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A thorough analysis of Thymus serpyllum's traditional uses, phytochemistry, pharmacology, and toxicity

Ms A R Sridevi,Ms.B.Geethanjali Bai.,Mr C G Bhaskar,Ms.A.AksaAnvija,Ms B silpa
Department of pharmacology
Email ID: sridevipharma93@gmail.com , Mobile no: 9182727657
GOKULA KRISHNA COLLEGE OF PHARMACY

Abstract:

The Lamiaceae family's understudied perennial plant Thymus serpyllum L. has a long history of use in the treatment of gastrointestinal and respiratory disorders in the higher foothills of India. Our present understanding of T. serpyllum's traditional applications, phytochemistry, and pharmacology is not well-rounded, and that is the goal of this review. Gathering up-to-date knowledge on this plant is our top priority, as is promoting more in vivo and in vitro studies to back up local claims. Due to its varied pharmacological qualities, such as antioxidative, antibacterial, anti-inflammatory, and anticancer activity, the essential oil extracted from T. serpyllum has garnered substantial interest as a plant-derived product. When it comes to creating novel medications to tackle a wide range of health sector issues, ethnomedicinal research has shown that T. serpyllum has a lot of potential. Pharmacological investigations alone are insufficient to support the widespread usage of T. serpyllum. In most cases, researchers use either in vitro or in vivo methods. To evaluate these medical assertions, more research is needed in the form of carefully orchestrated pharmacological trials. The findings of this evaluation will serve as a springboard for more studies. Despite T. serpyllum's extensive traditional usage, there has been a dearth of pharmacological research, with the majority of investigations conducted in either in vitro or in vivo settings. Important topics to explore include further chemical isolation, thorough pharmacological study, and potential culinary uses.

Keywords:

Pharmacological properties, phytochemistry, *Thymus serpyllum*, toxicity, traditional applications

Introduction :

The contemporary world is responsible for improving immune responses and achieving excellent health via the use of medicinal herbs. For generations, from 4000 to 5000 B.C., people have turned to traditional remedies as a cost-effective and easily accessible means of illness treatment. The first known medicinal formulation derived from herbs was acquired by the Chinese. The first text on the use of plants as medicines in India was found in the Rig-Veda, which dates back to 1600-3500 B.C. Traditional Indian medicine has long made use of herbs for their therapeutic properties.[1] New medicinal treatments may be derived from plants.

 in a direct or indirect manner. The majority of the population in industrialized nations relies on conventional medicine for their health, as stated in studies by the World Health Organization (WHO).Both industrialized and developing nations are seeing a rise in the demand for medicinal herbs.

As a member of the Lamiaceae family and a major genus within it, thyme has a prominent place. There is evidence of this adaptable herb's use as a spice all across the globe. There are 7534 species in the thyme genus, including 220 species of thymus L., as reported in the World Checklist (http://apps.kew.org/wcsp/ incfamilies.do).the third Richard has successfully identified many species of Thymus all over whole planet.[4] The medicinal, cosmetic, perfume, and culinary sectors all make extensive use of members of the thyme genus.[5]

The common cold, flu, indigestion, nausea, kidney illness, ulceration, headache, diabetes, and asthenia are just some of the many ailments that thyme may help alleviate.[6] The main focus of studies is thyme oil, which contains phenolic chemicals, esters, and terpenes. The fragrant and medicinal properties of thyme have contributed to its status as one of the world's most beloved plants, and thyme oil is no exception. Many consider it to be among the top 10 essential oils (EOs) in the world.[7] Therefore, the purpose of this study is to provide up-to-date information on T. serpyllum's pharmacological characteristics, phytochemical components, traditional uses, and safety profile. This study compiles pharmacological and phytochemical data that may be used to explore new avenues of treatment, fill knowledge gaps, and create effective intervention strategies.

Botanical Description and GeographicDistribution

T. serpyllum is a little shrub with a pleasant aroma and a cluster of glossy, pointed, blue-green leaves that gradually get browned. It goes under many names, including creeping thyme, wild thyme, Breckl and thyme. It may be found in many parts of East Africa as well as Asia, Europe, and North America. It grows in India specifically in the states of Uttarakhand, Jammu & Kashmir, and Himachal Pradesh.[8]

Perennial T. serpyllum shrubs may reach a height of 5–7 cm. Clusters of tiny, pinkish-purple blooms adorn its hairy, crawling look.[8] The lengthy trichomes cover the oval-shaped leaves, which are smooth on both sides and measure around 4-6 mm in length and 2-4 mm in breadth. Although the lateral veins at the margin's base are less evident, the central vein is powerful. All year round, these leaves are there. The hermaphroditic T. serpyllum plant depends on pollinators such as bees, flies, and butterflies that are drawn to its unique scent. It grows best in situations with a medium to dry moisture content and good drainage, and it loves sandy, rocky, loose, and nutrient-poor soil. Although it thrives in dry, windy conditions, this species is more common in

shaded regions.[9] It needs more light and grows rapidly on normal damp soil. Propagation via stem cuttings is a simple process.

Thymus serpyllum: A Traditional Herb with Modern Uses

and for therapeutic objectives. In addition to their long history of use in medicine, they have become an integral component of our culinary traditions and cultural practices.It has the quickest healing and bravery qualities, and it is historically taken by martyrs and fighters to gain physical strength, in addition to psychological perception [10].Greek doctors have long utilized the plant's juice to alleviate asthma and coughs, and they also recommend using the paste topically for the treatment of arthritis and the disinfection of cuts and scrapes.Greek medicine has a long history of using this plant's juice to cure asthma and coughs, while the plant's paste has exterior uses such as treating arthritis and disinfecting cuts and scrapes.in [13] In addition, the leaves and flowering stems alleviate period cramps, period discomfort, and a host of skin problems, such as rashes and itching.[14] Along with its diuretic qualities, an infusion produced from T. serpyllum leaves and "jaggery" is well-known.In addition to their utility in treating respiratory and gastrointestinal issues, the aerial portions of T. serpyllum offer antiseptic, antiplasmodic, deodorant, and disinfecting properties [15].T. serpyllum is an immunostimulant and has better blood circulation in the Western Balkans [16].Traditional medicine practitioners in India have traditionally relied on T. serpyllum to alleviate menstruation cramps [17].Furthermore, it has been used to reduce inflammation, edema, and eczema [18].in [13] Ethnoveterinary medicine has also acknowledged its antidiarrheal effects.The year 19 One study found that acute pharyngitis was efficiently treated by mixing T. serpyllum with blackberry leaves (British Pharmacopoeia, Commission Secretariat of the Medicines, and Healthcare Products Regulatory Agency, 2015). On top of that,To make herbal tea, T. serpyllum is a common ingredient.In [20],

In addition to its usage in mouthwashes and gargles, the calming and disinfecting properties of T. serpyllum EO make it an effective weapon against a variety of illnesses.[21]

Plant biology

Over the last 20 years, a plethora of studies have investigated the phytoconstituents profile of T. serpyllum EO [Table 1].[22] is a The genus Thymus is classified by a number of chemical substances, including germacrene thymol, carvacrol, □-terpinyl acetate, linalool, geraniol, citral, and (E)-caryophyllene.[23] Thymol levels in essential oils extracted from thyme cultivated in India ranged from 60% to 64.6%, in contrast to those in essential oils extracted from thyme cultivated in Estonia, which ranged from 0% to 0.4%.Thymol (16.5%–18.8%), 4,8-cineole (14.0–18.0%), and thymoquinone (2.6%) were all reported by Aziz et al. [24].The essential oils of T. serpyllum cultivated in Muzaffarabad, Jammu include 1,8-cineole (14.0%-18.0%) and spathulenol (1.3%-2.1%).

Table 1: Various classes of phytocompounds present in *Thymus serpyllum*

Category of phytocompounds	Phytoconstituents

Phenolic acids and flavonoids	Gallic acid, rosmarinic acid, caffeic acid, ferulic acid, rosmarinic acid-glucoside, protocatechic acid, protocatechic acid-hexoside, chlorogenic acid, naringin, luteolin-o-diglucuronide, kaempferol-o-glucuronide, rutin, luteolin-o-glucuronide, apigenin-o-glucuronide, methyl kaempferol-o-rutinoside, luteolin, luteolin-7-o-rutinoside, luteolin-7-o-glucoside, apigenin-7-o-glucoside, apigenin, quercetin, eriodictyol-7-o-glucuronide, 8-prenylnaringenin, taxifolin, catechin, apigenin 6,8-di-c-glucoside[28,29]
Triterpenic acid	Oleanolic acid, betulinic acid, ursolic acid, corosolic acid[29]
Monoterpene hydrocarbon	Tricyclene, α -Pinene, *o*-cymene, camphene, sabinene, β -pinene, β -cymene, α-phellandrene, myrcene, thymol, α-terpinene, *p*-cymene, limonene, α-thujene, terpinene, thymol acetate[30,31]
Monoterpene oxidized	1,8-Cineole, linalool, δ^3-carene, terpenolene, α-thujone, cis-sabinene hydrate, camphor, α-campholene, sabinene hydrate, trans-sabinene hydrate, borneol, isoborneol, *p*-mentha-3,8-diene, terpinen-4-ol, cis-sabinol, p-cymen-8-ol, cis-chrysanthenol, carvacrol acetate, geranial, methyl carvacrol, methyl thymol, thymol methyl ether, menthol, nerol, carvone, fenchyl alcohol, carvacrol methyl ether, thymoquinone, geraniol, bornyl acetate, β -citronellol, carvacrol, geranyl acetate, linalyl acetate, terpinyl acetate[30,31]
Sesquiterpene hydrocarbons	Copaene, β -bourbonene, α -elinene, γ -cadinene, calamenene, δ -cadinene, α -cadinene, germacrene D, β -abolene, epi-sesquiphellandrene, bicyclogermacrene, valencene, α -bisabolol, cis-bisabolene, α -cymene, β -cymene, β -ocinene, α -ylangene, β -longipinene, longifolene, cubebene, β -elemene, muurolene, amorphene, aromadendrene, α -humulene, allo-aromadendrene, (E)-β -farnesene, β -caryophyllene, isoledene, iso-caryophyllene, trans-caryophyllene, spathulenol, elemol, trans-nerolidol,

	caryophyllene oxide, cadrol, α -campholene aldehyde, linalyl propanoate, isopulegone, tetra decanal, trans-carbyl propionate, ethyl cinamate, geranyl butyrate, bicyclogerma, piperitol, cadrol,crene, p-mentha-1-(7),8-diene, isoborneol, cubebene, longkyclene, longifolene, isovaleric acid,
	cis-dihydrocarvone, p-cymene-2,5-diol, β-bisabolene, heptanoic acid, hexadecanoic acid, 2-nonanone,caffeic acid ethyl ester[30]
Others	1-octen-3-ol, 3-octanol, 3-octanone, 3-penten-2-ol, 4-methyl-2-pentanol, 6-methyl-5-hepten-2-one[31]

Indian state of Jammu and Kashmir. According to Aziz et al. [24], spathulenol, cyclohexane, and safrole were found in the essential oil of T. serpyllum. The researchers from Northern Kazakhstan also found a greater concentration of thymol (58.25%), transgeraniol (55.93%), lavandulyl acetate (28.51%), nerol (2.76%), and E-citral (2.58%). The primary components of the essential oil of T. serphyllum from various locations of Southern Italy were determined to be trans-geraniol, lavandulyl acetate, nerol, and Ecipitral.[25] The Thymol and carvacrol are well-known food additives that attract a lot of business due to their high concentrations and safety, as certified by the World Health Organization's food additives recommendations.[26]According to the FDA standard (www.fda.gov/downloads/ICECI/ComplianceManuals/ CompliancePolicyGuidanceManual/UCM142644.pdf; accessed July 5, 2019), thymol and T. serpyllum plants may be used as spices. On the other hand, there has been a surge of interest in T. serpyllum's nonvolatile secondary metabolites, such as rosmarinic acid, ursolic acid, and oleanolic acid.[27] Figures 1-4 show the two-dimensional structures of phytocompounds, while Table 1 displays the several phytoconstituents found in T. serpyllum essential.

Thymus serpyllum: A Pharmacological Tool

actions of Trichoderma serpyllum. Extensive research has shown that T. serpyllum extracts and compounds have a wide range of biological activity, including anticancer, antibacterial, antioxidative, and anti-inflammatory properties. Additionally, new research has examined how thymol and carvacrol interact with the COVID-19 nucleocapsid phosphoprotein.[32] An additional investigation indicated that 25 phytocompounds of T. serpyllum essential oil exhibited poor binding to SARS coronavirus 2 (PDB ID: 6VYO).[32] On the other hand, suitable in vitro and in vivo trials may further validate these in silico research.Below, we will go over some of the significant biological uses of T. serpyllum.

Features of an antioxidant

A number of investigations looked at the antioxidant capabilities of T. serpyllum extracts.The antioxidant activity of the essential oil of T. serpyllum flower tops and stalks was shown by

Kulisic et al. [33] using the 2,2-diphenylpicrylhydrazyl (DPPH) technique, with an IC50 of around 0.40 ± 0.05 g/L. The antioxidant capabilities of T. serpyllum were also shown by its ethanolic and aqueous extracts, with DPPH test results indicating IC50 values of 13.2 ± 0.3 □g/ml and 31.6 ± 0.8 □g/ml, respectively.on page 34 Additionally, Mihailovic-Stanojevic reported the antioxidant activity of a water extract of T. serpyllum using the Ferric ion reducing antioxidant power (FRAP) test (IC50-16.59 ± 1.06 mM Fe (II) equivalents) and the ABTS assay (IC50-8.60 ± 0.05 mM Trolox).

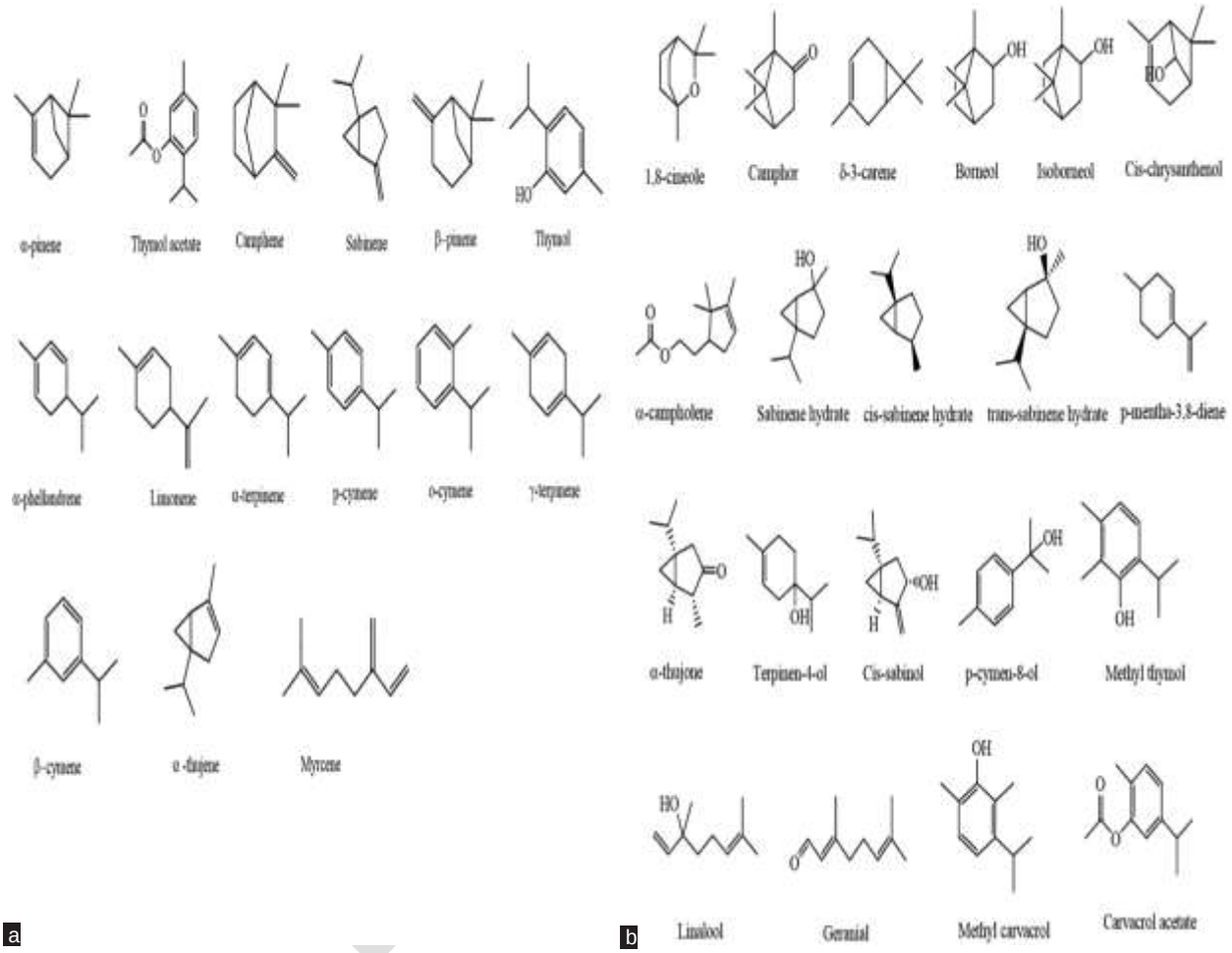
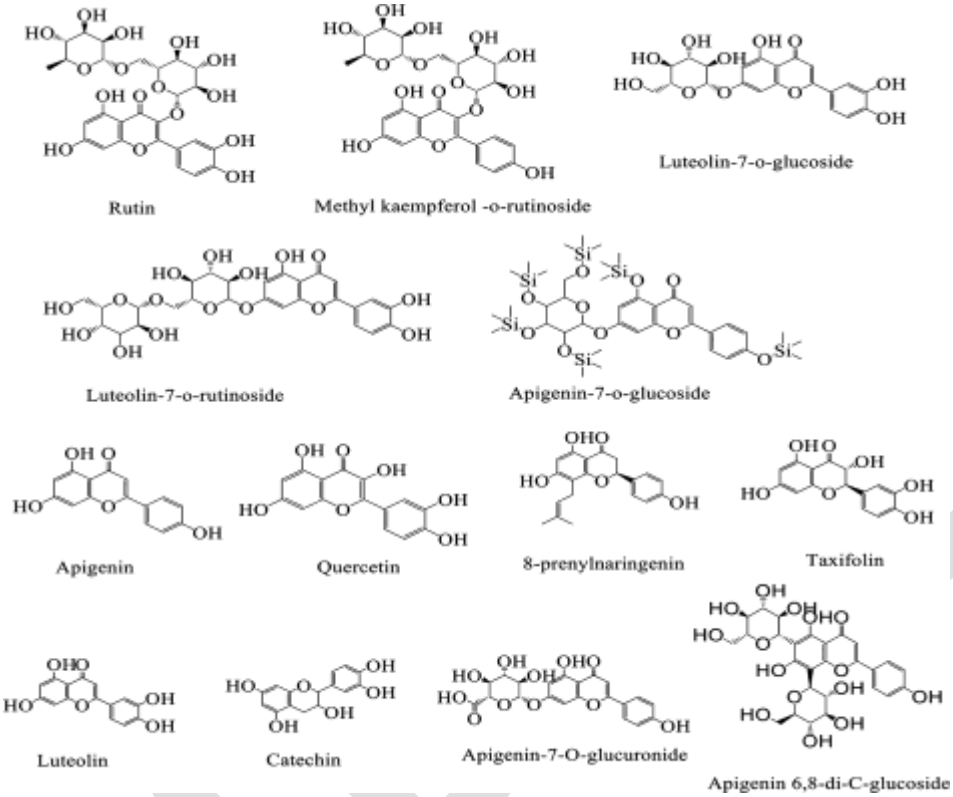


Figure 1: 2-dimensional structures *Thymus serpyllum* phytocompounds: (a) Monoterpene hydrocarbons present in



Thymus serpyllum and (b) Oxidized

Figure 2: 2-dimensional structures of phenolics and flavonoids present in *Thymus serpyllum*

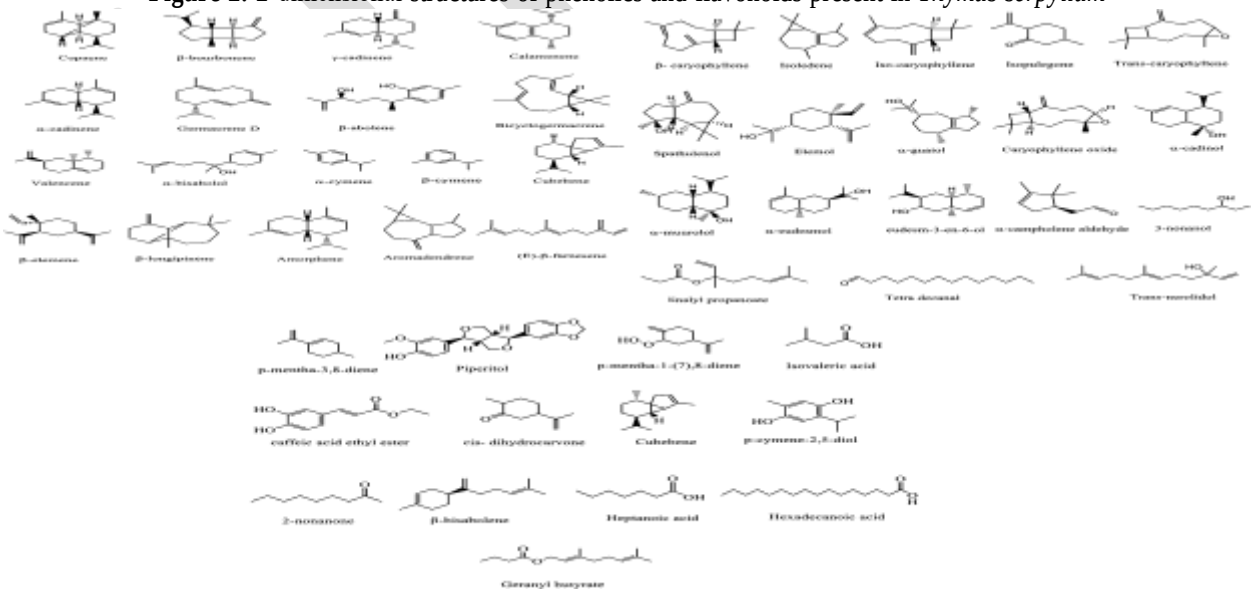


Figure 3: 2-dimensional structures of sesquiterpene hydrocarbons present in *Thymus serpyllum*

with others.The free radical scavenging activity was shown with an IC50 of 3.00-3.17 mg/mL in T. serpyllum extracts that were aided by ultrasound (22).[35] Antioxidant activity of T. serpyllum EO isolated from entire plants was also shown by Nikolic et al. [15] using the DPPH technique (IC50 0.96 g/mL). The phenolic concentration, together with the rosmarinic and caffeic acids[22], gave this plant its antioxidant efficacy.[36]

Impact on microbes

The antibacterial properties of extracts and essential oils from different T. serpyllum plants have been shown in several investigations.(15, 28, 30, 37–40) Table 1 summarizes the antimicrobial and antifungal activity. The thymol and carvacrol in T. serpyllum are responsible for its antibacterial properties, according to the research.[15] Curcumin and According to Farrukh et al., T. serpyllum methanolic and ethyl acetate extracts were found to have antibacterial and antifungal properties. These properties were tested against a variety of bacteria and yeasts, including Pseudomonas aeruginosa, Staphylococcus epidermidis, Staphylococcus aureus, Escherichia coli, Aspergillus fumigatus, Candida albicans, Candida parapsilosis, and Aspergillus niger. The minimum inhibitory concentration (MIC) ranged from 2000 g/ml to 4000 g/ml.[42] The bactericidal efficacy of T. serpyllum EO was 100% against all strains tested after 30 minutes of exposure. The EO of T. serpyllum, as described by Varga et al. [28], contains 32.2% thymol and 25.8% carvacrol. The EO has been tested in both concentrated (100%) and diluted forms.

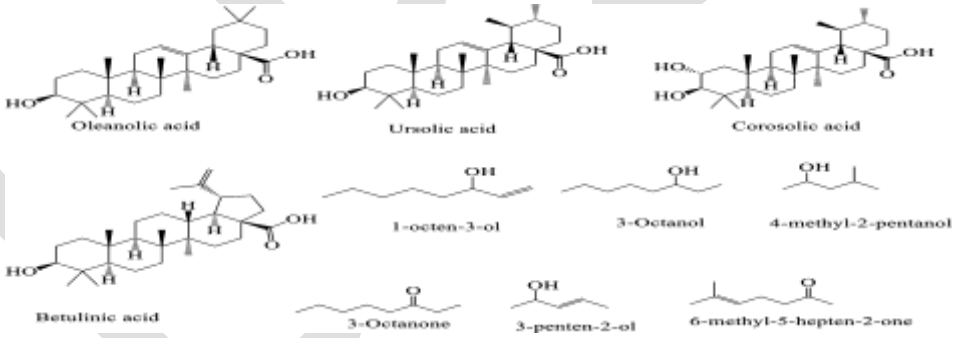


Figure 4: 2-dimensional structure of triterpenic acids and other phytocompounds in *Thymus serpyllum*

In an agar well diffusion experiment, half of the samples tested for Cronobacter sakazakii, Pseudomonas aeruginosa, Streptococcus pyogenes, Listeria innocua, Candida albicans, and Saccharomyces cerevisiae exhibited 100% cell death. The chemical and antibacterial potentials of both the main and secondary EO of T. serpyllum L. were assessed by Verma et al. [30]. There were 92.5% phenolic phytocompounds in the secondary EOs of T. serpyllum, as opposed to 42.1% in the main EO. Curiously, the secondary EO exhibited antibacterial solid action against all bacterial and fungal strains tested, with MIC values ranging from 1/3200 to 1/6400 and Ferric ion reducing antioxidant powers (ZOI) ranging from 20 to >35 mm. The combined effects of

wild thyme (T. serpyllum), oregano (Origanum compactum), and marjoram (O. majorana) essential oils were investigated by Ouedrhiri et al. [38]. They found that the combination had a practical synergistic impact ($P < 0.001$) against S. aureus germs. On the other hand, a synergistic effect against S. aureus and E. coli was shown when wild thyme essential oil and oregano were combined. The synergistic potential of EO from T. serpyllum with antifungal drugs to cure candida infections has been described recently by Salaria et al. [40]. In their study, Erci and Torlak [39] found that silver nitrate nanoparticles (AgNPs) derived from water-based T. serpyllum extracts were effective against bacteria. The area that B. cereus could not cross in the presence of AgNPs was 12.23 ± 0.54 mm. When treated against S. aureus, on the other hand, the inhibition zone measured 13.86 ± 0.58 mm. The sizes of the inhibitory zones for E. coli and S. typhimurium, respectively, were 9.98 ± 1.02 mm and 10.60 ± 0.53 mm, as measured using AgNPs. Research from these research demonstrated unequivocally the therapeutic value of essential oils and wild thyme extracts in combating microbe-borne diseases.

Impact on inflammation reduction

Kindl et al. examined T. serpyllum's anti-inflammatory response in vitro by blocking the Src tyrosine kinase and interleukin-6 production in splenocytes of Balb/c mice.[44] In contrast to polyphenols like luteolin (IC50 = 8 □M), luteolin-7-O-glucoside (IC50 = 40 □M), and rosmarinic acid, a mild dose-dependent inhibition of Src kinase was seen with T. serpyllum methanolic extract (IC50 = 115-167 □g/ml).

staurosporine (a Src tyrosine kinase inhibitor) and acid (IC50-61 □M at 0.01 □M) both have IC50-0.005 □g/ml. Polyphenols and T. serpyllum extract were also tested for cytotoxic activities using the MTS assay. The generation of IL-6 was inhibited by adding T. serpyllum extract and polyphenols (200-0.8 □g/ml). The cytokine production in the treated cells was decreased by over 95% at a high concentration of T. serpyllum (200 □g/ml), and the IC50 value for IL-6 production was determined to be 49.5 ± 9.6 □g/ml. There was no evidence of cytotoxicity when T. serpyllum extract (200-0.8 □g/ml) was used.

Activity against cancer and cytotoxicity

The cytotoxic and anticancer properties of Thymus sp. solvent extracts, essential oils, and phytocompounds have been shown in several studies. The cytotoxic and Hep-2 activity against a mouse leukemia model was shown by Jaafari et al. [45]. In a study conducted by Nikolic et al., [15] it was shown that T. serpyllum essential exhibited anticancer properties against MCF-7, NCI-H460, HCT-15, HeLa, and others. The essential T. serpyllum showed a 50% inhibition of growth (GI 50-52.69 ± 3.28 µg/ml), GI50-37.17 ± 3.18 µg/ml), GI50-7.02 ± 0.07 ± 0.07 ± 0.07 g/ml), and GI50-17.71 ± 3.23 g/ml.

Table 2: Antimicrobial activity of extracts and *Thymus serpyllum* essential oil against different bacterial and fungal species

Part used	Extracts/EO	Method	Tested strains	Key results
Aerial parts	EO	Agar well diffusion and broth dilution	*K. pneumoniae* *P. aeruginosa* *E. coli* *S. aureus* *B. subtilis*	15–40 mm, 100% bactericidal after 30 min exposure. In effective against *P. aeruginosa*[43]
Aerial part	Ethanol, butanol, methanol, hexane, ethyl-acetate, and aqueous extracts	Micro dilution method	*E. coli, P. aeruginosa, S. aureus, S. epidermidis, C. albicans, C. parapsilosis* *A. fumigatus* *A. niger*	Only ethyl-acetate and methanolic extracts exhibited significant activity against all tested bacteria and fungi, displaying MIC values ranging from 2000–4000 µg/mL[42]
Whole plant	EO	Micro dilution method	Ochratoxin a producing strains: *A. ochraceus, A. ochraceus, A. carbonarius*, and *A. niger*	MIC ranged between 0.625 and 2.5 µL/mL[37]
Aerial parts	EO	Agar diffusion method	*P. aeruginosa, C. sakazakii, L. innocua and S. pyogenes, C. albicans, S. cerevisiae*	Complete inhibition of the growth of all the strains by 50% and 100% EO[28]
Aerial parts	Primary EO and secondary EO	Disk diffusion method and micro dilution method	*S. aureus, S. epidermidis, E. faecalis, S. mutans, E. aerogenes, K. pneumoniae* and pathogenic fungi: *C. neoformans* and *C. albicans*	Φ - 20–>35mm MIC ranged between 1/3200 and 1/6400[30]
Aerial parts	EO of *T. serpyllum* in combination with EO of *O. compactum* (oregano), and *O. majorana* (marjoram)	Micro dilution method and checkerboard assay	*B. subtilis, S. aureus* and *E. coli*	Antibacterial synergistic effect was observed with combination of EO of *T. serpyllum* with EO of marjoram against *S. aureus*, while combination of EO of oregano and EO of *T. serpyllum* showed significant synergistic activity against *S. aureus* and *E. coli*[38]
Aerial parts	EO of *T. serpyllum in* combination with EO of *O. majorana*	Micro dilution method and checkerboard	*E. coli* and *S. aureus*	Synergistic antibacterial effect of EO of *O. majorana* and *T. serpyllum* with FIC index of 0.725[38]

	(marjoram)	assay		
Leaves	AgNPs of aqueous extracts	Agar well diffusion	*B. cereus*	Φ - 12.23±0.54 mm
			S. aureus	Φ - 13.86±0.58 mm
			E. coli	Φ - 9.98±1.02 mm
			S. typhimurium	Φ - 10.60±0.53 mm

K. pneumoniae=Klebsiella pneumoniae, *P. aeruginosa=Pseudomonas aeruginosa*, *E. coli=Escherichia coli*, *S. aureus=Staphylococcus aureus*, *B.* subtilis=Bacillus subtilis, S. epidermidis=Staphylococcus epidermidis, C. albicans=Candida albicans, C. parapsilosis=Candida parapsilosis, A. fumigatus=Aspergillus fumigatus,

A. niger=Aspergillus niger, A. ochraceus=Aspergillus ochraceus, A. carbonarius=Aspergillus carbonarius, C. sakazakii=Cronobacter sakazakii, L. innocua=Listeria innocua, S. pyogenes=Streptococcus pyogenes, S. cerevisiae=Saccharomyces cerevisiae, E. faecalis=Enterococcus faecalis, S. mutans=Streptococcus mutans,

E. aerogenes=Enterobacter aerogenes, C. neoformans=Cryptococcus neoformans, B. cereus=Bacillus cereus, S. typhimurium=Salmonella typhimurium,

T. serpyllum=Thymus serpyllum, O. majorana=Origanum majorana, O. compactum=Origanum compactum, Φ=Zone of inhibition in mm, MIC=Minimum inhibitory concentration, FIC=Fractional inhibitory concentration, EO=Essential oil, AgNPs=Silver nitrate nanoparticles

The HepG2 gene has a half-life of about 34.96 ± 2.90 µg/ml. The MCF-7, LNCaP, and NIH3T3 fibroblast cell lines were shown to be cytotoxic by T. serpyllum EO. Research indicates that the antiproliferative activities of the EO are due in part to molecules such □-caryophyllene, a sesquiterpene.[46] The antiproliferative effect of the EO of T. serpyllum against oral squamous cell carcinoma cultures and the SCC-25 cell line was shown to be restricted by Lazarevic et al. [47]. With IC50 values of 95.8, 105.0, and 105.0 mg/ml, respectively, the oil exhibited comparable effects against MCF-7, LNCaP, and NIH-3T3 cell lines.[46] Berdowska et al. [48] reported that the cytotoxicity of the T. serpyllum water extract was tested against both cancer cells (MCF-7/Adr) and wild-type MCF-7 (wt) cells. Acute promyelotic leukemia (HL-60) cells were shown to have antiproliferative activity when exposed to thymol, a primary component of T. serpyllum essential oil.[49] Thymol and carvacrol exhibited cytotoxicity against breast cancer that was dosage dependant. tumors, colorectal cancer, and the P815 mastocytoma cell proliferation model. Similarly, Jaafari et al. observed that the cytotoxic activity of T. serpyllum EO was correlated with its carvacrol concentration.[45] So, it is possible to study the therapeutic usefulness of thyme essential oils and phytocompounds in treating cancer in people.

Activity against malaria

Researchers Hussain et al.[31] used an antihem biocrystallization test to look at the antimalarial effects of T. serpyllum essential oil. The antimalarial activity of T. serpyllum oil was found to be

46.1% at a concentration of 10 mg/ml. The antimalarial potential of T. serpyllum EO and its components has to be further investigated in in-depth investigations using different doses and model systems.

Safety Investigations

When taken in the approved therapeutic doses, thyme has been designated as "food safe" by the US Food and Drug Administration. Researchers Xie et al.[50] found that mice were able to breathe in thymol hydrofluoroalkane at concentrations ranging from 0.1% to 0.5% for 6 months without experiencing any negative effects on their respiratory systems or lungs. On the other hand, data about the harmful effects of T. serpyllum EO administration is few. To further understand the safety profile of T. serpyllum EO, it is essential to do comprehensive studies that concentrate on the toxicity aspects utilizing different doses and model systems.

Alternative Uses of Biotechnology

Activity of food preservatives

The phytocompounds contained in T. serpyllum EO, including as thymol, carvacrol, terpenoids, and others, have shown to be valuable in improving food safety and quality by inhibiting the development of food microorganisms. These phytocompounds either function as antimicrobials to combat food-borne diseases or inhibit the deteriorating action of bacteria in food goods.[51] Because of its antioxidant and antibacterial characteristics, wild thyme is a vital therapeutic herb.[15] Hagan et al.[52] found that fermenting cakes with T. serpyllum EO helped prevent fungal infections.

Pest control ability

Research has shown that the principal active element in T. serpyllum's essential oil, thymol, is resistant to the larvae and pupae of common houseflies (Musca domestica). New evidence suggests that T. serpyllum thymol may cause fumigant and contact toxic reactions. These results indicate that thymol and T. serpyllum EO are both poisonous to housefly larvae and pupae, which might make them useful tools for managing housefly populations. The insecticidal activities of carvacrol and thymol from T. vulgare have already been reported by Szczepanik et al. [53]. Unfortunately, the insecticidal capabilities of T. serpyllum EO have not been studied so far. But the insecticidal effect of T. serpyllum EO has not been studied before.

Environmental protection

A wide range of pharmacological effects are shown by T. serpyllum. T. serpyllum has piqued the curiosity of both scientists and the general public in the hopes of creating new herbal remedies.

Indian, Chinese, Nepalese, Pakistanese, North American, and East African cuisines mostly include T. serpyllum.[8] Because of its great medical value and scarcity of supply, scientists are attempting to grow T. serpyllum in vitro using tissue culture methods. Dear Sir/Madam

Rajan Rolta, Advisor at Tridev Aushadhi Utpadhan Society, Rohal, Chirgaon, District Shimla, Himachal Pradesh, India, is also trying to cultivate the T. *serpyllum* in its natural habitat to fulfill the industrial demand for this herb.

Another individual who is attempting to meet the industrial need for T. serpyllum is an advisor at the Tridev Aushadhi Utpadhan Society in Rohal, Chirgaon, District Shimla, Himachal Pradesh, India.

Considerations for the Future and Final Thoughts

Aerial parts of T. serpyllum have been used to treat esophageal, gastric, and urinary tract infections. Essential oils from this species have become more popular in contemporary medicine because of their pharmacological significance. Important for industrial, cosmetic, and medicinal uses, the phytocompound composition and yield of T. serpyllum EO are affected by a number of variables, including as growth stage, geographical location, and harvesting season. New studies show that T. serpyllum essential oil has powerful antibacterial and antioxidant effects. The possible use of thymol, carvacrol, and other components against cytotoxicity, inflammation, malaria, and hypertension needs more research, however. The herb's varied pharmacological effects make it valuable to the pharmaceutical business, while its potential antioxidant and nutritional supplement uses make it attractive to the food industry.

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