Journal of Population Therapeutics & Clinical Pharmacology

RESEARCH ARTICLE
DOI: 10.53555/jptcp.v31i1.4084

A COMPLETE REVIEW ON LAVENDER AND THYME ANTIFUNGAL AGENT

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Abstract:
Thyme is a Mediterranean-native perennial wild shrub belonging to the *Lamiaceae* family. It has been studied for centuries because of its special significance in the food, medicine, and beauty industries. Thyme is rich in vitamins, minerals, and phytonutrients. Although it has a strong flavour, it is high in moisture, proteins, crude fiber, vitamins, and minerals. Its chemical makeup varies depending on the region, but flavonoids and antioxidants make up the majority of it. Prior research has demonstrated the medicinal benefits of thyme and its essential oils, particularly carvacrol and thymol, against a range of illnesses. Plants that bloom throughout Europe and the Mediterranean region include the lavandula species. Humans can benefit from lavender's many health benefits. It is extensively utilized in the fields of foods, cosmetics, fragrances, and aromatherapy in addition to herbal medicine. Lavender has been used as a wound cleaner, to relieve biliousness, to cure colic and chest illnesses, and to worry about headaches. Among its many benefits include antifungal, antibacterial, neurologic, antimicrobial, anti-parasitic, anti-diabetic, and analgesic. There are potential biological uses for the lavender species, particularly in the field of dermatology.

Keywords: Anti-Fungal agent, Thymonin, Linalool, Lavandula.

Introduction

Filamentous fungus is the most frequent pathogenic microorganisms that impair agricultural production and quality and generate significant crop economic losses. Mycotoxigenic fungi are recognized for colonizing a broad variety of cereal grains, vegetables, spices, and fruits. This mould generates mycotoxins, which have been linked to a variety of adverse effects on human health, including genotoxicity, carcinogenicity, and immunosuppressant. [1] Essential oils and their components have shown a variety of ways of action in preventing infections against which they are effective.[2] Essential oils are widely recognized in traditional medicine as antiseptics and antimicrobial agents, and they have a broad spectrum of action, including antibacterial and antifungal activity [3].

Linalool and linalyl acetate, two major monoterpenes present in lavender essential oils, have been showed to limit spore germination and diminish mycelium development. [4] Essential oil composition varies greatly, with the typical essential oil including more than twenty terpene elements, and each species and cultivar has a distinct oil composition. Lavandula angustifolia Mill. (*Lamiaceae*) essential oil (lavender oil) is mostly used in aromatherapy as a relaxing, carminative, and sedative agent [5].

Lavender is often utilized in fragrances, soaps, bath and talc powders, candles, and scented sachets nowadays [2].
Thymus (thyme) is a genus of roughly 215 herbaceous perennials and sub shrubs that are well suited to hot and dry regions. T. vulgaris essential oils have been identified to have antiseptic, antiviral, and antibacterial properties. Thymol and p-cymene are the primary components; however other thyme species also include carvacrol, a-terpinyl acetate, and cis-myrtanol.
The current study describes the antibacterial and antifungal activities of a common thyme essential oil and lavender, as well as its potential use as a natural food additive due to its inhibitory effects on the growth of susceptible and multidrug-resistant pathogenic and non-pathogenic food spoilage bacteria and fungi. [6].

1.Thyme (*thymus vulgaris*):
Thymus vulgaris, also known as "thyme," has been utilized for its flavoring, culinary, and medicinal qualities for many years. Thyme gets its name from the Greek word thymos, which denotes bravery or strength. Thyme's primary usage in the first century AD was as a medicinal plant, according to Dioscorides' research.[7]
The thymus genus is a subfamily of the *Lamiaceae* (Labiate) family of aromatic plants. 214 species and 36 subspecies, grouped into eight groups by the names Micantes, Mastichina, Piperella, Teucrioides, Pseudothymbra, Thymus, Hyphodromi, and Serpyllum, are known, according to Jalas [8] and Morales [9]. The Western Mediterranean region is populated to the species T. vulgaris L. and T. zygis L. Thymus. From Spain to Italy, T. vulgaris is a native of Southern Europe [7]. According to Talhouk et al. [10], T. vulgaris is the native species that is known to be found in Lebanon.
Below, the systematic classification of this species is listed:
Kingdom: *Plantae*
Subkingdom: Tracheobionta
Superdivision: Spermatophyta
Division: Magnoliophyta
Class: Magnoliopsida
Subclass: Asteridae
Order: Lamiales
Family: *Lamiaceae*
Genus: Thymus L.
Species: *Thymus vulgaris L.* [11]

Chemical Composition:
Thyme has a monoterpene amount of 56.53%, as well as monoterpene hydrocarbons of 28.69%, sesquiterpene hydrocarbons of 5.04%, and oxygenated sesquiterpenes of 1.84% [12].

Thyme is rich in flavonoids and phenolic antioxidants as zeaxanthin, lutein, pigenin, naringenin, luteolin, and thymonin [11].
Due to its high concentration of vitamins and minerals that are vital for optimum health, fresh thyme has one of the highest amounts of antioxidants. Concentrated in the leaves are potassium, iron, calcium, manganese, magnesium, and selenium. Thymol is the major chemical in the oil which is extracted. The antioxidant activity of thyme is mostly due to its important phenolic component thymol [11]. The flowering stem of thyme contains tannins, phenolic acids such cafeic and rosmarinic acids, and flavonoid derivatives like apigenol and luteolol [13].

Antifungal Activity of Thyme:
Thymol and carvacrol, two phenolic chemicals, are primarily responsible for thyme's antifungal effect. Carvacrol was discovered to have strong fungitoxic properties when tested on fruits more than 20 years ago [14]. The findings of the various research on antifungal capacity are not always comparable because of changes in herb quality, qualitative and quantitative variations in essential oil constituents, discrepancies in the fungal strains studied, and methodological variations [15].
Candida, certain species of which are pathogenic microbes and infect hosts with reduced immune systems or other conditions, is one of the most prevalent pathogens in fungal diseases. Invasive infections have the potential to be life-threatening and can be either superficial or invasive. Antifungal medications including azoles and echinocandins are widely used to treat Candida infections. Although many species now exhibit greater resistance to these antifungal medications, this has an adverse effect on clinical settings and patient care [16].
Studies examining the herb's impact on Candida and its potential as a source of anti-candidal drugs thus comprise a significant body of research, together with knowledge of thyme's bioactivity and its potential antifungal capabilities. Examples include research on the effectiveness of thyme essential oil against vaginal or blood-borne fluconazole-resistant C. albicans isolates. It effectively inhibited the growth of the isolates on culture media and, at low dosages, was both fungistatic and fungicidal. Additionally, the oil prevented the growth of fungal pathogens and their ability to budding, and it was more effective than fluconazole against resistant isolates [17].
In fact, C. albicans' capacity to alter its shape and create biofilms is essential to both its pathogenicity and the development of its antifungal drug resistance [18]. As a result, the impact of thyme essential oil on Candida biofilm formation has been examined by two separate research teams. In one study, thymol inhibited hyphae production in C. tropicalis biofilm and caused the disaggregation and distorted morphology of C. albicans biofilm cells. Additionally, thymol and fluconazole demonstrated synergy in their ability to inhibit both the planktonic and biofilm growth phases in both species [19].
Thyme oil was found to have a variety of compounds that were present in the cell wall, cell membrane, cytoplasm, and vacuoles of C. albicans, demonstrating a multidirectional action in addition to the anti-biofilm activity in a different study that showed a statistically significant reduction in the number of biofilm cells [20]. A recent study of plant-derived preparations and chemicals that inhibit Candida biofilm formation by at least 50% included both thyme oil and thymol at concentrations lower than 16 mg/L [21].
Some research [22] also demonstrated that thyme oil caused significant alterations in C. albicans cellular and colony morphology as well as metabolic pathways, such as the loss of the capacity to assimilate saccharides. We expected that these modifications would significantly affect C. albicans' capacity to spread infection. Thymol suppressed the growth of uncommon yeasts in vitro, suggesting it as a potential natural adjuvant for infections brought on by those organisms, in addition to C. albicans and non-albicans species and rare yeast species that are increasingly emerging as major opportunistic pathogens [23].
In addition to Candida, numerous species of the fungus Aspergillus can negatively impact the health of plants, animals, and people by direct infection and/or the production of aflatoxins, which are among the most dangerous mycotoxins [24]. In a recent work, Oliveira and Colleagues [25] examined the antifungal and anti-aflatoxigenic properties of thyme essential oil in Aspergillus flavus.

Through apoptosis, nuclear condensation, and disruption to the plasma membrane, thyme essential oil displayed antifungal action. Additionally, the oil adversely impacted secondary metabolism and virulence pathways, lowered aflatoxin formation, and gene expression. Thyme oil mixed with lemongrass oil was the most effective synergistic antifungal against A. fumigatus, according to a study by Helbová et al. that evaluated 25 different plant essential oils against indoor species of Aspergillus. The synergistic combination may be helpful for reducing resistance to current synthetic antifungals or controlling fungal growth [26].

Thymol, which has roughly three times the inhibitory potential of thyme essential oil, was able to produce long-lasting suppressive activity on a variety of mold genera, including Aspergillus, Penicillium, Ulocladium, Absidia, Mucor, Cladosporium, Trichoderma, Rhizopus, and Chaetomium, isolated from wall scrapings of damp homes in Croatia. This indicated the possibility of disinfecting moldy walls using thymol or thyme essential oil at low concentrations [27]. When combined with itraconazole, thyme was found to be a natural and affordable adjuvant against Cryptococcus neoformans [28], a fungus that causes pneumonia and meningitis in immunocompromised people.

Korean researchers looked at the ways by which thymol inhibits C. neoformans in 2021.Thymol was discovered to regulate calcineurin's numerous signaling pathways, as well as to lower endogenous ergosterol levels by lowering the expression of genes involved in ergosterol manufacture [29]. The essential oil of thyme demonstrated intriguing results when tested against Microsporum and Trichophyton, the two main genera of dermatophytes obtained from clinical specimens, in terms of skin infection with dermatophytes that cause tinea, suggesting a natural substitute for topical antifungal medications [30].

One of the novel formulations that recently demonstrated excellent fungicidal activity, not only against dermatophytes but also against other molds and several pathogenic fungi of plants, was a nano-emulsion of thyme oil made by ultrasonification [31], perhaps highlighting the abundance of natural ingredients and the flexibility of design and formulation.

2. Lavender:

The variety Lavandula, regularly known as lavender, is one of the economically significant individuals from the Lamiaceae (Labiatea) family, containing about 39 species and 400 assortments [32-34].

According to some sources, the name “lavender” has its etymological roots in the Latin verb “lavare,” which meaning “to wash” or “to bathe.” This is because lavender has long been used externally for cleansing and disinfecting in addition to internally for treating illnesses [35].

Lavender and its related substances are known by a number of common names, including garden lavender, English lavender, lavender, limonene, lavender burnamii, lavender dentate, lavender dhofarensis, lavender latifolia, lavender officinalis L., lavender stoechas, pink lavender, true lavender, and white lavender.[45,46]

Since they have antibacterial, antimicrobial, carminative, spasmolytic, sedative, analgesic, antioxidant activity tonic, and antidepressant qualities, a number of lavender essential oils are widely utilized in aromatherapy. [36-39]

Scientific classification of Lavandula angustifolia
Kingdom: Plantae
Phylum: Tracheophyte
Class: Magnoliopsida
Order: Lamiales
Family: *Lamiaceae*
Genus: Lavandula
Species: Angustifolia

Chemical Composition:

The primary constituents of lavender are oxygenated monoterpenes, monoterpene hydrocarbons, and sesquiterpenes, specifically linalool (27.3–42.2%), linalyl acetate (27.2–46.6%), (Z)-β-ocimene (0.2–11.6%), terpinen-4-ol (0.70–4.6%), lavandulyl acetate (0.50–4.8%), β-caryophyllene (1.8–5.1%), €-β-ocimene (0.30–3.8%), α-terpineol (0.30–2.0%), and 1,8-cineole (0.10–1.2%) [40,41].

The quality of an oil is determined by its linalool and linalyl acetate concentration. On the other hand, modest levels of ocymen, cineole, camphor, or terpin-4-ol are recommended because of their substantial influence on aroma [42].

Other minor components of the essential oil include tridecan-1-ol (0.48%), panisic acid ethyl ester (0.28%), geranyl isovalerate (0.55%), cis-z-å -bisabolene oxide (0.99%), and cedrol (0.68%). [43,44].

Antifungal Activity of Lavender:

There are many research studies,Reporting mixed results, about the antifungal effects of Lavender. One study, for instance, demonstrated that Lavender oil had considerable antifungal effects on Candida albicans; whereas, another one reported that Lavender oil had very weak inhibitory effects. At both concentrations, B. cinerea proved to be the most susceptible fungus. After seven days of incubation, the oil containing 40 parts per milliliter of lavender oil shown potent antifungal action against the mycelial development of A. alternata as compared to the control.[47]

The growth of F. oxysporium was shown to be more strongly inhibited by 40 ppm of oil than by 10 ppm of oil. Lavender oil demonstrated distinct fungistatic properties against F.oxysporum at each dosage. Additionally, after incubating on the same fungi for three days, lavender oil exhibited minimal action. B. cinerea was the most impacted fungus from lavender oil, followed by A. alternata and F. oxysporum. A 40 ppm dose of oil had a moderate inhibitory effect on F. oxysporum's mycelial growth. As a result, the 40 ppm oil dosage completely (100%) inhibited the mycelial growth of B. cinerea. According to the investigation, the fungistatic activity of lavender oil varied based on the dosage.[48]

Plant fungal diseases such F. oxysporum and Alternaria alternata, as well as Phomopsis sp., F. solani, F. sporotrichioides, F. verticilioides [49], and Verticillium spp. [50], are inhibited in their ability to grow their mycelia by lavender oil.

The authors who were referenced provide results that indicate a minimum inhibitory concentration (MIC) ranging from 1 to 3 mg/mL. Our findings concur with those of a previous study [51], in which the oil of Lavender stoechas shown a strong antifungal action against Botrytis cinerea (IC50 – 1.64 ppm). According to certain studies, there is a connection between the antibacterial activity of the studied essential oils and the chemical structures of the most prevalent molecules [52-54].

Conclusion:

The passage highlights the versatile uses and benefits of both thyme and lavender, two members of the *Lamiaceae* family with rich histories in various industries. Thyme, renowned for its role in food, medicine, and beauty, is packed with nutrients, antioxidants, and medicinal compounds like carvacrol and thymol. Similarly, lavender, with its diverse health benefits including antibacterial, neurologic, and analgesic properties, has found extensive application in food, cosmetics, aromatherapy, and herbal medicine. Both plants offer significant potential in various fields, especially in medicinal and dermatological applications.

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