



An overview on genus *Thymus*

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ABSTRACT

The genus *Thymus* L. belongs to the Lamiaceae family, consist of about 215 species of herbaceous perennials and small shrubs in the world. They originated from Mediterranean region. This genus is presented in Iranian flora by 14 species, including: *T. daenensis*, *T. carmanicus*, *T. fallax*, *T. persicus*, *T. trautvetteri*, *T. migricus*, *T. kotschyanus*, *T. pubesens*, *T. nummularius*, *T. transcaspicus*, *T. eriocalyx*, *T. caucasicus*, *T. transcaucasicus*, and *T. fedtschenkoi*. Thyme is an aromatic and medicinal herb that has been widely used in folk medicine, food preservatives and pharmaceutical preparations. Overall, this genus is one of the most popular plants throughout the entire world due to its volatile constituents. Thymol and carvacrol are the major compounds in most of the *Thymus* essential oils. The therapeutic potential of thyme rests on contents of thymol, carvacrol, flavonoids, eugenol, aliphatic phenols as well as luteolin, saponins, and tetra methoxylated flavones. The essential oil of thyme has antibacterial, antiseptic, antifungal, anti-parasitic and antioxidant activity.

1. Introduction

The mint family (Lamiaceae) is one of the largest and most distinctive families of flowering plants, with about 220 genera and almost 4000 species worldwide. This family has an almost cosmopolitan distribution. The Lamiaceae are best known for the essential oils common to many members of the family. Many biologically active essential oils have been isolated from various members of this family. These plants are frequently aromatic in all parts and include many widely used culinary herbs, such as thyme. The genus *Thymus* L. belongs to the Nepetoideae subfamily of Lamiaceae family is a well-known aromatic herb and consists of about 215 species of herbaceous perennials and small

shrubs in the world. The Mediterranean region can be described as the center of the genus (Jamzad, 2010; Morales, 2002; Cronquist, 1988). *Thymus*, with the common Persian name of "Avishan or Azorbe," (Safari et al., 2010) is presented in *Iranica* flora by 14 species, including: *T. daenensis*, *T. carmanicus*, *T. fallax*, *T. persicus*, *T. trautvetteri*, *T. kotschyanus*, *T. pubesens*, *T. nummularius*, *T. transcaspicus*, *T. eriocalyx*, *T. caucasicus*, *T. migricus*, *T. transcaucasicus* and *T. fedtschenkoi* (Mozaffarian, 2008; Naghdi Badi and Makkizadeh, 2003; Rechinger, 1963–1998) Which *T. carmanicus* Jalas., *T. daenensis* subsp. *daenensis* Celak., and *T. daenensis* subsp. *lancifolius*, *T. persicus* (Roniger ex Reach. F.), and *T. trautvetteri* Klokov and Desj.-Shost. are endemic (Rechinger, 1982).

2. Pharmaceutical importance of *Thymus*

Overall the aerial parts and volatile constituents of *Thymus* are commonly used as medicinal herb. Thyme has long history of been used in traditional medicine for treatment of various diseases for instance to treat respiratory diseases (whooping cough, bronchitis and asthma), in the form of tea, ointment, tincture, syrup or by steam inhalation. It is also used to prevent hardening of the arteries, treatment of toothache, urinary tract infection and dyspepsia (Hashim and Gamil, 1988). It also expels fungus from stomach and intestine and it has ability to increase appetite because of its important component thymol, which has ability to kill bacteria and parasites.

Nowadays, thyme has changed from a traditional herb to a serious drug rational phytotherapy. It is incredible wellspring of iron, calcium, manganese, vitamin K and likewise upgrades blood flow and pushes an invigorating impact for the entire system. This herb invigorated activity on anxious framework made it as a cure for physical and mental weakness and additionally for diminishing insomnia. The remedial potential of *Thymus* is due to the presence of flavonoids, thymol, carvacrol, eugenol, phenols, luteolin and tetramethoxylated. Its controls numerous valuable effects, such as, antispasmodic, antimycotic, mammalian age-delaying properties, bactericides, antiseptics, antioxidants, anthelmintic properties and has late been recommended as substitute as cancer prevention agent (Monira *et al.*, 2012; Omidbaigi, 2009; Brown, 2002). Moreover, infusion and decoction of aerial parts of *Thymus* species are used to produce tonic, carminative, digestive, antispasmodic, anti-inflammatory and expectorant and for the treatment of colds in Iranian traditional medicine (Ghasemi Pirbalouti, 2009; Nickavar *et al.*, 2005; Zargari, 1989–1992). Recent studies have shown that *Thymus* species have strong antibacterial, antifungal, antiviral, antiparasitic, spasmolytic and antioxidant activities (Mozaffarian, 2008; Omidbayg, 2007; Sefidkon, 2002; Zargari, 1990). On the other hand, *Thymus* species are commonly used as herbal tea, flavoring agents (condiments and spices) because of their biological and pharmacological properties (Burnett *et al.*, 2005; Stahl-Biskup and Saez, 2002).

3. Oil constituents of *Thymus*

So far various researches on essential oil of different species of *Thymus* of over the world and in Iran has been carried out. Previous chemical investigation on *Thymus* species have shown the presence of aromatic terpenes and terpenoids, flavonoids, and phenolic acid (Teimouri, 2012; Ebrahimi *et al.*, 2008; Miguel *et al.*, 2004; Stahi-Biskup *et al.*, 2002; Miri *et al.*, 2002; Kasumov, 1983). Thymol and carvacrol are the main phenolic compound of thyme oil. The major nonphenolic compounds were linalool and *p*-cymene (Piccaglia and Marotti, 1991). Sefidkon *et al.* (2002) in two separate studies investigated the essential oil of the species of *Thymus* and found out that essential oil contains carvacrol, thymol, gamma-terpinene, *p*-cymene, and borneol.

The different components of essential oils in different species of *Thymus* are variable due to hybridization and polyploidization, despite its rare self-pollination (Lopez-Pujol *et al.*, 2004). In general, intraspecific hybrids of the genus *Thymus* seem to possess intermediate composition of essential oil in comparison with the relevant characteristics of the parent plants (Loziene *et al.*, 2002). Thyme oil contains polyphenolic acid (oleanic acid, rosmarinic acid, triterpene and caffeic acid). Thyme oil also contains other components such as, borneol, genniol, pinene, linalool, 1-8, cineole, sabinen, myrcene, and limonene (Rizk, 1986).

4. Cytogenic traits

Chromosomal information is an important key for taxonomy, phylogeny, evolution, genetics and breeding in thyme plants. However, the identification of chromosomes has been difficult in thyme because of the small chromosome size and the similarity in chromosome morphology (Ziaei Nasab *et al.*, 2012). Since *Thymus* is an out-crossing plant and have inter and intra species hybridization, so they show morphologically and genetically variations among themselves. One of the genetically variations in *Thymus* is the number of chromosomes that it is clearly detectable. Overall chromosomal information *Thymus* genus represents two ploidy levels (diploid and tetraploid) and five different chromosome numbers: $2n=2x= 28, 30$, and $2n= 4x= 54, 56$, and 58 (Lopez *et al.*, 2004).

In other work, *T. praecox* was considered as a species with various chromosome numbers of 24, 28, 50, 54, 56, and 58 (Fernandes *et al.*, 1984). The mean value of

chromosomes total length (TL) was varied from 1.625 mm in *T. kotschyanus* (Bahrini, 2002) to 0.849 in *T. daenensis* (Baytop, 1997). The mean value of chromosomes long arm (LA) and short arm (SA) was varied from 0.957, 0.669 mm in *T. kotschyanus* (Bahrini, 2002) to 0.479 and to 0.370 in *T. daenensis* respectively (Baytop, 1997). The chromosome number of different populations of *T. daenensis* were different ($2n=2x=30$ and $2n=4x=60$) but among populations of *T. kotschyanus*, *T. pubescens* and *T. carmanicus* were the same ($2n=4x=60$) and *T. fallax* with one population was diploid ($2n=2x=30$).

5. Antimicrobial activity

Recent studies have shown that *Thymus* species have antibacterial, antifungal, and antioxidant activities (Rahimmalek *et al.*, 2009; Jordan *et al.*, 2009; Bassam *et al.*, 2004). The anti-bacterial characteristic of *Thymus* spp. is due to the occurrence of thymol in this genus. This substance can be used as a disinfectant. Previous studies showed that the essential oil and extract from *T. daenensis* exhibited antimicrobial activities against *Candida albicans* (Ghasemi Pirbalouti *et al.*, 2009a), *Listeria monocytogenes* (Ghasemi Pirbalouti *et al.*, 2009b), *Campylobacter jejuni* and *Campylobacter coli* (Ghasemi Pirbalouti *et al.*, 2010a), *Staphylococcus aureus*, *Escherichia coli*, *Pseudomonas aeruginosa*, *Klebsiella pneumoniae* (Ghasemi Pirbalouti *et al.*, 2010b), *Escherichia coli* O157:H7 (Ghasemi Pirbalouti *et al.*, 2010c), and *Saprolegnia parasitica* (Ghasemi Pirbalouti *et al.*, 2009c).

6. Ecological requirement

These species are heliophylous plants and like the sun, a fact which reflects the ecology of the genus. Thyme grows well in a temperate to warm, dry, sunny climate, and where the plants are not shaded (Table 1). It needs full sun to grow to its best potential. *Thymus* plants frequently live on rocks or stones and it is very important that the soils are well drained. Thyme prefers light, well-drained soils with a pH of 5 to 8. Thyme species do best in coarse, rough soils that would be unsuitable for many other plants. Although thyme grows easily, especially in calcareous light, dry, stony soils, it can be cultivated in heavy wet soils, but it becomes less aromatic. But different *Thymus* species require very different substrata. Thymes are very resistant plants, which allows them to live under extreme climatic conditions

concerning temperature and water supply. They do not avoid either cold or aridness. Vegetation period of this plant is 200-210 days. In appropriate conditions, it germinates after 4-5 days. 40-50 days after vegetation, the plant flowers and as soon as the flowers are opened and before seed formation, it is harvested.

T. daenensis Celak.

The Persian and local names of *T. daenensis* are “Avishan-e-denaee” and “Ooshon-e-kohi”, respectively (Ghasemi Pirbalouti, 2009; Mozaffarian, 2006). A perennial dwarf shrub native plant to semi-arid zones and generally grows in high altitude places in the high altitudes in Zagros Mountains range, western and south western Iran. This plant is considered as an aromatic and medicinal plant. The aerial parts of *T. daenensis* are commonly used as spices, condiments and flavoring agents (Nickavar *et al.*, 2005; Zargari, 1990; Reching, 1982). It is recognized from other species by its narrow leaves (Bahrini, 2002). The essential oil and extracts from the aerial parts of *T. daenensis* contains mainly monoterpenes, sesquiterpenes, phenolic compounds and flavonoids (Ghasemi Pirbalouti *et al.*, 2011). Earlier studies have identified thymol, carvacrol, *p*-cymene and γ – terpinene as the major constituents of the essential oils of *T. daenensis* (Ghasemi Pirbalouti *et al.*, 2013). The essential oil and extracts isolated from *T. daenensis* have been shown to have biological and pharmacological activities, including anti-bacterial (Ghasemi Pirbalouti *et al.*, 2013). Previous studies (Ghasemi Pirbalouti *et al.*, 2011) on the antimicrobial activity of the essential oils of *T. daenensis* showed that this species which possess large quantities of phenolic monoterpenes, have shown activity against viruses, bacteria, food-derived microbial strains and fungi.

T. pubescens Boiss. & Kotschy ex Celak.

T. pubescens is (Avishan-e-korkaloud) that grows wild and abundantly in the North and North-West of Iran (Reching, 1982). It is a perennial plant widely spread out in Iran and Turkey. This plant has low shrubs with woody based stems and recumbent to upright (Zargari, 1990). The flower branch is 2 to 13 cm. The flowers are red or purple-blue and are 5 to 8 mm and flowering begins from spring until summer (Jamzad, 2009). *T. pubescens* has been used by the local people as a food additive, and as herbal remedy for gastrointestinal disorders. There are several reports on the chemical compositions of *T. pubescens* from different

parts of Iran available to date (Askari *et al.*, 2002). All those previous reports indicated thymol, carvacrol, *p*-cymen and γ -terpinene as the major components in the oils. In other study the main compounds in the *T. pubescens* oil were found to be carvacrol (32.1%), thymol (19.1%) and α -terpineol (14.6%) (Morteza-Semnani *et al.*, 2006). There are evidences that within

the genus *Thymus*, chemical polymorphism of the essential oils is a widespread phenomenon, and more than 20 essential oil chemotypes exist in different species of the genus *Thymus* (Stahl-Biskup, 1991).

Table 1. Climatic and planting requirements of *Thymus* genus

Temperature	Warm, dry, sunny climate, and where the plants are not shaded.
Rainfall	Does not like excessive moisture because of its susceptibility to rot diseases. Suitable is 500 to 1000 mm per year
Soil requirements	Light, well-drained soils with a pH of 5,0 to 8,0
Planting season	Transplant cuttings: in spring
Propagation	Seeds, stem cuttings, and layering
Irrigation	Drip and overhead irrigation are suitable, but do not over-irrigate.
Spacing	15 to 30 cm apart in the row with a row width of 60 cm.
Reference (Department Agriculture, Forestry and Fisheries Republic of Africa), (2012).	

T. caramanicus Jalas

T. caramanicus Jalas, is an endemic species grown in Iran. Kermanian thyme is a wooden plant, perennial and Grey colored with C3 metabolism system that will be 25-50 cm tall depending the climate of growth region and soil quality (Zargari, 1990). At present time, this plant is cultivated in medium scale in Iran, showing antibacterial, antimycotic, antioxidative, natural food preservative, and mammalian age delaying properties (Stahl-Biskup and Saez, 2002). In Iranian folk medicine, leaves of this plant are used in treatment of rheumatism, skin disorders and as an antibacterial agent (Zargari, 1990). The major constituent of essential oil and extract from the aerial parts of this plant are carvacrol, thymol, *p*-cymene, γ -terpinene and borneol respectively (Safaei-Ghomi, 2009). The beneficial health properties of thymol and carvacrol as main components of *T. caramanicus* have encouraged us to look into its anticancer activity.

T. fallax Fisch Mey

T. fallax Fisch Mey, is a pleasant smelling perennial shrub, which grows in several regions of the world such as Western Mediterranean, Southern Italy, Iran, and Turkey (Baytop, 1997; Davis, 1982). *T. fallax*, a perennial shrub by plant that grows on rocky slopes and grassy areas at 1400-2500 m. Thyme is used for seasoning, poultry, soups, and vegetables in herbal teas prepared for colds and flues as well. Thyme and its oil

have been used as fumigants, antiseptics, antioxidants, and mouth washes (Gulluce *et al.*, 2007).

T. kotschyanus Boiss. & Hohen

T. kotschyanus is a perennial plant. It grows up to 20cm of height. On the small wooden branches, dark, green sharp and pointy leaves grow. The aromatic leaves are used as spice and medicine. The white flowers are scented. This species grows in mountainous regions and although is dispersed almost all over the world, but actually accumulates in Mediterranean region. This species has the largest dispersion in Iran (Damavand region) (Jamshidi *et al.*, 2006). In a study, pulegone (18.7%), isomenthone (17.8%), and thymol (14.9%) were the main constituents in *T. kotschyanus* (Morteza-Semnani *et al.*, 2006). Aminzadeh *et al.*, (2010) reported in this species the percentage of the carvacrol and the altitude of the region have a direct and significant effect with the plant height. The altitude of the region, organics percentage, SAR has a direct and significant effect on thymol and the percentage of nitrogen and CaCo₃ have a negative relationship with the changes of thymol.

T. transcaspicus

T. transcaspicus is an aromatic and medicinal plant, which it has been widely distributed in the north of Khorasan Razavi province, Iran, and southern areas of Turkmenistan as reported by Rechinger (1982). This plant has antifungal activities According to a previous

reports. Thymol, carvacrol, γ terpinene and p-cymene are the major components of the oil of the aerial parts of this plant (Miri *et al.*, 2002). Thirty-eight constituents, representing 98.59% of the total components in the oil of *T. transcaucasicus* were characterized by thymol (60.61%) and p-cymene (9.32%) as the main compounds, followed by carvacrol (4.61%), 1,8-cineole, (3.08%) and pentacosane (3.17%). Monoterpenes comprised 91.34%, while sesquiterpenes consisted of 3.48% of the oil.

T. persicus

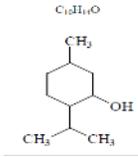
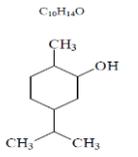
Thymus persicus (Ronniger ex Rech.) Jalas is an endemic species which is distributed in restricted regions of the northwest of Iran including Zanzan and West Azerbaijan provinces (Jamzad, 2009; Reching, 1982). Morphologically, *T. persicus* is well differentiated in the genus *Thymus* by the small leaves width among *Thymus* species with long non-glandular and shorts-talked glandular hairs. The major constituents of *T. persicus* are thymol (10.71%), carvacrol (25.71%), γ -terpinene (5.63%), α -pinene (1.14%), β -pinene (1.02%), limonene (11.65%) *trans*-sabinene hydrate (7.78%), and 1-borneol (4.07%)(Sefidkon *et al.*, 2002). In other study the major compounds in *T. persicus* oil were found to be carvacrol (39.0% and 27.1%), geraniol (15.7% and

9.4%), p-cymene (7.5% and 10.2%), and thymol (6.5% and 11.9%) before flowering and at the full flowering stage, respectively (Sefidkon *et al.*, 2002).

T. vulgaris

T. vulgaris is a perennial with a woody, fibrous root. The stems are numerous, round, hard, branched, and usually from 4 to 8 inches high, when of the largest growth scarcely attaining a foot in height. The leaves are small, only about 1/8 inch long and 1/16 inch broad, narrow and elliptical, greenish-grey in color, reflexed at the margins, and set in pairs upon very small foot-stalks. The flowers terminate the branches in whorls. The calyx is tubular, striated, closed at the mouth with small hairs and divided into two lips, the upper most cut into three teeth and the lower into two. The entire plant smells pleasantly aromatic. The seeds are small round nuts, often carried away by ants and sometimes planted on ant hills, maybe to protect against disease-carrying pathogens (Hoffman, 2003). The plant has an agreeable aromatic smell and a warm pungent taste. The fragrance of its leaves is due to an essential oil, which gives it its flavoring value for culinary purposes, and is also the source of its medicinal properties. It is in flower from May to August (Hoffman, 2003).

Table 2. Properties of thymol and carvacrol

	Thymol	Carvacrol
Name	2-isopropyl-5-methylphenol	5-isopropyl-2-methylphenol
Color	white-colored crystalline	white-yellow
Molecular Structural	$C_{15}H_{14}O$ 	$C_{15}H_{14}O$ 
Molecular Weight	150.22	150.21
Boil point	233 C0	236-237 C0
Refractive index	1.522 in 20 C0	1.5209 in 20 C0
Solvent	Alcohol and organic solvents	Alcohol and organic solvents

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