

# Chapter 9

## Turkish Oregano (*Origanum* spp.): Biodiversity, Cultivation, Traditional and Commercial Uses



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**Abstract** Different genera and species containing thymol and carvacrol in their essential oil are classified under the name of “Kekik” in Turkey. It is divided into two groups, as oregano and thyme, in the international commerce. Today, most of the *Origanum* species are cultivated under field conditions but it can also be gathered from nature. The main region where *Origanum* species are naturally distributed is the Mediterranean Region. It is also distributed into many parts of the world, though in different ways. Turkey has the largest share in the world’s oregano trade. *Origanum* species have been used for many different purposes since ancient times and they have preserved their important place among medicinal and aromatic plants even today. Due to the strong antibacterial, antifungal and antioxidant effects of their essential oils, they are used for many different purposes in the spice, food and pharmaceutical industries.

**Keywords** *Origanum* · Essential oil · Carvacrol · Tyhmol

### 9.1 Introduction

Different plant species with thymol and carvacrol as their main essential oil components are known as “Kekik” in Turkish because they have similar aroma and flavor. There are about 61 species with such characteristics, and they belong to the Lamiaceae and Verbenaceae families worldwide. The most important genus in the Lamiaceae family is *Origanum*. *Origanum vulgare* and *Origanum onites* appears to be economically important species in this genus. Also, *Lippia* and *Lanata* species from the Verbenaceae family are known as oregano. It is known that oregano consists of two groups: Mediterranean oregano and Mexican oregano. Mediterranean oregano is *Origanum* spp., Mexican oregano is *Lippia* sp. forms. The species known as oregano with economic importance are *Origanum vulgare* (Greek

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oregano), *Origanum onites* (Turkish oregano), *Thymbra capitata* (Spanish oregano), *Lippia origanoides* Kunth (Mexican oreganus). Turkey has the largest share in the world's oregano trade. Mainly *O. onites*, *O. vulgare* subsp. *hirtum*, *O. minutiflorum* Schwartz & P. H. Davis, *O. majorana* L. and *O. syriacum* L. subsp. *bevanii* Greuter&Burget. In addition to these, *T. capitata*, *T. spicata* L. and *T. sintenisii* Bornm. & Azn., *Satureja cuneifolia* Ten., *S. hortensis* L., *S. montana* L., *S. spicigera* and *Thymus eigii* Jalas are exported species (Başer 2001).

## 9.2 Taxonomic Characteristics, Geographical Distribution

There is not a definitive consensus on the taxonomy of *Origanum* spp. and it is still a matter of debate. It consists of 49 taxa and 44 species, according to the morphological features of the *Origanum* genus and classification of the chemical content of essential oils. Iestwaart's classification is still widely accepted today, and it is used in the classification of species belonging to the *Origanum* genus (Table 9.1). These sections are as follows; Sect. Amaracus (Gleditsch) Vogel, Sect. Anatolicon Ietsw., Sect. Breviflametum Ietsw., Sect. Longitubus Ietsw., Sect. Chilocalyx (Briq.) Ietsw., Sect. Majorana (Mill.) Benth., Sect. Campanulaticaly x Ietsw., Sect. Elongataspica Ietsw. Sect. Origanum, and Sect. ProlaticorollaIetsw. It is stated that with the discovery of new species, the number of species increased to 44, and the number of hybrids increased to 20 with natural and artificial hybrids. In general, the chromosome number of *Origanum* species and their hybrids is  $2n = 30$ . There are 21 *Origanum* species in Turkey and out of 13 hybrids 12 are endemic (Arabacı et al. 2021; Genç et al. 2020; Narini 2014; Kintzios 2004).

*Origanum dubium* Boiss. is grown in the wild flora of Turkey, Greece and Cyprus. *O. dubium* is composed of carvacrol, linalool, and linalool carvacrol chemotypes, as well as the thymol chemotype. Recently, Lukas et al. (2013) reported a new basis about the taxonomic uncertainties concerning section Majorana. They assessed the taxonomic status of *O. onites*, *O. syriacum*, *O. dubium* and *O. majorana* and discuss evolutionary relationships in section Majorana by considering molecular, morphological and phytochemical evidence. According to their results, "cymyl" chemotype of *Origanum majorana* L. is classified as *Origanum dubium* Boiss (Turgut et al. 2017).

Nearly about 70% of *Origanum* species are endemic, spreading from the Azores to Taiwan. Most of the species belonging to the *Origanum* genus originate from the Mediterranean region. 75% of these are located in the Eastern Mediterranean Region. In addition, these species spread from coastal regions to high mountains, from east to west in different regions of the world. The distribution table of the *Origanum* section is given below (Henry et al. 2020; Skoula and Harborne 2002; Iestwaart 1980) (Table 9.1). Observing the distribution of the sections, it is seen that Turkey, Greece and Aegean islands are rich in species diversity.

**Table 9.1** Sections of *Origanum* species (Ietswaart 1980)

Section	sp/spp/ssp	Distribution
Amaracus Bentham	<i>O. boissieri</i> Ietswaart	Turkey
	<i>O. calcaratum</i> Jussieu	Greece – Aegean Island, Greece-Crete
	<i>O. cordifolium</i> Vogel	Cyprus, Syria
	<i>O. dictamnus</i> L.	Greece-Crete
	<i>O. saccatum</i> Davis	Turkey
	<i>O. solymicum</i> Davis	Turkey
	<i>O. symes</i> Carlström	Greece – Aegean Island
Anatolicon Bentham	<i>O. akhdarensense</i> Ietswaart et Boulos	Libya
	<i>O. cyrenaicum</i> Beguinot et Vaccari	Libya
	<i>O. hypercifolium</i> Schwarz et Davis	Turkey
	<i>O. libanoticum</i> Boissier	Lebanon
	<i>O. pampaninii</i> Ietswaart	Libya
	<i>O. scabrum</i> Boissier et Heldreich	Greece, Greece-Crete
	<i>O. sipyleum</i> L.	Turkey, Greece – Aegean Island
	<i>O. vetteri</i> Briquet et Barbey	Greece – Aegean Island
Brevifilamentum Ietswaart	<i>O. acutidens</i> Ietswaart	Turkey
	<i>O. bargyli</i> Mouterde	Turkey, Syria
	<i>O. brevidens</i> Dinsmore	Turkey
	<i>O. hausskenechti</i> Boissier	Turkey
	<i>O. husnucan-baserii</i> H. Duman, Z. Aytaç et A. Duran	Turkey
	<i>O. leptocladum</i> Boissier	Turkey
	<i>O. rotundifolium</i> Boissier	Turkey, Georgia
Longitubus Ietswaart	<i>O. amanum</i> Post	Turkey
Chilocalyx Ietswaart	<i>O. bilgeri</i> Davis	Turkey
	<i>O. micranthum</i> Vogel	Turkey
	<i>O. microphyllum</i> Vogel	Greece-Crete
	<i>O. minutiflorum</i> Schwarz et Davis	Turkey
Majorana Bentham	<i>O. majorana</i> L.	Turkey, Cyprus, Greece – Aegean Island
	<i>O. onites</i> L.	Turkey, Greece, Greece – Aegean Island, Greece-Crete, Egypt-Sinai
	<i>O. syriacum</i> L.	Turkey, Cyprus, Syria, Lebanon, Israel, Jordan, Egypt-Sinai
	<i>O. syriacum</i> L. var. <i>syriacum</i>	Israel, Jordan, Syria
	<i>O. syriacum</i> L. var. <i>bevanii</i> Ietswaart	Turkey, Cyprus, Syria, Lebanon
	<i>O. syriacum</i> L. var. <i>sinaicum</i> Ietswaart	Egypt-Sinai

(continued)

**Table 9.1** (continued)

Section	sp/spp/ssp	Distribution
Campanulaticaly x Ietswaart	<i>O. dayi</i> Post	Israel
	<i>O. isthmicum</i> Danin	Israe-N. Sinai
	<i>O. jordanicum</i> Danin and Künne	Jordan
	<i>O. petraeum</i> Danin	Jordan
	<i>O. punonense</i> Danin	Jordan
	<i>O. ramonense</i> Danin	Israel-Negev
Elongataspica Ietswaart	<i>O. elongatum</i> Emberger ex Maire	Morroco
	<i>O. floribundum</i> Munby	Algeria
	<i>O. grosii</i> Pau et Font Quer ex Ietswaart	Morroco
Origanum	<i>O. vulgare</i> L	Azores-Taiwan, N. Africa-Scandinavia
	<i>O. vulgare</i> L. ssp. <i>vulgare</i>	Britian-Scandinavia-Taiwan
	<i>O. vulgare</i> L. ssp. <i>glandulosum</i> Ietswaart	Algeria, Tunisia
	<i>O. vulgare</i> L. ssp. <i>gracile</i> Ietswaart	Turkey-Afganistan-S. Siberia
	<i>O. vulgare</i> L. ssp. <i>hirtum</i> Ietswaart	Turkey, Balkan
	<i>O. vulgare</i> L. ssp. <i>virens</i> Ietswaart	Azores, Madeira, Balearic Israel, Portugal, Spain, Morroco
	<i>O. vulgare</i> L. ssp. <i>viride</i> Hayek	Corse-China
Prolaticorolla Ietswaart	<i>O. compactum</i> Bentham	Spain, Morroco
	<i>O. ehrenbergii</i> Boissier	Lebanon
	<i>O. laevigatum</i> Boissier	Turkey, Cyprus

Abbreviations in the Table: *sp* species, *spp* genres, *ssp* subspecies

### 9.3 Botanical Characteristics

The underground parts of *Origanum* species have a woody structure. The roots of many species, especially those grown in the Eastern Mediterranean, are thick and woody. Above ground parts have a bushy form. The height of the branches varies according to the species, and in some species, it is 10–30 cm tall. Most often the branch height is 30–60 cm, although in some species it can be 60 cm or taller than 1 meter. Stems usually have lateral branches. Except for a few species, all stems are hairy. The leaves are sessile except for a few species. Mostly, the leaves are of similar length, but in certain species they may be larger. Leaf lengths vary between 2 and 40 mm, and widths vary between 2 and 30 mm. There are two types of glands in the leaves, petiolate and non-petiolate. These glands also occur on stems, bracts, calyces, and corollas. The leaves of *Origanum* species may differ in size, shape and thickness, as well as the density, type and size of glandular and non-glandular hairs covering their surfaces. While the glands are numerous in vegetative organs, their

density decreases in generative organs. In the glands, thymol and carvacrol are secreted from the monoterpenes, which are the main components of the essential oil. There are morphological and chemical varieties of *Origanum* species, including carvacrol, thymol, linalool and p-cymene (Dirmenci et al. 2018; Kintzios 2002; Ceylan 1997; Iestwaart 1980). *Origanum syriacum* var. *bevanii* species is 65–70 cm long, the essential oil rate varies between 3–5% and the main component of the essential oil is cis-sabinne hydrate,  $\gamma$ -terpinene, carvacrol and thymol. *Origanum onites* can grow in regions up to 1–400 meters altitude in the Mediterranean climate (Fig. 9.1). The plant can reach up to 1 m in height and the essential oil rate is between 2% and 5%. Carvacrol, thymol and  $\alpha$ -terpinene components are noteworthy as the main components. Some chemotypes have very high levels of linalool. *Origanum vulgare* subsp. *hirtum* is a shorter plant (60–65 cm) than *O. onites*. Its main essential oil component is similar to *O. onites* and its ratio is 3.6–5.7%. The seeds are very small, thousand seeds weigh between 0.2 and 0.3 g. *O. minutiflorum* is an endemic species for Turkey. The essential oil ratio is the same as *O. onites* and contains 40–80% carvacrol, 25% thymol, 13–8% terpinene and 6% p-cymene as the major component. The *O. dubium* formerly called *O. majorana* species is 20–80 cm tall, the Turkish type has a high essential oil content (6.5–7.7%) and is cultivated for essential oil production. Carvacrol ratio varies between 78% and 90% (Aleksseeva et al. 2020; Bozdemir 2019) (Fig. 9.2).



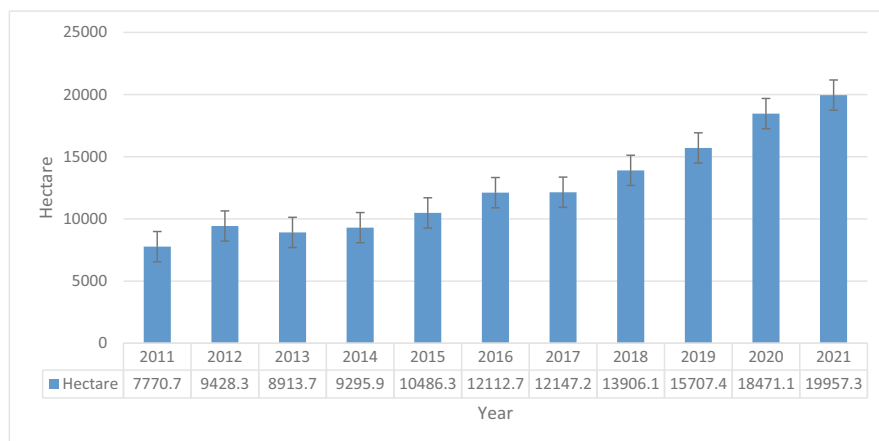
**Fig. 9.1** Natural *Origanum onites* plants in Perge ancient city, Antalya



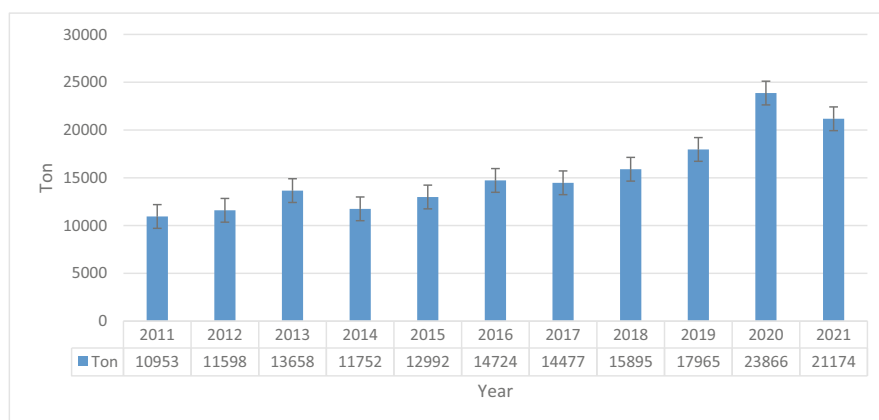
Fig. 9.2 *Origanum onites* field in Denizli Province

## 9.4 Economic Characteristics

*O. majorana* L. is cultivated in France, Greece, Hungary, the United States, Egypt, Germany and other Mediterranean countries. *O. vulgare* L. and *O. syriacum* L. are commercially grown in Israel. In addition, *O. vulgare* L., *O. heracleoticum* L. and *O. majorana* are cultivated in Albania. Turkey has the largest share in the world's oregano trade (Trumpy 2012). The species with thymol and carvacrol in their essential oil are called “kekik”. The Oregano species exported from Turkey are *O. onites* (İzmir oregano, Turkish oregano), *O. vulgare* subsp. *hirtum* (Istanbul oregano, black oregano), *O. minutiflorum* Schwarz & P.H. Davis (Sütçüler oregano, Yayla oregano), *O. dubium* formerly called *O. majorana* L. (White oregano, Alanya oregano) and *O. syriacum* L. subsp. *bevanii* Greuter&Burget (Mountain oregano, Syrian oregano, Israel oregano), *Thymbra capitata* (Spanish oregano), *T. spicata* L., and *T. sintenisii* Bornm. & Min. (Sharp oregano), *Satureja cuneifolia* Ten. (Sater), *S. hortensis* L., *S. montana* L., *S. spicigera* (K. Koch) Boiss. (Trabzon oregano) and *Thymus eigii* (Zohary& Davis) Jalas (Sönmez 2019; Tonçer et al. 2009, 2010; Schulz et al. 2005; Kintzios 2002; Başer 2001; Azcan et al. 2000). Although several *Origanum* species (mainly *O. onites*) are cultivated in Turkey, there are also natural gatherings. Analysing data of the last ten decade, it is seen that the production of oregano increased from 7771 ha in 2011 to 19,957 ha, in 2021 (Fig. 9.3). One of the reasons for this increase may be the high profit margin compared to other products.



**Fig. 9.3** Changes in the territory of Turkish Oregano production in the period 2011–2021. TURKSTAT, Crop Production Statistics, 2022



**Fig. 9.4** Changes in Turkish Oregano production in the period 2011–2021. TURKSTAT, Crop Production Statistics, 2022

Oregano production also increased from 10,953 tons in 2011 to 21,174 tons in 2021. It can be seen that there has been a steady increase over the years (Fig. 9.4). Oregano is mainly cultivated in Denizli (85%) and followed by Manisa (4%) and Uşak (4%). One of the reasons why Turkey has a leading position in the oregano trade is the quality.

In Turkey, studies on cultivar breeding of *Origanum* and *Thymus* species were carried out and eight commercial varieties were developed by institutions and companies. Six out of these varieties generate from *Origanum* species with high yield and quality and two from *T. vulgaris* L. (Table 9.2). More information on these varieties can be found below (Table 9.2). With these varieties, significant

**Table 9.2** Turkey's registered oregano and thyme varieties

Variety name	Registered year	Species	Institution/Company
Ceylan-2002	2002	<i>Origanum onites</i> L.	Ege University, Faculty of Agriculture
Tayşi-2002	2002	<i>Origanum onites</i> L.	Ege University, Faculty of Agriculture
Winter	2015	<i>Thymus vulgaris</i> L.	Anadolu Seed Company
Timo	2015	<i>Thymus vulgaris</i> L.	AG Seed Company
Tınmaz-2015	2015	<i>Origanum vulgare</i> subsp. <i>hirtum</i>	Republic of Turkey Ministry of Agriculture and Forestry, Atatürk Horticultural Central Research Institute
Başer-2015	2015	<i>Origanum vulgare</i> subsp. <i>hirtum</i>	Republic of Turkey Ministry of Agriculture and Forestry, Atatürk Horticultural Central Research Institute
Oğuz-2012	2018	<i>Origanum onites</i> L.	Republic of Turkey Ministry of Agriculture and Forestry, Aegean Agricultural Research Institute
Tekin-2017	2020	<i>O. onites</i> × <i>O. syriacum</i>	GAP International Agricultural Research and Training Center

Bozdemir (2019)

developments have been achieved in the cultivation of high yield crops with the standard quality demanded by the industry.

Due to the open pollination of the plants, the cultivars were developed using the clone selection method, which necessitates vegetative propagation by preventing the propagation of plants using seeds. Tekin-2017 is a commercial variety obtained through hybridization of *O. nites* and *O. syriacum* species.

## 9.5 Cultivation of Turkish Oregano

*Origanum* species are widely traded in the world and *O. onites* L. is the first species cultivated under field conditions. The general principles of Oregano cultivation such as; seed sowing, seedling production, tillage, sowing and planting methods, fertilization, irrigation, weed control, harvest time and method are similar. It is possible to propagate perennial *Origanum* species vegetative and generatively. Since the seeds are very small and germination is very slow, there are some difficulties in sowing directly into the field. Therefore, it is not recommended. The suitable best time for seed sowing and vegetative reproduction in Mediterranean climate conditions is October–November. Seedling pads to be planted are filled with 1/3 sand, 1/3 soil and 1/3 mature animal manure. Then, planting the seeds in specially prepared seedling pads and transplanting the seedlings to the field is the most applied and recommended method. It is important that the seed material is clean and mature in



order to obtain well-developed smooth seedlings. Ripe seeds retain their ability to germinate for 2–3 years (Ceylan 1997). Seed Test Association (ISTA) reported that the seeds of *O. vulgare* and *O. majorana* species started to germinate in seven days at 20–30 °C, and germination was completed in 21 days (ISTA 2014). 1–2 g of seeds is sufficient for approximately 1 m<sup>2</sup> of area. Seedlings should be irrigated regularly, ventilation and weed control should be proper. Plants should be transferred to the field in early spring, approximately 4–5 months after sowing. Old stems or young stems can be used in vegetative production. By cutting the stems, hormones such as IBA (Indole Butyric Acid) that will increase rooting can be applied. In the Mediterranean climate zone, October–November is the best time for bud cuttings. The rooted seedling transferred to field conditions in the spring before the weather gets too hot. Although *Origanum* species can grow in different soils, the most suitable conditions are clay-loam, alluvial, well-drained, soils with a pH of 6–8. For young plants propagated from seed or cuttings, plant spacing varies according to the mechanization conditions, but it is sufficient to plant 14,000–15,000 (plants/ha) plants per hectare. Under irrigated conditions it is possible to harvest more than once. While *O. onites* L. are adapted to arid conditions, *O. vulgare* subsp. *hirtum*, on the other hand, are better adapted to moist soils. Irrigation is required in order to obtain yielded products of standard quality in field conditions. Irrigation amount varies according to climate and soil conditions. The plants should be irrigated after each harvest and during the flowering period. Nitrogen fertilization increases the yield and can be applied two or three times (50–150 kg/ha). Fertilizer should be applied for the first time in the spring, the second fertilizer after the first harvest, and the third time following the second harvest. Phosphorus and potassium fertilizers are recommended during planting and in the spring. Although green herb yield and drug herb yield are low in the first harvest year, yields increase in the following years. Under Aegean Region conditions, average green herb yield is 15,000 kg/ha, drug herb yield is around 5000 kg/ha. Yields vary according to the years, regions and cultivation technique. Seed should be harvested when the seeds are fully ripe (Alekseeva et al. 2020; Harini 2014; Ceylan 1997).

Twenty years ago, 80% of the traded oregano were collected from natural flora. However, these figures are reversed due to the success story in Denizli Province. After Turkish tobacco law comes into force in 2002, tobacco production area in Denizli were sharply declined. Therefore, tobacco producers started *O. onites* cultivation as an alternative crop. In fact, *O. onites* was naturally grown and wild collected in that area. Oregano farmers in Denizli generally use their own seedlings obtained from seeds and cultivated without irrigation as a perennial crop (Fig. 9.2). Oregano plants are harvested by cutting in the flowering stage and then they are dried under sun. The average dry leaf yield in Denizli is 150 kg/da. After that, dry leaves are marketed as drug (Folia Origani) and after steam distillation as carvacrol rich essential oils (4–7%) (Baydar and Arabaci 2013). Turkey provides more than 50% of the world's exported oregano (*Origanum* types). Turkey produces 21,000 tonnes dried oregano leaves per year and earns 64 million USD export income (TURKSTAT 2022). Denizli has become the centre of oregano production in Turkey with %85 of Turkey's oregano production.

## 9.6 Traditional Uses and Usage Areas

According to mythology, *Origanum* was taken from the depths of the ocean by Aphrodite, the goddess of love, and brought to the heights of the mountains, where the sunlight shone the brightest (Gezgin 2007). The earliest records of the use of *Origanum* were found in Hittite tablets from 1200–1600 BC. Some sources claim that *Oregano* was transported to North America by European colonies. Hippocrates describes him as the prince of herbs. *Oregano* plants have been associated with love, protection, purification, healing and happiness, and religious traditions and myths (Meyers 2005). It has been used in many areas because of the scent. It is known that they were used as incense in temples and as a repellent to insects in homes during the Ancient Greek period. In ancient Greek and Roman times *Origanum* spp. was also used in alcoholic beverages and to give flavor to cheese. In addition, in Egypt, they were aware of the antiseptic and preserving properties of these plants and they were used in the mummification process. The earliest records of the use of *oregano* for healing date back centuries. Early writers such as Theophrastus, Mithradates, Pliny, Dioscorides, and Galen mentioned these plants (Bozdemir 2019; Gezgin 2007; Başer 1997).

Since ancient times, *Origanum* species, classified among medicinal plants, have been used as a spice in the kitchen, fragrance in perfumery and raw material in the pharmaceutical industry due to their pleasant odour and benefit to human health. Such qualities are due to the type of plant, the climatic conditions of its location and the essential oil content. Other metabolic chemicals are important compounds such as fixed oils and flavonoids. Carvacrol and sabinene hydrate are two chemicals related to taste in *oreganos* used for seasoning in kitchens. Carvacrol is the key ingredient responsible for the harsh and pungent aroma of *Origanum* species such as *O. vulgare* subsp. *hirtum*, *O. onites*, *O. minutiflorum* and *O. syriacum*. Sabinene hydrate has a sweet aroma and is highly prevalent in *O. majorana* and its hybrids and subspecies of *O. vulgare*. *O. majorana* was used during the Renaissance in salads and in the servings of eggs, rice, meat and fish. *Origanum* species are used in herbal teas and alcoholic and non-alcoholic beverages. In folk medicine, *oreganos* are herbal remedies used for respiratory problems, cough, stomach problems, painful menstruation, urinary tract diseases, diuretic, rheumatism, muscle pain. (Alekseeva et al. 2020; Bajer 2019; Faydaoğlu and Sürücüoğlu 2011; Conforti et al. 2011; Üçer 2010; Baytop 1999; Başer 1997; Asımgil 1993). Tymol, found in *Origanum* species, is characterized by a thyme-type aroma. Other chemicals are linalool, gamma-terpinene, p-cymene and terpinene-4-ol, which are essential oil components (Meyers 2005).

## 9.7 Chemistry and Modern Medicine Approaches

The essential oils of *Origanum* are rich in terpenic substances. The monocyclic monoterpenes carvacrol and tymol are the main components in commercialized *Origanum* species. In addition, methyl ethers and acetates of  $\gamma$ -terpinene,  $\alpha$ -terpinene, p-cymene,

p-cymenene, carvacrol and thymol, terpinen-4-ol, p-cymen-8-ol, p-cymen-7-ol, thymoquinone and thymohydroquinone are components found in different proportions. Apart from these, thujene, sabinene, camphene,  $\alpha$ -pinene,  $\beta$ -pinene, borneol, cis-sabinene hydrate, trans-sabinene hydrate, cis-sabinene hydrate acetate, trans-sabinene hydrate acetate, cis-sabinol, trans-sabinol, camphor and Isoborneol are bicyclicmonoterpene compounds contained in these plants. Sesquiterpenes commonly isolated from these plants are  $\beta$ -bisabolene,  $\beta$ -caryophyllene, aromandrene, germacrene,  $\alpha$ -humulene,  $\beta$ -bourbonene,  $\beta$ -cubene,  $\alpha$ -muurolene,  $\gamma$ -muurolene,  $\alpha$ -copaene,  $\beta$ -caryophyllene  $\gamma$  oxide,  $\alpha$ -cadinene,  $\alpha$ -cadinol, germacrene-D-ol and bicyclogermacrene. In *Origanum* species, ursolic and oleanolic acids are the main triterpenoids. The most common phenolic compounds isolated from *Origanum* species are hydroquinone, hydroquinone monomethyl ether, and glucoside arbutin. In addition, these plants are characterized by phenolics such as p-hydroxybenzoic, vanillic, syringic, protocatechuic acids, hydroxycinnamic acids, caffeic and cinnamic acids, ester forms of rosmarinic acid, chlorogenic acid. Many flavonoid group substances such as; apigenin, genkwanin, chrysin, neglectein, mosloflavone, apigenin 7-O-glucuronide, isovitexin etc., have also been determined in *Origanum* species (Marelli et al. 2018; Asensio et al. 2015).

**Thymol** and **carvacrol** have antifungal and antibacterial properties and are present in different proportions in *Origanum* species. It has been stated in various sources that there is an increase in the amount of thymol and carvacrol in plants grown in arid conditions and especially exposed to water stress. The essential oils of *Origanum* genus have an antimicrobial effect on microorganisms such as *E. coli*, a subspecies of *Salmonella enterica*, *Salmonella enteritidis*, *Pseudomonas aeruginosa*, *Enterococcus faecalis*, *Salmonella enteritidis*, *Staphylococcus aureus*, *Bacillus subtilis* subsp. *spizizenii*, *Staphylococcus aureus*, *Candida albicans* etc. and stop their development. It is thought that *Origanum* essential oil phenolics penetrate the phospholipid layer in the cell walls of bacteria, damage the cell wall and cytoplasmic membrane, bind to proteins and interfere with their normal functions. Some compounds such as butylatedhydroxytoluene (BHT), propyl gallate (PG), butylatedhydroxyanisole (BHA), tertiarybutylhydroquinone (TBHQ) are commonly used as synthetic antioxidants. However, due to the toxic effects of these synthetic antioxidants, there is an increase in interest in natural ones. It was determined that the antioxidant activity of *Origanum* species is quite high following the extraction with different solvents. Thus, species of *Origanum* genus containing antioxidant compounds are important for pharmacology and food industry. Studies on the effectiveness of *Origanum* species on different cancer types are still ongoing (Alekseeva et al. 2020; Hijazeen 2018; Beltran and Esteban 2016; Busatta et al. 2007).

## 9.8 Conclusions

*Origanum* species have been used throughout human history, in folk medicine, ethnobotanically, against many infectious diseases and in pain relief. In addition to the production of food, spices, fragrances, alcoholic and non-alcoholic beverages,

scientific research has proven that these plants have strong biological activities. Due to their content of phenolic compounds, *Origanum* species, whose biological activity has been determined, have the potential to be used as an alternative to synthetic antioxidants. Various research projects on origanums are aimed at finding solutions to protect human and animal health and to cure current problems. Species with proven pharmacological effects are preferred for use in the pharmaceutical industry. For such purposes, instead of sourcing *Origanum* species from their wild populations, the cultivation of sustainably cultivated, registered varieties is preferably, as they produce reliable standard quality plant materials.

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