoeia of Tassili N'ajjer. J Ethnopharmacol 2006; 105: 358–367

[113] Mossa JS, Al-Yahya MA, Al-Meshal IA. Medicinal Plants of Saudi Arabia. Riyadh: King Saud University Press; 2000

[114] Rahman MA, Mossa JS, Al-Said MS, Al-Yahya MA. Medicinal plant diversity in the flora of Saudi Arabia: a report on seven plant families. Fitoterapia 2004; 75: 149–161

[115] Alachkar A, Jaddouh A, Elsheikh MS, Bilia AR, Vincieri FF. Traditional medicine in Syria: folk medicine in Aleppo governorate. Nat Prod Commun 2011; 6: 79–84

[116] Bulut G, Doğan A, Şenkardeş İ, Avci R, Tuzlaci E. The medicinal and wild food plants of Batman City and Kozluk District (Batman-Turkey). Agric Conspec Sci 2019; 84: 29–36

[117] Demirci S, Özhatay N. An ethnobotanical study in Kahramanmaraş (Turkey); wild plants used for medicinal purpose in Andirin, Kahramanmaraş. Turk J Pharm Sci 2012; 9: 75–92

[118] Güneş S, Savran A, Paksoy MY, Koşar M, Çakılcıoğlu U. Ethnopharmacological survey of medicinal plants in Karaisalı and its surrounding (Adana-Turkey). J Herb Med 2017; 8: 68–75

[119] Cakilcioglu U, Khatun S, Turkoglu I, Hayta S. Ethnopharmacological survey of medicinal plants in Maden (Elazig-Turkey). J Ethnopharmacol 2011; 137: 469–486

[120] Çakilcioğlu U, Şengün MT, Türkoğlu I. An ethnobotanical survey of medicinal plants of Yazikonak and Yurtbaşi districts of Elaziğ province, Turkey. J Med Plants Res 2010; 4: 567–572

[121] Akgul A, Akgul A, Senol SG, Yildirim H, Secmen O, Dogan Y. An ethnobotanical study in Midyat (Turkey), a city on the silk road where cultures meet. J Ethnobiol Ethnomed 2018; 14: 12

[122] Akin M, Oguz D, Saracoglu H. Antibacterial activity of essential oil from *Thymbra spicata* var. *spicata* L. and *Teucrium polium* (Stapf Brig.). Interventions 2010; 8: 53–58

[123] Polat R, Cakilcioglu U, Satil F. Traditional uses of medicinal plants in Solhan (Bingöl – Turkey). J Ethnopharmacol 2013; 148: 951–963

[124] Le Floc'h E. Contribution a une etude ethnobotanique de la flore tunisienne, vol 2. Tunis: Publications Scientifiques Tunisiennes; 1983

[125] Facciola S. Cornucopia – A Source Book of edible Plants. California, USA: Kampong Publications; 1990

[126] Jamous RM, Ali-Shtayeh MS, Abu-Zaitoun SY, Markovics A, Azaizeh H. Effects of selected Palestinian plants on the *in vitro* exsheathment of the third stage larvae of gastrointestinal nematodes. BMC Vete Res 2017; 13: 308

[127] Ali-Shtayeh MS, Jamous RM, Jamous RM. Complementary and alternative medicine use amongst Palestinian diabetic patients. Complement Ther Clin 2012; 18: 16–21

[128] Meguellati H, Ouafi S, Saad S, Djemouai N. Evaluation of acute, subacute oral toxicity and wound healing activity of mother plant and callus of *Teucrium polium* L. subsp. *geyrii* Maire from Algeria. S Afr J Bot 2019; 127: 25–34

[129] Meguellati H, Ouafi S, Saad S. Callogenesis and analgesic evaluation of adult plant extracts and callus in *Teucrium polium* L. subsp. *geyrii* Maire. J Biol Sci 2018; 18: 192–200

[130] Liu XC, Liu SL, Liu ZL. GC-MS Analysis of the Essential Oil and Insecticidal Activity of *Teucrium quadrifarium* Buch.-Ham. (Lamiaceae) Aerial Parts against *Liposcelis bostrychophil*. J Essent Oil Bear Pl 2019; 19: 1794–1800

[131] Ben Sghaier M, Chraief I, Skandrani I, Bouhlel I, Boubaker J, Kilani S, Neffati A, Mahmoud A, Hammami M, Chekir-Ghedira L, Ghedira K. Chemical composition and antimicrobial activity of the essential oil of *Teucrium ramosissimum* (Lamiaceae). Chem Biodivers 2007; 4: 1480–1486

[132] Henchiri H, Bodo B, Deville A, Dubost L, Zourgui L, Raies A, Grellier P, Mambu L. Sesquiterpenoids from *Teucrium ramosissimum*. Phytochemistry 2009; 70: 1435–1441

[133] Srivastava DK, Saggoo MIS. Few medicinal plants of family Labiatae and Scrophulariaceae in the high altitude cold desert areas of Lahaul-Spiti and its adjoining areas of Himachal Pradesh (India). Insight Int J Sci 2015; 2: 75–81

[134] Ahmed MJ, Akhtar T. Indigenous knowledge of the use of medicinal plants in Bheri, Muzaffarabad, Azad Kashmir, Pakistan. Eur J Integr Med 2016; 8: 560–569

[135] Aksoy-Sagirli P, Ozsoy N, Ecevit-Genc G, Melikoglu G. *In vitro* antioxidant activity, cyclooxygenase-2, thioredoxin reductase inhibition and DNA protection properties of *Teucrium sandrasicum* L. Ind Crops Prod 2015; 74: 545–550

[136] Chemli R, Elaissi A, Ben Salah M, Marzouk Z, Mahmoud A. Enquête Ethnobotanique en Tunisie. Tunis: Secrétariat d'état de la recherche scientifique de Tunisie; 1993

[137] Allen ED, Hatfield G. Medicinal Plants in Folk Medicine: an Ethonobotany of Britain & Ireland. Portland, Oregon, USA: Timber Press Inc.; 2004

[138] Zargari A. Medicinal Plants, Vol. 4. Tehran: Tehran University Publications; 1993: 132–133

[139] Lans C, Turner N, Khan T, Brauer G, Boepple W. Ethnoveterinary medicines used for ruminants in British Columbia, Canada. J Ethnobiol Ethnomed 2007; 3: 11

[140] Gastaldo P. Compendio della flora officinale italiana. Padova: Piccin Editor; 1987

[141] Pardo-de-Santayana M. Salud y tradición popular. Guía de las plantas medicinales de Cantabria. Santander: Librería Estudio; 2004

[142] Hisham A, Pathare N, Al-Saidi S. The composition and antimicrobial activity of the essential oil of *Teucrium stocksianum* subsp. *stocksianum* leaf from Oman. Nat Prod Commun 2006; 1: 195–199

[143] Migahid AM. Flora of Saudi Arabia, II. Saudi Arabia: Riyadh University Press; 1978: 463

[144] Sonboli A, Bahadori MB, Dehghan H, Aarabi L, Savehdroudi P, Nekuei M, Pournaghi N, Mirzania F. Chemotaxonomic importance of the essential-oil composition in two subspecies of *Teucrium stocksianum* Boiss. from Iran. Chem Biodivers 2013; 10: 687–694

[145] Ahmad L, Semotiuk A, Zafar M, Ahmad M, Sultana S, Liu QR, Zada MP, Abidin SZU, Yaseen G. Ethnopharmacological documentation of medicinal plants used for hypertension among the local communities of DIR Lower, Pakistan. J Ethnopharmacol 2015; 175: 138–146

[146] Rehman K, Mashwani ZUR, Khan MA, Ullah Z, Chaudhary HJ. An ethno botanical perspective of traditional medicinal plants from the Khattak tribe of Chonthra Karak, Pakistan. J Ethnopharmacol 2015; 165: 251–259

[147] Ullah R, Hussain Z, Iqbal Z, Hussain J, Khan FU, Khan N, Muhammad Z, Ayaz S, Ahmad S, Rehman NU, Hussain I. Traditional uses of medicinal plants in Darra Adam Khel NWFP Pakistan. J Med Plants Res 2010; 4: 1815–1821

[148] Rahim G, Qureshi R, Arshad M, Gulfraz M. Phytochemical analysis and antioxidant properties of *Teucrium stocksianum* flower from Malakand Division, Pakistan. Int J Agr Biol 2013; 15: 377–381

[149] Rahim G, Qureshi R, Gulfraz M, Arshad M, Rahim S. Preliminary phytochemical screening and ethnomedicinal uses of *Teucrium stocksianum* from Malakand Division. J Med Plants Res 2012; 6: 704–707

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[150] Uddin G, Rauf A, Siddiqui BS, Khan H, Barkatullah, Ullah R. Antinociceptive, antioxidant and phytochemical studies of Pakistani medicinal plants. Pak J Pharm Sci 2016; 29: 929–933

[151] Ibrar M, Hussain F. Ethnobotanical studies of plants of Charkotli hills, Batkhela district, Malakand, Pakistan. Front Biol China 2009; 4: 539–548

[152] Hao X, Zhang J, Zhan G, Xue Y, Luo Z, Yao G, Zhang Y. Chemical constituents from *Teucrium viscidum*. Biochem Syst Ecol 2013; 51: 78–82

[153] Srithi K, Trisonthi C, Wangpakapattanawong P, Balslev H. Medicinal plants used in Hmong women's healthcare in northern Thailand. J Ethnopharmacol 2012; 139: 119–135

[154] Tounekti T, Mahdhi M, Khemira H. Ethnobotanical study of indigenous medicinal plants of Jazan region, Saudi Arabia. Evid Based Complement Alternat Med 2019; 2019: 3190670

[155] Mothana R, Gruenert R, Bednarski PJ, Lindequist U. Evaluation of the *in vitro* anticancer, antimicrobial and antioxidant activities of some Yemeni plants used in folk medicine. Pharmazie 2009; 64: 260–268

[156] Ali NAA, Wurster M, Arnold N, Lindequist U, Wessjohann L. Chemical composition of the essential oil of *Teucrium yemense* Deflers. Rec Nat Prod 2008; 2: 25–32

[157] Charters ML. California Plant Names: Latin and Greek Meanings and Derivations. A Dictionary of Botanical and Biographical Etymology. Accessed June 17, 2020 at: http://www.calflora.net/botanicalnames/pageT.html

[158] Navarro T, El Oualidi J. Sinopsis of *Teucrium* L. (Lamiaceae) in the Mediterranean region and surrounding areas. Flora Med 2000; 10: 349–363

[159] Bahramikia S, Yazdanparast R. Phytochemistry and medicinal properties of *Teucrium polium* L. (Lamiaceae). Phytother Res 2012; 26: 1581–1593

[160] Stanković MS, Zlatić MN. Ethnobotany of *Teucrium* species. In: Martinez JL, Muñoz-Acevedo A, Rai M, eds. Ethnobotany: Local Knowledge and Traditions. Boca Raton, USA: CRC Press, Taylor & Francis Group; 2019: 214–231

[161] de Boer YS, Sherker AH. Herbal and dietary supplement-induced liver injury. Clin Liver Dis 2017; 21: 135–149

[162] Arnold N. Contribution à la connaissance ethnobotanique et médicinale de la flore de Chypre. Tome III. Paris: Université René Descartes; 1985: 1203–1210

[163] Muselli A, Desjobert JM, Paolini J, Bernardini AF, Costa J, Rosa A, Dessi MA. Chemical composition of the essential oils of *Teucrium chamaedrys* L. from Corsica and Sardinia. J Essent Oil Res 2009; 21: 138–143

[164] Djabou N, Lorenzi V, Guinoiseau E, Andreani S, Giuliani MC, Desjobert JM, Bolla JM, Costa J, Berti L, Luciani A, Muselli A. Phytochemical composition of Corsican *Teucrium* essential oils and antibacterial activity against foodborne or toxi-infectious pathogens. Food Control 2013; 30: 354–363

[165] Bezić N, Vuko E, Dunkić V, Ruščić M, Blažević I, Burčul F. Antiphytoviral activity of sesquiterpene-rich essential oils from four Croatian *Teucrium* species. Molecules 2011; 16: 8119–8129

[166] Morteza-Semnani K, Akbarzadeh M, Rostami B. The essential oil composition of *Teucrium chamaedrys* L. from Iran. Flavour Frag J 2005; 20: 544–546

[167] Kazemizadeh Z, Basiri A, Habibi Z. Chemical composition of the essential oil of *Teucrium hyrcanicum* and *T. chamaedrys* L. subsp. *chamaedrys* from Iran. Chem Nat Comp 2008; 44: 651–653

[168] Hajdari A, Mustafa B, Hyseni L, Bajrami A, Mustafa G, Quave CL, Nebija D. Phytochemical study of eight medicinal plants of the lamiaceae family traditionally used as tea in the Sharri Mountains region of the Balkans. Sci World J 2020; 2020: 4182064

[169] Kovacevic NN, Lakusic BS, Ristic MS. Composition of the essential oils of seven *Teucrium* species from Serbia and Montenegro. J Essent Oil Res 2001; 13: 163–165

[170] Özel MZ, Göğüş F, Lewis AC. Determination of *Teucrium chamaedrys* volatiles by using direct thermal desorption-comprehensive two-dimensional gas chromatography-time-of-flight mass spectrometry. J Chromatogr A 2006; 1114: 164–169

[171] Bagci E, Yazgin A, Hayta S, Cakilcioglu U. Composition of the essential oil of *Teucrium chamaedrys* L. (Lamiaceae) from Turkey. J Med Plants Res 2010; 4: 2588–2590

[172] Küçük M, Güleç C, Yaşar A, Üçüncü O, Yayli N, Coşkunçelebi K, Terzioğlu S, Yayli N. Chemical composition and antimicrobial activities of the essential oils of *Teucrium chamaedrys* subsp. *chamaedrys*, *T. orientale* var. *puberulens*, and *T. chamaedrys* subsp. *lydium*. Pharm Biol 2006; 44: 592–599

[173] Kaya A, Demirci B, Başer KHC. Compositions of essential oils and trichomes of *Teucrium chamaedrys* L. subsp. *trapezunticum* Rech. fil. and subsp. *syspirense* (C. Koch) Rech. fil. Chem Biodivers 2009; 6: 96–104

[174] Sajjadi SE, Shookohinia Y. Composition of the essential oil of *Teucrium chamaedrys* L. subsp. *syspirense* (C. Koch) rech. fil. growing wild in Iran. J Esset Oil Bear Pl 2010; 13: 175–180

[175] Tzakou O, Roussis V, Loukis A, Harvala C, Galati EM, Germanò MP. Essential oil analysis of *Teucrium divaricatum* Heldr. ssp. *divaricatum* growing in Greece. Flavour Fragr J 1997; 12: 113–115

[176] Stanic G, Petricic J, Blazevic N, Plazibat M. Essential oil of *Teucrium flavum* L. from Croatia. J Essent Oil Res 1993; 5: 625–627

[177] Menichini F, Conforti F, Rigano D, Formisano C, Piozzi F, Senatore F. Phytochemical composition, anti-inflammatory and antitumour activities of four *Teucrium* essential oils from Greece. Food Chem 2009; 115: 679–686

[178] Baher ZF, Mirza M. Volatile constituents of *Teucrium flavum* L. from Iran. J Essent Oil Res 2003; 15: 106–107

[179] Presti ML, Crupi ML, Costa R, Dugo G, Mondello L, Ragusa S, Santi L. Seasonal variations of *Teucrium flavum* L. essential oil. J Essent Oil Res 2010; 22: 211–216

[180] Sagratini G, Maggi F, Blek T, Papa F, Vittori S. Analysis of the volatile compounds of *Teucrium flavum* L. subsp. *flavum* (Lamiaceae) by headspace solid-phase microextraction coupled to gas chromatography with flame ionisation and mass spectrometric detection. Nat Prod Res 2012; 26: 1339–1347

[181] Maggi F, Bilek T, Cristalli G, Papa F, Sagratini G, Vittori S. Comparison of the characterization of the fruit-like aroma of *Teucrium flavum* L. subsp. *flavum* by hydrodistillation and solid-phase micro-extraction. J Sci Food Agric 2009; 89: 2505–2518

[182] Flamini G, Cioni PL, Baldini R, Maccioni S, Bedini G. Composition of the essential oil of two populations of *Teucrium flavum* L. subsp. *flavum*, collected on calcareous soil (Caprione – Eastern Liguria) and on ophiolitic soil (Leghorn Hills). Atti Soc Tosc Sci Nat Mem, Serie B 2011; 118: 15–21

[183] Formisano C, Rigano D, Senatore F, Bruno M, Maggio A, Piozzi F. Chemical composition of the essential oil of *Teucrium flavum* ssp. *flavum* from Zakynthos, Greece. Rec Nat Prod 2012; 6: 306–310

[184] Djabou N, Battesti MJ, Allali H, Desjobert JM, Varesi L, Costa J, Muselli A. Chemical and genetic differentiation of Corsican subspecies of *Teucrium flavum* L. Phytochemistry 2011; 72: 1390–1399

[185] Hammami S, El Mokni R, Faidi K, Falconieric D, Piras A, Procedda S, Mighria Z, El Aouni MH. Chemical composition and antioxidant activity of essential oil from aerial parts of *Teucrium flavum* L. subsp. *flavum* growing spontaneously in Tunisia. Nat Prod Res 2015; 29: 2336–2340

[186] Djabou N, Andreani S, Varesi L, Tomi F, Costa J, Muselli A. Analysis of the volatile fraction of *Teucrium marum* L. Flavour Fragr J 2013; 28: 14–24

[187] Sanz J, Mus M, Rossello JA. Volatile components variation in the *Teucrium marum* complex (Lamiaceae) from the Balearic Islands. Bot J Linn Soc 2000; 132: 253–261

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[188] Ricci D, Fraternale D, Giamperi L, Bucchini A, Epifano F, Burini G, Curini M. Chemical composition, antimicrobial and antioxidant activity of the essential oil of *Teucrium marum* (Lamiaceae). J Ethnopharmacol 2005; 98: 195–200

[189] Kaya A, Demirci B, Dinç M, Dogu S, Baser HC. Compositions of the essential oils of *Teucrium cavernarum* and *Teucrium paederotoides*, two endemic species from Turkey. J Essent Oil Bear Pl 2013; 16: 588–594

[190] De Martino L, Formisano C, Mancini E, De Feo V, Piozzi F, Rigano D, Senatore F. Chemical composition and phytotoxic effects of essential oils from four *Teucrium* species. Nat Prod Commun 2010; 5: 1969–1976

[191] Javidnia K, Miri R, Khosravi AR. Composition of the Essential Oil of *Teucrium persicum* Boiss. From Iran. J Essent Oil Res 2007; 19: 430–432

[192] Masoudi S, Aghajani Z, Rustaiyan A, Feizbakhsh A, Kakhky AM. Volatile constituents of *Teucrium persicum* Boiss., *Thymus caucasicus* Willd. ex Ronniger subsp. *grossheimii* (Ronniger) Jalas. and *Marrubium crassidens* Boiss. three labiatae herbs growing wild in Iran. J Essent Oil Res 2009; 21: 5–7

[193] Cavaleiro C, Salgueiro LR, Miguel MG, Proença da Cunha A. Analysis by gas chromatography-mass spectrometry of the volatile components of *Teucrium lusitanicum* and *Teucrium algarbiensis*. J Chromatogr A 2004; 1033: 187–190

[194] Hachicha SF, Skanji T, Barrek S, Zarrouk H, Ghrabi ZG. Chemical composition of *Teucrium alopecurus* essential oil from Tunisia. J Essent Oil Res 2007; 19: 413–415

[195] Baser KHC, Demirci B, Duman H, Aytaç Z. Composition of the essential oil of *Teucrium antitauricum* T. Ekim. J Essent Oil Res 1999; 11: 61–62

[196] Elabbara FA, Habel AM, Bozkeh NMA, El-Tuonsi ATM, Awin TM. The essential oil composition of *Teucrium apollinis* (Lamiaceae) from Libya. Der Chemica Sinica 2014; 5: 26–27

[197] Pérez I, Blázquez MA, Boira H. Chemotaxonomic value of the essential oil compounds in species of *Teucrium pumilum* aggregate. Phytochemistry 2000; 55: 397–401

[198] Palá-Paúl J, Pérez-Alonso MJ, Velasco-Negueruela A, García-Jiménez N, Jiménez RG, Vargas L. Composition of the essential oil of *Teucrium carolipaui* Pau grown in Spain. J Essent Oil Res 2001; 13: 452–453

[199] Pérez-Alonso MJ, Velasco-Negueruela A, López-Sáez JA. The essential oils of two Iberian *Teucrium* species. J Essent Oil Res 1994; 5: 397–402

[200] Gaspar H, Brito Palma FMS, de La Torre MC, Rodríguez B, Barroso JG, Figueiredo AC. Composition of the essential oil of *Teucrium haenseleri* Boiss. Flavour Fragr J 1997; 12: 355–357

[201] El-Shazly AM, Hussein KT. Chemical analysis and biological activities of the essential oil of *Teucrium leucocladum* Boiss. (Lamiaceae). Biochem Syst Ecol 2004; 32: 665–674

[202] Blázquez MA, Pérez I, Boira H. Essential oil analysis of *Teucrium libanitis* and *T. turredanum* by GC and GC-MS. Flavour Fragr J 2003; 18: 497–501

[203] Velasco-Nagueruela A, Perez Alonzo MJ. Volatile oils of *Teucria* species endemic to Spain. I. *Teucium lusitanicum* subsp. *aureiformis*. Anal Bromatol 1989; 21: 241–248

[204] Al Oraimi MM, Al-Sabahi JN, Weli AM, Selim D, Akhtar MS, Al-Riyami Q, Al-Khanjari S. Chemical composition of essential oil of *Tecurium mascatenses* Bois grown in Oman. J Essent Oil Bear Pl 2012; 15: 822–826

[205] Baser KHC, Demirçakmak B, Duman H. Composition of the essential oils of three *Teucrium* species from Turkey. J Essent Oil Res 1997; 9: 545–549

[206] Vuković N, Milošević T, Sukdolak S, Solujić S. The chemical composition of the essential oil and the antibacterial activities of the essential oil and methanol extract of *Teucrium montanum*. J Serbian Chem Soc 2008; 73: 299–305

[207] Vukovic N, Milosevi T, Sukdolak S, Solujic S. Antimicrobial activities of essential oil and methanol extract of *Teucrium montanum*. Evid Based Complement Alternat Med 2007; 4 (Suppl. 1): 17–20

[208] Radulović N, Dekić M, Joksović M, Vukićević R. Chemotaxonomy of Serbian *Teucrium* species inferred from essential oil chemical composition: the case of *Teucrium scordium* L. ssp. *scordioides*. Chem Biodivers 2012; 9: 106–122

[209] Pavela R, Benelli G, Canale A, Maggi F, Mártonfi P. Exploring essential oils of Slovak medicinal plants for insecticidal activity: The case of *Thymus alternans* and *Teucrium montanum* subsp. *jailae*. Food Chem Toxicol 2020; 138: 111203

[210] Bendif H, Lazali M, Souilah N, Miara MD, Kazernavičiūtė R, Baranauskienė R, Venskutonis PR, Maggi F. Supercritical CO2 extracts and essential oils from *Teucrium polium* L. growing in Algeria: chemical composition and antioxidant activity. J Essent Oil Res 2018; 30: 488–497

[211] Bendjabeur S, Benchabane O, Bensouici C, Hazzit M, Baaliouamer A, Bitam A. Antioxidant and anticholinesterase activity of essential oils and ethanol extracts of *Thymus algeriensis* and *Teucrium polium* from Algeria. J Food Meas Charact 2018; 12: 2278–2288

[212] Djabou N, Muselli A, Allali H, Dib MEA, Tabti B, Varesi L, Costa J. Chemical and genetic diversity of two Mediterranean subspecies of *Teucrium polium* L. Phytochemistry 2012; 83: 51–62

[213] Fertout-Mouri N, Latrèche A, Mehdadi Z, Toumi-Bénali F, Khaled MB. Chemical composition and antibacterial activity of the essential oil of *Teucrium polium* L. of Tessala Mount (Western Algeria). Phytothérapie 2017; 15: 346–353

[214] Belmekki N, Bendimerad N, Bekhechi C, Fernandez X. Chemical analysis and antimicrobial activity of *Teucrium polium* L. essential oil from Western Algeria. J Med Plants Res 2013; 7: 897–902

[215] Lograda T, Ramdani M, Chalard P, Figueredo G, Deghar A. Chemical analysis and antimicrobial activity of *Teucrium polium* L. essential oil from Eastern Algeria. Am J Adv Drug Deliv 2014; 2: 697–710

[216] Zouaoui N, Chenchouni H, Bouguerra A, Massouras T, Barkat M. Characterization of volatile organic compounds from six aromatic and medicinal plant species growing wild in North African drylands. NFS J 2020; 18: 19–28

[217] Maizi Y, Meddah B, Meddah ATT, Hernandez JAG. Seasonal variation in essential oil content, chemical composition and antioxidant activity of *Teucrium polium* L. growing in Mascara (North West of Algeria). J Appl Biotechnol Rep 2019; 6: 151–157

[218] Chizzola R. Volatile compounds from some wild growing aromatic herbs of the Lamiaceae from southern France. Plant Biosyst 2006; 140: 206–210

[219] Vokou D, Bessiere JM. Volatile constituents of *Teucrium polium*. J Nat Prod 1985; 48: 498–499

[220] Eikani MH, Goodarznia I, Mirza M. Comparison between the essential oil and supercritical carbon dioxide extract of *Teucrium polium* L. J Essent Oil Res 1999; 11: 470–472

[221] Ashnagar A, Gharib Naseri N, Foroozanfar S. Isolation and identification of the major chemical components found in the upper parts of *Teucrium polium* plants grown in Khuzestan Province of Iran. Chin J Chem 2007; 25: 1171–1173

[222] Vahdani M, Faridi P, Zarshenas MM, Javadpour S, Abolhassanzadeh Z, Moradi N, Bakzadeh Z, Karmostaji A, Mohagheghzadeh A, Ghasemi Y. Major compounds and antimicrobial activity of essential oils from five Iranian endemic medicinal plants. Pharmacognosy Journal 2011; 3: 48–53

[223] Zare P, Mahmoudi R, Ehsani A. Biochemical and antibacterial properties of essential oil from *Teucrium polium* using resazurin as the indicator of bacterial cell growth. Pharm Sci 2011; 17: 183–188

[224] Gholivand MB, Piryaei M, Abolghasemi MM, Maassoumi SM. Rapid analysis of volatile components from *Teucrium polium* L. by nanoporous silica-polyaniline solid phase microextraction fibre. Phytochem Anal 2013; 24: 69–74

This document was downloaded for personal use only. Unauthorized distribution is strictly prohibited.

[225] Sadeghi H, Jamalpoor S, Shirzadi MH. Variability in essential oil of *Teucrium polium* L. of different latitudinal populations. Ind Crops Prod 2014; 54: 130–134

[226] Mahmoudi R, Nosratpour S. *Teucrium polium* L. essential oil: phytochemiacl component and antioxidant properties. Int Food Res J 2013; 20: 1697–1701

[227] Mahmoudi R, Zare P, Hassanzadeh P, Nosratpour S. Effect of *Teucrium polium* essential oil on the physicochemical and sensory properties of probiotic yoghurt. J Food Process Pres 2014; 38: 880–888

[228] Mahmoudi R, Zare P, Nosratpour S. Application of *Teucrium polium* essential oil and *Lactobacillus casei* in yoghurt. J Essent Oil Bear Pl 2015; 18: 477–481

[229] Raei F, Ashoori N, Eftekhar F, Yousefzadi M. Chemical composition and antibacterial activity of *Teucrium polium* essential oil against urinary isolates of *Klebsiella pneumoniae*. J Essent Oil Res 2014; 26: 65–69

[230] Keykavousi M, Tarzi BG, Mahmoudi R, Bahhoda H, Kabudari A, Mahalleh SFRP. Study of antibacterial effects of *Teucrium polium* essential oil on *Bacillus cereus* in cultural laboratory and commercial soup. Carpath J Food Sci Technol 2016; 8: 176–183

[231] Sabzeghabaie A, Asgarpanah J. Essential oil composition of *Teucrium polium* L. fruits. J Essent Oil Res 2015; 28: 77–80

[232] Sayyad R, Farahmandfar R. Influence of *Teucrium polium* L. essential oil on the oxidative stability of canola oil during storage. J Food Sci Technol 2017; 54: 3073–3081

[233] Boroomand N, Sadat-Hosseini M, Moghbeli M, Farajpour M. Phytochemical components, total phenol and mineral contents and antioxidant activity of six major medicinal plants from Rayen, Iran. Nat Prod Res 2018; 32: 564–567

[234] Nikpour H, Mousavi M, Asadollahzadeh H. Qualitative and quantitative analysis of *Teucrium polium* essential oil components by GC-MS coupled with MCR and PARAFAC methods. Phytochem Anal 2018; 29: 590–600

[235] Masoudi S. Volatile constituents from different parts of three Lamiaceae herbs from Iran. Iran J Pharm Res 2018; 17: 365–376

[236] Ebadollahi A, Taghinezhad E. Modeling and optimization of the insecticidal effects of *Teucrium polium* L. essential oil against red flour beetle (*Tribolium castaneum* Herbst) using response surface methodology. Inf Process Agric 2020; 7: 286–293

[237] Moghtader M. Chemical composition of the essential oil of *Teucrium polium* L. from Iran. American-Eurasian J Agric Environ Sci 2009; 5: 843–846

[238] Rowshan V, Najafian S. Comparison of volatile compounds in *Teucrium polium* L. by headspace and hydrodistillation techniques. Int J Appl Biol Pharm 2012; 3: 151–157

[239] Purnavab S, Ketabchi S, Rowshan V. Chemical composition and antibacterial activity of methanolic extract and essential oil of Iranian *Teucrium polium* against some of phytobacteria. Nat Prod Res 2015; 29: 1376–1379

[240] Heydarzade A, Moravvej G. Contact toxicity and persistence of essential oils from *Foeniculum vulgare, Teucrium polium* and *Satureja hortensis* against *Callosobruchus maculatus* (Fabricius) (Coleoptera: Bruchidae) adults. Turk Entomol Derg 2012; 36: 507–518

[241] Aburjai T, Hudaib M, Cavrini V. Composition of the essential oil from Jordanian germander (*Teucrium polium* L.). J Essent Oil Res 2006; 18: 97–99

[242] Afifi FU, Abu-Irmaileh BE, Al-Noubani RA. Comparative analysis of the essential oils of *Teucrium polium* L. grown in different arid and semiarid habitats in Jordan. Jordan J Pharma Sci 2009; 2: 42–52

[243] Al-Qudah TS, Shibli RA, Alali FQ. *In vitro* propagation and secondary metabolites production in wild germander (*Teucrium polium* L.). In Vitro Cell Dev Biol Plant 2011; 47: 496–505

[244] Popović A, Šućur J, Orčić D, Štrbac P. Effects of essential oil formulations on the adult insect *Tribolium castaneum* (Herbst) (Col., Tenebrionidae). J Cent Eur Agric 2013; 14: 181–193

[245] El Atki Y, Aouam I, El Kamari F, Taroq A, Lyoussi B, Oumokhtar B, Abdellaoui A. Phytochemistry, antioxidant and antibacterial activities of two Moroccan *Teucrium polium* L. subspecies: Preventive approach against nosocomial infections. Arab J Chem 2020; 13: 3866–3874

[246] Hussain J, Rehman NU, Al-Harrasi A, Ali L, Khan AL, Albroumi MA. Essential oil composition and nutrient analysis of selected medicinal plants in Sultanate of Oman. Asian Pac J Trop Dis 2013; 3: 421–428

[247] Rudakova Y, Popova O. Chemical composition of the essential oil of the *Teucrium polium* L. Clin Pharmacol 2016; 11: 425–428

[248] Hassan MMA, Muhtadi FJ, Al-Badr AA. GLC-mass spectrometry of *Teucrium polium* oil. J Pharm Sci 1979; 68: 800–801

[249] Ibrahim SR, Abdallah HM, Mohamed GA, Farag MA, Alshali KZ, Alsherif EA, Ross SA. Volatile oil profile of some Lamiaceous plants growing in Saudi Arabia and their biological activities. Z Naturforsch C J Biosci 2017; 72: 35–41

[250] Basudan N, Abu-Gabal NS. Phytochemistry and biological properties investigation of *Teucrium polium* L. Int J Pharm Biol Sci 2018; 8: 660–670

[251] Guetata A, Al-Ghamdia FA. Analysis of the essential oil of the germander (*Teucrium polium* L.) aerial parts from the northern region of Saudi Arabia. Int J Appl Biol Pharm 2014; 5: 128–135

[252] Al-Sarar AS, Hussein HI, Abobakr Y, Al-Zabib AAS, Bazeyad AY. Mosquitocidal and repellent activities of essential oils against *Culex pipiens* L. Entomol Res 2020; 50: 182–188

[253] Skouti E, Kattah A, Alachkar A, Ben Hedda J, Vincieri F. Biochemical, antinociceptive and hepatotoxic effects of the chronic administration of *Teucrium polium* essential oil in rats. Int J Pharm Pharm Sci 2012; 4 (Suppl. 3): 193–197

[254] Boulila A, Béjaoui A, Messaoud C, Boussaid M. Variation of volatiles in Tunisian populations of *Teucrium polium* L. (Lamiaceae). Chem Biodivers 2008; 5: 1389–1400

[255] Bakari S, Ncir M, Felhi S, Hajlaoui H, Saoudi M, Gharsallah N, Kadri A. Chemical composition and *in vitro* evaluation of total phenolic, flavonoid, and antioxidant properties of essential oil and solvent extract from the aerial parts of *Teucrium polium* grown in Tunisia. Food Sci Biotechnol 2015; 24: 1943–1949

[256] Essid R, Rahali FZ, Msaada K, Sghair I, Hammami M, Bouratbine A, Aoun K, Limam F. Antileishmanial and cytotoxic potential of essential oils from medicinal plants in Northern Tunisia. Ind Crops Prod 2015; 77: 795–802

[257] Çakir A, Duru ME, Harmandar M, Ciriminna R, Passannanti S. Volatile constituents of *Teucrium polium* L. from Turkey. J Essent Oil Res 1998; 10: 113–115

[258] Sevindik E, Abacı ZT, Yamaner C, Ayvaz M. Determination of the chemical composition and antimicrobial activity of the essential oils of *Teucrium polium* and *Achillea millefolium* grown under North Anatolian ecological conditions. Biotechnol Biotechnol Equip 2016; 30: 375–380

[259] Hayta S, Yazgin A, Bagci E. Constituents of the volatile oils of two *Teucrium* species from Turkey. Bitlis Eren Univ J Sci Technol 2017; 7: 140–144

[260] Kamel A, Sandra P. Gas chromatography-mass spectrometry analysis of the volatile oils of two *Teucrium polium* varieties. Biochem Syst Ecol 1994; 22: 529–532

[261] Kabouche A, Kabouche Z, Ghannadi A, Sajjadi SE. Analysis of the essential oil of *Teucrium polium* ssp. *aurasiacum* from Algeria. J Essent Oil Res 2007; 19: 44–46

[262] Kabouche Z, Boutaghane N, Laggoune S, Kabouche A, Ait-Kaki Z, Benlabed K. Comparative antibacterial activity of five Lamiaceae essential oils from Algeria. Int J Aromather 2005; 15: 129–133

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[263] Bencheikh SE, Ladjel S, Goudjil MB, Mehani M, Zighmi S. Chemical analysis, antimicrobial and antioxidant activity of the essential oil of *Teucrium polium* ssp. *aurasianum* Labiatae. Der Pharma Chem 2015; 7: 308–314

[264] Kerbouche L, Hazzit M, Ferhat MA, Baaliouamer A, Miguel MG. Biological activities of essential oils and ethanol extracts of *Teucrium polium* subsp. *capitatum* (L.) Briq. and *Origanum floribundum* Munby. J Essent Oil Bear Pl 2015; 18: 1197–1208

[265] Mitić V, Jovanović O, Stankov-Jovanović V, Zlatkovic B, Stojanovic G. Analysis of the essential oil of *Teucrium polium* ssp. *capitatum* from the Balkan Peninsula. Nat Prod Commun 2012; 7: 83–86

[266] Cozzani S, Muselli A, Desjobert JM, Bernardini AF, Tomi F, Casanova J. Chemical composition of essential oil of *Teucrium polium* subsp. *capitatum* (L.) from Corsica. Flavour Fragr J 2005; 20: 436–441

[267] Koutsaviti A, Antonopoulou V, Vlassi A, Antonatos S, Michaelakis A, Papachristos DP, Tzakou O. Chemical composition and fumigant activity of essential oils from six plant families against *Sitophilus oryzae* (Col: Curculionidae). J Pest Sci 2018; 91: 873–886

[268] Fanourioua E, Kalivasb D, Dafererac D, Tarantilisc P, Trigasd P, Vahamidisa P, Economoua G. Hippocratic medicinal flora on the Greek Island of Kos: Spatial distribution, assessment of soil conditions, essential oil content and chemotype analysis. J Appl Res Med Aromat Plants 2018; 9: 97–109

[269] Khani A, Heydarian M. Fumigant and repellent properties of sesquiterpene-rich essential oil from *Teucrium polium* subsp. *capitatum* (L.). Asian Pac J Trop Med 2014; 7: 956–961

[270] El Amri J, El Badaoui K, Haloui Z. The chemical composition and the antimicrobial properties of the essential oil extracted from the leaves of *Teucrium capitatum* L. Asian J Pharm Clin Res 2017; 10: 112–115

[271] Antunes T, Sevinate-Pinto I, Barroso JG, Cavaleiro C, Salgueiro LR. Micromorphology of trichomes and composition of essential oil of *Teucrium capitatum*. Flavour Fragr J 2004; 19: 336–340

[272] Othman MB, Bel Hadj Salah-Fatnassi K, Ncibi S, Elaissi A, Zourgui L. Antimicrobial activity of essential oil and aqueous and ethanol extracts of *Teucrium polium* L. subsp. *gabesianum* (L.H.) from Tunisia. Physiol Mol Biol Plants 2017; 23: 723–729

[273] Roukia H, Mahfoud HM, Didi OEM. Chemical composition and antioxidant and antimicrobial activities of the essential oil from *Teucrium polium geyrii* (Labiatae). J Med Plants Res 2013; 7: 1506–1510

[274] Allain P, El Oualidi J, Puech S, Pellecuer J. La variabilité chimique de l'huile essentielle chez Teucrium puechiae Greuter et Burdet sur le littoral Languedocien (France). Biochem Syst Ecol 1994; 22: 239–248

[275] Lahmar A, Bedoui A, Mokdad-Bzeouich I, Dhaouifi Z, Kalboussi Z, Cheraif I, Ghedira K, Chekir-Ghedira L. Reversal of resistance in bacteria underlies synergistic effect of essential oils with conventional antibiotics. Microb Pathog 2017; 106: 50–59

[276] Ghazouani N, Abderrabba M, Bouajila J. *Teucrium ramosissimum* (Lamiaceae): volatile composition, seasonal variation, and pharmaceutical activity. Anal Lett 2015; 49: 1258–1271

[277] Ghazouani N, Sifaoui I, Bachrouch O, Abderrabba M, Pinero JE, Lorenzo-Morales J. Essential oil composition and anti Acanthamoeba studies of *Teucrium ramosissimum*. Exp Parasitol 2017; 183: 207–211

[278] Lahmar A, Morcuende D, Andrade MJ, Chekir-Ghedira L, Estévez M. Prolonging shelf life of lamb cutlets packed under high-oxygen modified atmosphere by spraying essential oils from North-African plants. Meat Sci 2018; 139: 56–64

[279] Salah KBH, Mahjoub MA, Chaumont JP, Michel L, Millet-Clerc J, Chraeif I, Ammar S, Mighri Z, Aouni M. Chemical composition and *in vitro* antifungal and antioxidant activity of the essential oil and methanolic extract of *Teucrium sauvagei* Le Houerou. Nat Prod Res 2006; 20: 1089–1097

[280] Al Yousuf MH, Bashir AK, Dobos Á, Veres K, Nagy G, Máthé I, Blunden G. The composition of the essential oil of *Teucrium stocksianum* from the United Arab Emirate. J Essent Oil Res 2002; 14: 47–48

[281] Bakhtiari M, Asgarpanah J. Volatile constituents of *Teucrium stocksianum* Boiss. fruits from South of Iran. J Essent Oil Bear Pl 2015; 18: 1174–1179

[282] Shah SMM, Ali Khan F, Ali M, Shah SMS, Afridi MS, Ullah N. Molecular profiling of the essential oil of *Teucrium stocksianum* collected at three different stages. Am-Eurasian J Toxicol Sci 2015; 7: 279–285

[283] Shah SMM, Khan S, Shah SMH, Shah SMS. Antimicrobial and cytotoxic potential of the essential oil of *Teucrium stocksianum* Boiss. Am-Eurasian J Toxicol Sci 2016; 8: 42–46

[284] Shah SMM, Ullah F, Shah SMH, Zahoor M, Sadiq A. Analysis of chemical constituents and antinociceptive potential of essential oil of *Teucrium stocksianum* Bioss collected from the North West of Pakistan. BMC Complement Altern Med 2012; 12: 244

[285] Jaimand K, Rezaee MB, Soltanipoor MA, Mozaffarian V. Volatile constituents of *Teucrium stocksianum* Boiss. ssp. *stocksianum* from Iran. J Essent Oil Res 2006; 18: 476–477

[286] Mojab F, Javidnia K, Yazdani D, Rustaiyan A. Essential oil of the aerial parts of *Teucrium stocksianum* Boiss. subsp. *stocksianum* (Lamiaceae) from Iran. Faslnamah-i Giyahan-i Daruyi 2003; 2: 49–53, 60

[287] Ali NAA, Ali NAA, Shari K, Chhetri BK, Dosoky NS, Setzer WN, Al-Fahad AJA, Wessjohann L. Antimicrobial, antioxidant, and cytotoxic activities of *Ocimum forskolei* and *Teucrium yemense* (Lamiaceae) essential oils. Medicines (Basel, Switzerland) 2017; 4: 17

[288] Abdelshafeek KA, Elgattar AA, Zarkoon AH, Alwahash MA, Shahat AA. Investigation of the volatile oils, lipid constituents and biological activity of *Ballota andreuzziana, Teucrium zanonii* and *Verbena tenuisecta* in Libya. Asian Pac J Trop Med 2010; 3: 594–601

[289] Mohan L, Pant CC, Melkani AB, Dev V. Terpenoid composition of the essential oils of *Teucrium royleanum* and *T. quadrifarium*. Nat Prod Commun 2010; 5: 939–942

[290] Tandon S, Mittal AK. Insecticidal and growth inhibitory activity of essential oils of *Boenninghausenia albiflora* and *Teucrium quadrifarium* against *Spilarctia obliqua*. Biochem Syst Ecol 2018; 81: 70–73

[291] Ahmadi L, Mirza M, Shahmir F. Essential oil of *Teucrium melissoides* Boiss. et Hausskn. ex Boiss. J Essent Oil Res 2002; 14: 355–356

[292] Morteza-Semnani K, Saeedi M, Akbarzadeh M. Essential oil composition of *Teucrium scordium* L. Acta Pharm 2007; 57: 499–504

[293] Sharififar F, Mahdavi Z, Mirtajaldini M, Purhematy A. Volatile constituents of aerial parts of *Teucrium scordium* L. from Iran. J Essent Oil Res 2010; 22: 202–204

[294] Gagliano Candela R, Ilardi V, Badalamenti N, Bruno M, Rosselli S, Maggi F. Essential oil compositions of *Teucrium fruticans, T. scordium* subsp. *scordioides* and *T. siculum* growing in Sicily and Malta. Nat Prod Res 2020. doi:10.1080/14786419.2019.1709193

[295] Velasco-Negueruela A, Pérez-Alonso MJ. The volatiles of six *Teucrium* species from the Iberian Peninsula and the Balearic Islands. Phytochemistry 1990; 29: 1165–1169

[296] Lawrence BM, Hogg JW, Terhune SJ, Morton JK, Gill LS. Terpenoid composition of some Canadian Labiatae. Phytochemistry 1972; 11: 2636–2638

[297] Djabou N, Paolini J, Desjobert JM, Allali H, Baldovini N, Costa J, Muselli A. Qualitative and quantitative analysis of volatile components of *Teucrium massiliense* L. – identification of 6-methyl-3-heptyl acetate as a new natural product. Flavour Fragr J 2010; 25: 475–487

[298] Giamperi L, Bucchini A, Fraternale D, Cara P, Ricci D, Epifano F, Genovese S, Curini M. Chemical composition and antioxidant activity of the essential oil of *Teucrium massiliense* L. J Essent Oil Res 2008; 20: 446–449

[299] Tahoum N, Arakrak A, Bakkali M, Jatunov SS, Franconetti AG, Guillen MG, Escribano FC, Laglaoui A. Chemical composition of essential oil of

This document was downloaded for personal use only. Unauthorized distribution is strictly prohibited.

Teucrium pseudoscorodonia subsp. *baeticum*, endemic plant of north of Morocco. Int J Adv Res 2017; 5: 914–919

[300] Saroglou V, Arfan M, Shabir A, Hadjipavlou-Litina D, Skaltsa H. Composition and antioxidant activity of the essential oil of *Teucrium royleanum* Wall. ex Benth growing in Pakistan. Flavour Fragr J 2007; 22: 154–157

[301] Cavaleiro C, Salgueiro LR, Antunes T, Sevinate-Pinto I, Barroso JG. Composition of the essential oil and micromorphology of trichomes of *Teucrium salviastrum*, an endemic species from Portugal. Flavour Fragr J 2002; 17: 287–291

[302] Servettaz O, Pinetti A, Bellesia F, Bini Malec L. Micromorphological and phytochemical research on *Teucrium scorodonia* and *Teucrium siculum* from the Italian Flora. Bot Acta 1994; 107: 416–421

[303] Djabou N, Allali H, Battesti MJ, Tabti B, Cost J, Muselli A, Varesi L. Chemical and genetic differentiation of two Mediterranean subspecies of *Teucrium scorodonia* L. Phytochemistry 2012; 74: 123–132

[304] Maccioni S, Baldini R, Tebano M, Cioni PL, Flamini G. Essential oil of *Teucrium scorodonia* L. ssp. *scorodonia* from Italy. Food Chem 2007; 104: 1393–1395

[305] Makowczynska J, Sliwinska E, Kalemba D, Piatczak E, Wysokinska H. *In vitro* propagation, DNA content and essential oil composition of *Teucrium scorodonia* L. ssp. scorodonia. Plant Cell Tiss Organ Cult 2016; 127: 1–13

[306] Blazevic N, Kalodera Z, Petricic J, Plazibat M. Essential oil content and composition of *Teucrium arduini* L. J Essent Oil Res 1993; 4: 223–225

[307] Dunkić V, Bezić N, Vuko E. Antiphytoviral activity of essential oil from endemic species *Teucrium arduini*. Nat Prod Commun 2011; 6: 1385–1388

[308] Kremer D, Müller ID, Dunkić V, Vitali D, Stabentheiner E, Oberländer A, Bezić N, Kosalec I. Chemical traits and antimicrobial activity of endemic *Teucrium arduini* L. from Mt Biokovo (Croatia). Cent Eur J Biol 2012; 7: 941–947

[309] Kremer D, Kosir IJ, Kosalec I, Koncic MZ, Potocnik T, Cerenak A, Bezic N, Srecec S, Dunkic V. Investigation of chemical compounds, antioxidant and antimicrobial properties of *Teucrium arduini* L. (Lamiaceae). Curr Drug Targets 2013; 14: 1006–1014

[310] Vukovic N, Sukdolak S, Solujic S, Mihailovic V, Mladenovic M, Stojanovic J, Stankovic MS. Chemical composition and antimicrobial activity of *Teucrium arduini* essential oil and cirsimarin from Montenegro. J Med Plants Res 2011; 5: 1244–1250

[311] Kremer D, Bolarić S, Ballian D, Bogunić F, Stesević D, Karlović K, Kosalec I, Vokurka A, Vuković Rodriguez J, Randić M, Bezić N, Dunkić V. Morphological, genetic and phytochemical variation of the endemic *Teucrium arduini* L. (Lamiaceae). Phytochemistry 2015; 116: 111–119

[312] Kazemizadeh Z, Habibi Z, Moradi A. Chemical composition of the essential oils of two populations *Teucrium hyrcanicum* L. in two different localities. J Med Plants 2008; 7: 87–93

[313] Mohammad AR, Vahideh N, Seyed AA, Fatemeh S. Variation in essential oil composition of *Teucrium hyrcanicum* L. from Iran-A rich source of (*E*)-α-bergamotene. Nat Prod Res 2018; 33: 1227–1232

[314] Morteza-Semnani K, Saeedi M, Akbarzadeh M. Chemical composition and antimicrobial activity of essential oil of *Teucrium hyrcanicum* L. J Essent Oil Bear Pl 2011; 14: 770–775

[315] Doğu S, Dinç M, Kaya A, Demirci B. Taxonomic status of the subspecies of *Teucrium lamiifolium* in Turkey: reevaluation based on macro- and micro-morphology, anatomy and chemistry. Nord J Bot 2013; 31: 198–207

[316] Barroso JG, Pedro LG, Figueiredo AC, Antunes T, Sevinate-Pinto I, Scheffer JJC. The essential oils of two endemic *Teucrium* species from Madeira: *T. abutiloides* L'Hér. and *T. betonicum* L'Hér. Flavour Fragr J 1993; 8: 277–280

[317] Barroso JG, Figueiredo AC, Pedro LG, Antunes T, Sevinate-Pinto I, Fontinha SS, Scheffer JJC. Composition of the essential oil of *Teucrium heteropbyllum* L'Hér. grown on Madeira. Flavour Fragr J 1996; 11: 129–132

[318] Velasco-Negueruela A, Pérez-Alonso MJ, Palá-Paul J, Ramos-Vázquez P, De Páz PLP, Vallejo MCG. Composition of the essential oil of *Teucrium heterophyllum* l'Hér. grown in the Canary Islands. J Essent Oil Res 1999; 11: 553–555

[319] Semiz G, Çelik G, Gönen E, Semiz A. Essential oil composition, antioxidant activity and phenolic content of endemic *Teucrium alyssifolium* Staph. (Lamiaceae). Nat Prod Res 2016; 30: 2225–2229

[320] Valentini G, Bellomaria B, Arnold N. Essential oil of *Teucrium creticum* L. from Cyprus. J Essent Oil Res 1997; 9: 649–652

[321] Flamini G, Cioni PL, Morelli I, Maccioni S, Monti G. Composition of the essential oil of *Teucrium fruticans* L. from the Maremma Regional Park (Tuscany, Italy). Flavour Fragr J 2001; 16: 367–369

[322] Polat T, Özer H, Öztürk E, Çakir A, Kandemir A, Demir Y. Chemical composition of the essential oil of *Teucrium multicaule* Montbret et Aucher ex Bentham from Turkey. J Essent Oil Res 2010; 22: 443–445

[323] Aberumand M, Asgarpanah J. Essential oil composition of *Teucrium orientale* subsp. *glabrescens* from Iran. Chem Nat Comp 2017; 53: 381–382

[324] Özek G, Özek T, Dinç M, Doğu S, Başera KHC. Chemical diversity of volatiles of *Teucrium orientale* L. var. *orientale*, var. *puberulens*, and var. *glabrescens* determined by simultaneous GC-FID and GC/MS techniques. Chem Biodivers 2012; 9: 1144–1154

[325] Yildirmis S, Aliyaziciogl R, Eyupoglu OE, Ozgen U, Alpay Karaoglu S. Biological activity and characterization of volatile compounds of *Teucrium orientale* var. *glabrescens* by SPME and GC-FID/MS. J Food Biochem 2017; 41: e12284

[326] Javidnia K, Miri R. Composition of the essential oil of *Teucrium orientate* L. ssp. *orientate* from Iran. J Essent Oil Res 2003; 15: 118–119

[327] Yildirim A, Cakir A, Mavi A, Yalcin M, Fauler G, Taskesenligil Y. The variation of antioxidant activities and chemical composition of essential oils of *Teucrium orientale* L. var. *orientale* during harvesting stages. Flavour Fragr J 2004; 19: 367–372

[328] Kucukbay FZ, Yildiz B, Kuyumcu E, Gunal S. Chemical composition and antimicrobial activities of the essential oils of *Teucrium orientale* var. *orientale* and *Teucrium orientale* var. *puberulens*. Chem Nat Comp 2011; 47: 833–836

[329] Amiri H. Antioxidant activity of the essential oil and methanolic extract of *Teucrium orientale* (L.) subsp. *taylori* (Boiss.) Rech. F. Iran J Pharm Res 2010; 9: 417–423

[330] Amiri H. Chemical composition of essential oil of *Teucrium orientate* L. subsp. *taylori* (Boiss.) Rech. f. J Med Plants 2008; 7: 100–104

[331] Bagci E, Hayta S, Yazgin A, Dogan G. Composition of the essential oil of *Teucrium parviflorum* L. (Lamiaceae) from Turkey. J Med Plants Res 2011; 5: 3457–3460

[332] Jaradat N, Al-lahham S, Abualhasan MN, Bakri A, Zaide H, Hammad J, Hussein F, Issa L, Mousa A, Speih R. Chemical constituents, antioxidant, cyclooxygenase inhibitor, and cytotoxic activities of *Teucrium pruinosum* Boiss. essential oil. Biomed Res Int 2018; 2018: 4034689

[333] Hammami S, Jmii H, El Mokni R, Khmiri A, Faidi K, Dhaouadi H, El Aouni MH, Aouni M, Joshi RK. Essential oil composition, antioxidant, cytotoxic and antiviral activities of *Teucrium pseudochamaepitys* growing spontaneously in Tunisia. Molecules 2015; 20: 20426–20433

[334] Kabouche A, Touafek O, Nacer A, Kabouche Z, Bruneau C. Volatile oil constituents of *Teucrium atratum* Pomel from Algeria. J Essent Oil Res 2006; 18: 175–177

[335] Ruberto G, Baratta MT. Antioxidant activity of selected essential oil components in two lipid model systems. Food Chem 2000; 69: 167–174

[336] Smahane B, Mounyr B, Faisl B, Stephane M, Sghir TM, Dalila B. Antimicrobial activities of essential oil of five plant species from Morocco

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against some microbial strains. Int J Res Phytochem Pharmacol 2016; 8: 1901–1906

[337] NIH National Library of Medicine. PubChem. Accessed March 30, 2020 at: https://pubchem.ncbi.nlm.nih.gov/

[338] Kani K, Momota Y, Harada H, Yamamura Y, Aota K, Yamanoi T, Takano H, Motegi K, Azuma M. γ-Tocotrienol enhances the chemosensitivity of human oral cancer cells to docetaxel through the downregulation of the expression of NF-κB-regulated anti-apoptotic gene products. Int J Oncol 2013; 42: 75–82

[339] Abdollahi M, Karimpour H, Monsef-Esfehani HR. Antinociceptive effects of *Teucrium polium* L. total extract and essential oil in mouse writhing test. Pharmacol Res 2003; 48: 31–35

[340] Abbas G, Albroumi MA, Rehman N, Hussain H, Al Harrasi AS. Evaluation of essential oils from *Boswellia sacra* and *Teucrium mascatense* against acetyl cholinesterase enzyme and urease enzyme. Int J Phytomed 2016; 8: 500–505

[341] Ben Sghaier M, Boubaker J, Neffati A, Limem I, Skandrani I, Bhouri W, Bouhlel I, Kilani S, Chekir-Ghedira L, Ghedira K. Antimutagenic and antioxidant potentials of *Teucrium ramosissimum* essential oil. Chem Biodivers 2010; 7: 1754–1763

[342] Bigham M, Hosseininaveh V, Nabavi B, Talebi K, Esmaeilzadeh N. Effects of essential oil from *Teucrium polium* on some digestive enzyme activities of *Musca domestica*. Entomol Res 2010; 40: 37–45

[343] Shahriari M, Sahebzadeh N, Zibaee A. Effect of *Teucrium polium* (Lamiaceae) essential oil on digestive enzyme activities and energy reserves of *Ephestia kuehniella* (Lepidoptera: Pyralidae). Invertebrate Surviv J 2017; 14: 182–189

[344] Ebadollahi A, Sendi JJ, Aliakbar A, Razmjou J. Acaricidal activities of essential oils from *Satureja hortensis* (L.) and *Teucrium polium* (L.) against the two spotted spider mite, *Tetranychus urticae* Koch (Acari: Tetranychidae). Egypt J Biol Pest Control 2015; 25: 171–176

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